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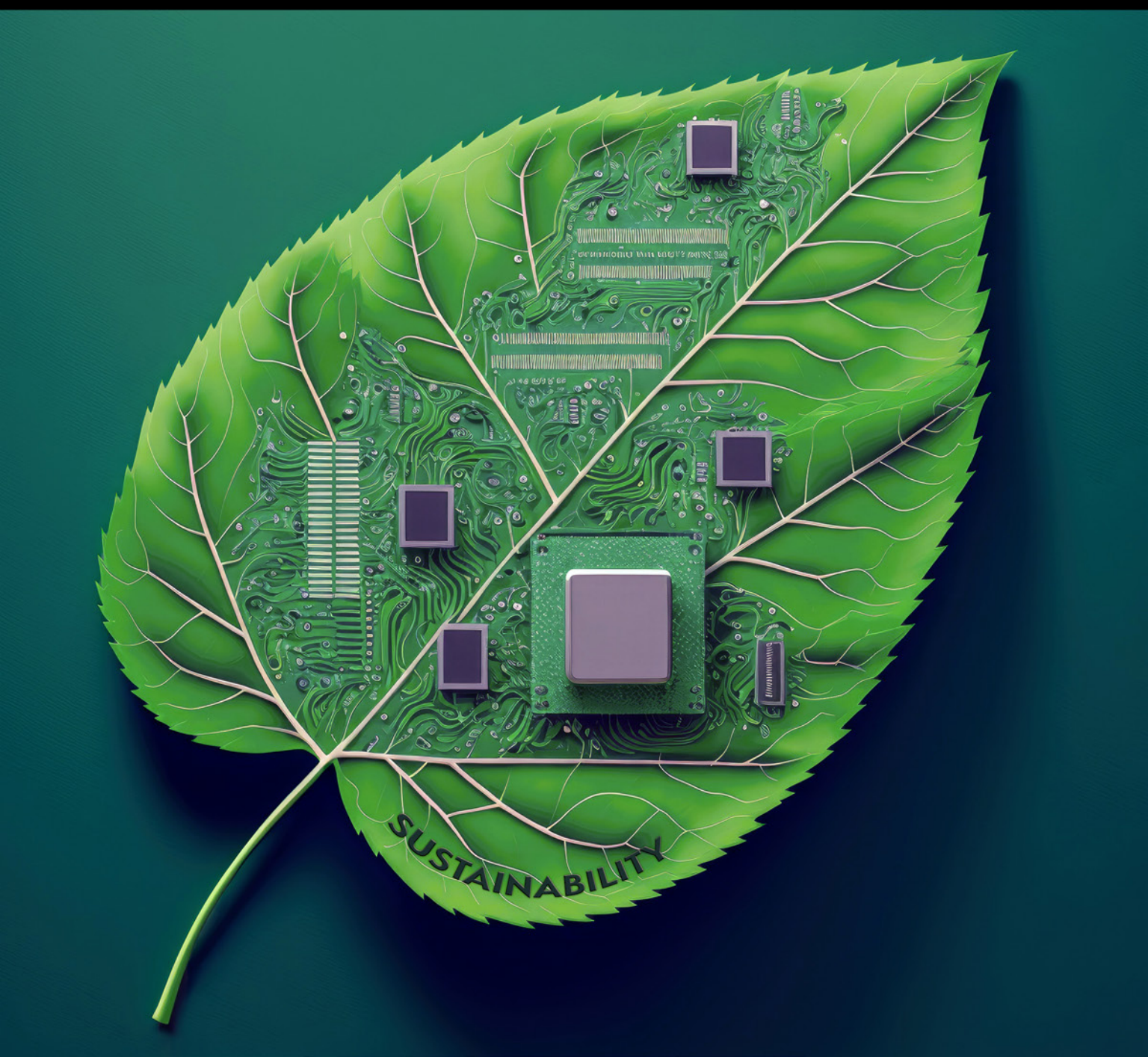

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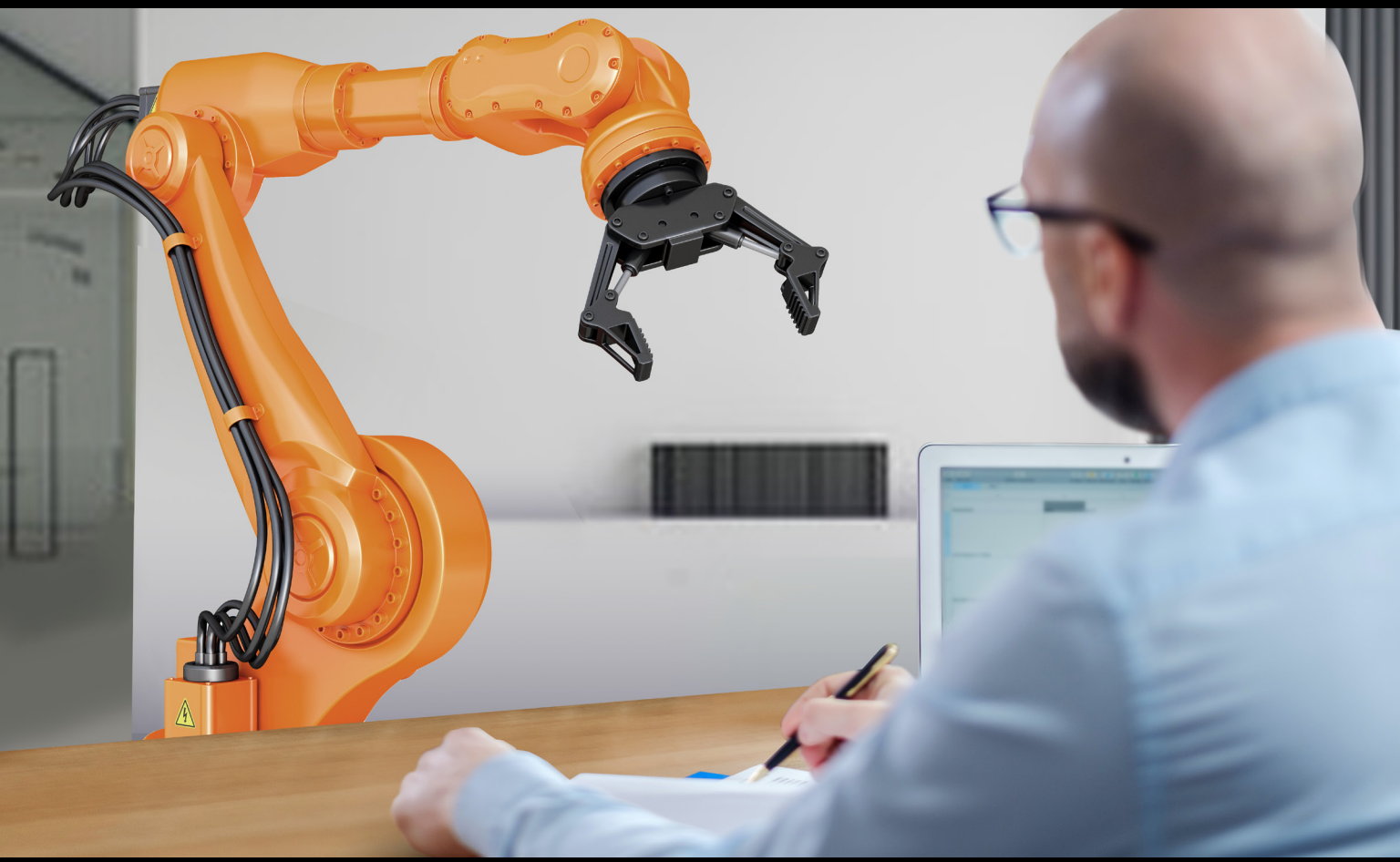

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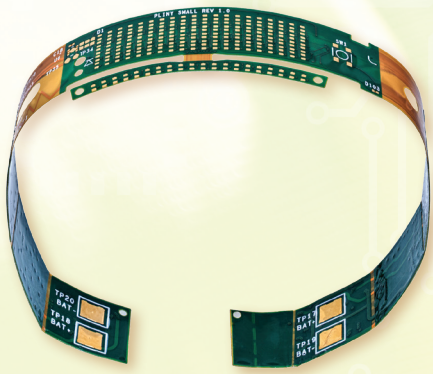

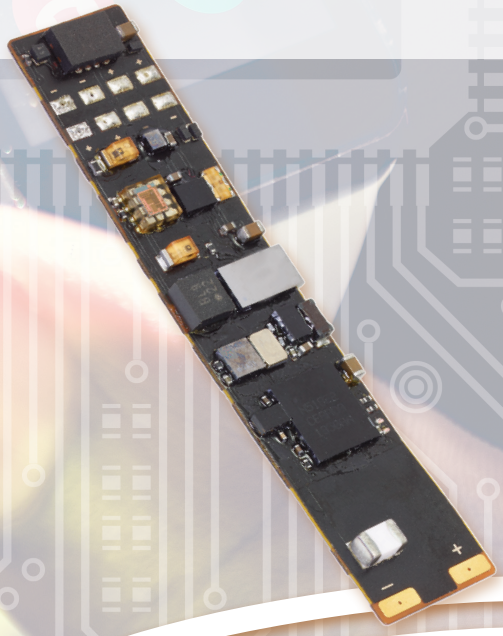

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Getting Real About Sustainability

Nolan's Notes

by Nolan Johnson, I-CONNECT007

As we gathered content for this issue of *SMT007 Magazine,* I kept reflecting on my early 1980s college history class on World War II. I had been surprised to find that my textbook was written by a physicist from the Manhattan Project and concluded with a chapter devoted to a physics thought experiment. The author had done some estimatory mathematics (as physicists do) to determine that 20th century man was heating up the planet at such a rate that it would become a world crisis. As I recall, he factored in CO_2 emissions and the amount of heat released into the atmosphere per household, coming from even simple activities like cooking and hot showers. It was thought provoking.

My point here is not to take a stand on climate change. Rather, it's to note that a physicist's musings 40 years ago have generally become mainstream in the sense of overall sustainability. Of course, responding to climate change is just a small part of what encompasses sustainability. We generally agree nowadays that our world is a closed system containing finite resources. The 19th-

century idea of "manifest destiny," though the thought lingers, is no longer valid.

Let's use copper as an example. Building out the global EV charging network will cause an exponential requirement of copper. Wood Mackenzie estimates that by 2030, there will be 20 million charging stations operating globally, consuming 250% more copper than in 2019[1]. USGS estimates that the global copper supply is enough to meet EV demand, but we know the demand for copper goes way beyond EVs. In fact, "electric vehicles require two and a half times as much copper as an internal combustion engine vehicle," and "copper demand will double to 50,000,000 metric tons annually by 2035, more than all the copper consumed in the world between 1900 and 2021."[2]

It seems that we now have a pretty good set of estimatory mathematics to tell us just how much copper (or lithium, silver, or molybdenum) is available before we've pulled it from all the accessible parts of the Earth's crust. These resources—especially the non-renewable ones—simply must be used again. Early environmentalists called it recycling; now the professional term is "circular economy."

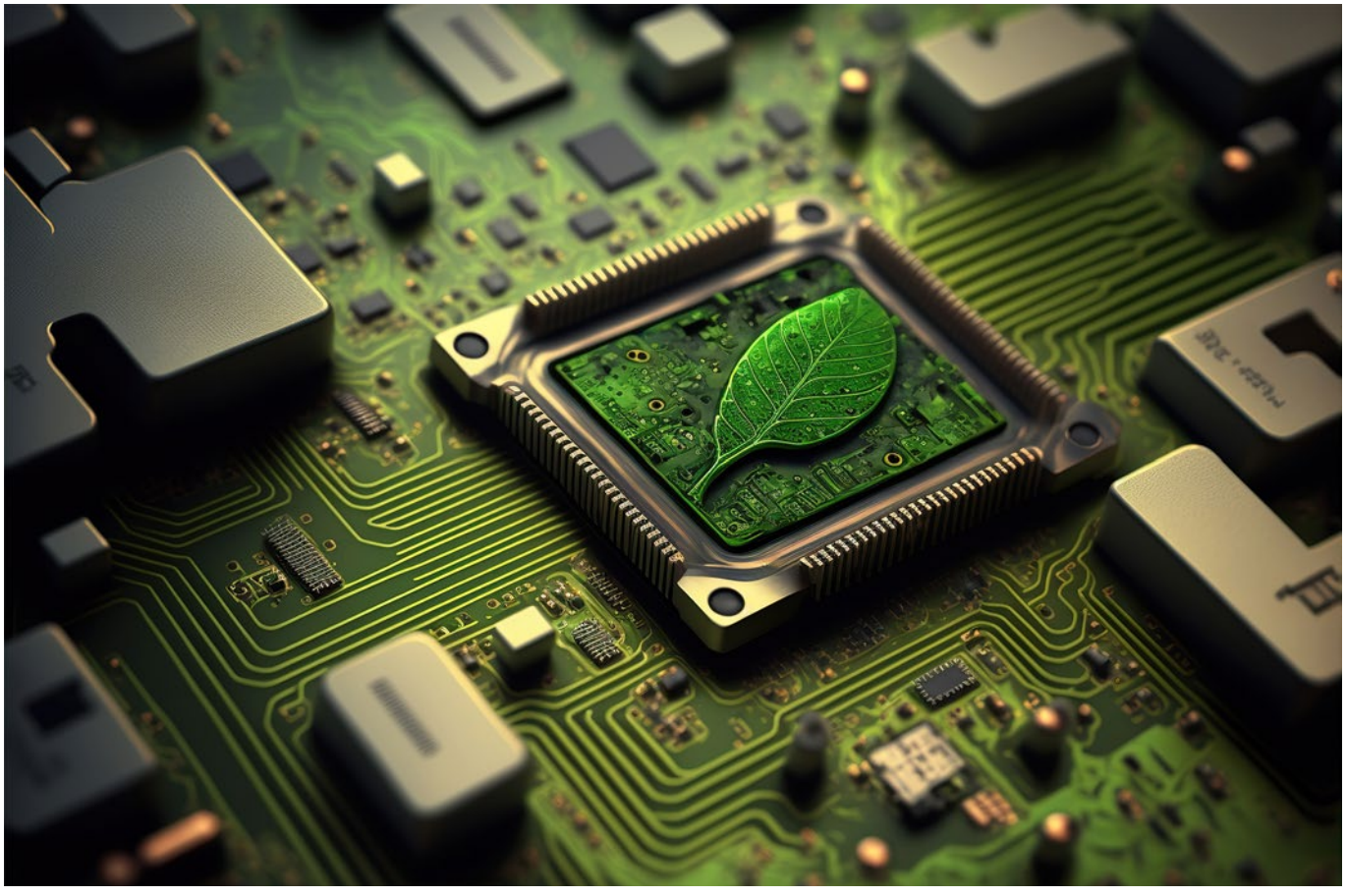
Thinking and acting sustainably touches virtually every aspect of our lives, from what we do personally to how we conduct business: Don't use something unless you have to, design products that minimize raw materials, and reclaim the materials once you're done with them—these are the new maxims for us all. We don't need to be misers; we just need to be smarter about our usage. So, how do we get started? In this issue, we take on that challenge. We asked several organizations either in the industry, or tangential to it, and as was expected, the responses lined up closely with their mission statements. Each organization is a narrow slice of knowledge, resources, tools, or connection. We found that these narrow slices suggest a larger picture, the hint of a continuum that—while not in place yet—will undoubtedly emerge, especially if we all work together to define the pieces.

We also found enthusiasm, awareness, and action in the content. Kelly Scanlon, IPC's lead sustainability strategist, for example, has jumped straight into the deep end, but admits there's still much to be defined—it just depends on who you ask and what they need, she says. There's no one right answer to the sustainability question. Sometimes, getting started begins by asking, "Where are we now?" iNEMI's Mark Schaffer shares his organization's estimator tools, which shed some light on how effective you are with your resources, and allows you to practice some what-if scenarios. We also introduce you to Pamela Brody-Heine of the Clean Electronics Production Network (CEPN), who shares her work to make manufacturing spaces environmentally friendly and safe. Additionally, NextFlex's Art Wall contributes an article on the sustainability potential in additive processes, and Kyzen's Tom Forsythe talks with us about cleaning and sustainability. Our columnists this month—Michael Ford, Ron Lasky, and Mike Konrad—likewise discuss topics that, whether directly or indirectly, touch on sustainability. Sustainability is happening, so how do you embrace it? How do you stay far enough ahead that you don't get swept to the side? The more we can work together to create better tools for estimation, and the more circular we make our processes, the better we will be. **SMT007**

References

1. "Copper: Powering up the electric vehicle," Aug. 13, 2019, Wood Mackenzie.
2. "Copper, the Critical Material for Transportation Electrification," by James Anderton, Feb. 6, 2023, engineering.com.

Nolan Johnson is managing editor of *SMT007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, click here.



Why Does Sustainability Matter?

Feature Interview with the I-Connect007 Editorial Team

In a recent conversation with Kelly Scanlon, IPC lead sustainability strategist, we dove deep into the topic of sustainability, asking what it is and how we achieve it. Because this is such a broad topic, we've excerpted just a portion of the conversation here, but what is clear is that we've only scratched the surface on sustainability; there is so much that is not yet fully defined.

Nolan Johnson: Kelly, why should we concern ourselves with sustainability?

One of the challenges of defining sustainability is answering the question, "What does sustainability mean?" You could be talking at the level of an individual—what we do in our homes or whether we carry a reusable shopping bag to the grocery market—or how this translates into what we do when we design, build, and use electronics.

Think on this long enough and the idea of sustainability becomes a journey of continuous improvement that can increase resource efficiencies and decrease impacts through conscientious and intentional lifecycle management. That's great. So, what does this mean to electronics manufacturing companies? Sustainability concepts, approaches, and metrics are challenging to define. Placing these concepts, approaches, and metrics in context with the variety of companies and stakeholders making up the complex and diverse electron-

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Kelly Scanlon

ics manufacturing supply chain is even more challenging.

John Mitchell has elevated sustainability at IPC, which has a robust sustainability for electronics initiative. We aim to identify the environmental, social, and corporate governance sustainability topics that are most pressing and put a roadmap into place for reassessing these topics over time. By identifying the most relevant or material topics, IPC wants to support the industry so it can focus on those things that matter, that is, that can be measured and adjusted to ensure sustainability goals for electronics are appropriate and achievable.

The sustainability initiative incorporates industry insights from electronics manufacturing experts with industry data and information. This industry-led, evidence-based approach ensures that IPC will be able to create industry solutions that move the design, development, and production of sustainable electronics forward to build electronics better. The Sustainability for Electronics Leadership Council, established in March 2023, meets regularly to prioritize sustainability topics, and identify solutions to address challenges the industry has with these topics. Supply chain communications, terminology harmonization, and greenhouse gas reporting are some of the highest priorities, based on current regulatory drivers. From a recent review of more than 60 industry sustainability reports, we see that emissions, product lifecycle management, DEI (diversity, equity, and inclusion), worker health and safety practices, business ethics, and security issues are more frequently mentioned than other environmental, social, and corporate governance topics.

By the end of 2023, IPC plans to have more insights into the relevant topics for the industry following the completion of an industry-wide materiality assessment, the first step in understanding the state of sustainability for electronics.

Barry Matties: Can a fabricator do a sustainability self-audit, if there is such a thing, for our industry? Is that something IPC envisions?

Our sustainability initiative officially kicked off in January 2023. We have only done a handful of things, but we have more on the way. There's a balance—what is the most right way to frame up an audit verification program? Is it built against a standard or a reporting protocol? If so, which one?

For example, let's consider a soldering iron that turns itself off when not in use. That is a new technology that allows it to heat up to temperature efficiently, and even more safely. You don't have a hot iron all day long. How do you classify that? Is that reducing greenhouse emissions, utility conservation, or worker safety? What is the electronics industry's role in dealing with social issues like the number of working hours or child labor? Is forced labor—people who are working against their will—relevant to the industry? If so, how does it get addressed?

You see it's that mantra of continuous improvement. When you translate that into a micro view of electronics as an industry, your business models may need to change. You are

following "plan, do, check, act," and you're probably thinking continuously about what you make, why you make it, and how to do it better.

Johnson: It seems that this is a multidisciplinary challenge, with some parts that are very specific and others that are very general. The common theme, though, is the fundamental use of TQM as a way of breaking down the challenge into actionable pieces. It's financially beneficial, because you're more profitable when you use fewer resources; when you're optimized and efficient, you are more sustainable.

Engineers in electronics manufacturing are looking to existing technologies and, of course, newer technologies and innovations to help them make electronics better, whether that's through improved manufacturing processes, a change in the product, or how that product is made. When it's done differently, it's a different product. Reducing energy consumption, reducing water, changing the chemicals that go into these different processes to reduce waste, or create safer, non-hazardous, recyclable waste—all those things are happening.

> **"People are trying to keep data and information secure and yet you can't always do that.**

Matties: What is driving this in the industry? Is it a requirement of government or something else?

We have six or seven different drivers. The local community could be a driver. Your shareholders could be a driver. A bank or other financial investor might be a driver. It can be your government, whether it's local, national, or even global. For example, Germany has a supply chain law, and this law has ripple effects throughout the globe. If you're a supplier to Germany and you're in Vietnam, you will be affected.

Matties: Like our industry-wide lead-free work was years ago.

That's exactly right. We now have an exploration report we're working on and learning from. We're also learning from a series of surveys and interviews. We just completed a European EMS Sustainability Survey and interview with about 15 different EMS companies. That effort was qualitative, but it gives us a deeper dive.

Matties: How does that security and data play into sustainability? Are the suppliers or the fabricators hesitant to share their information for fear of giving away their competitive advantage?

That relates to the supply chain transparency issues regarding what data can and should be shared, and also when sharing that confidential business information becomes a problem. People are trying to keep data and information secure and yet you can't always do that.

In this instance, it almost doesn't even matter that we're talking about sustainability as the topic. It comes down to data management which is a mechanism that can help you in all parts of your business. It is critical for being able to do the data collection and analysis to figure out how to be more sustainable, but it's also useful in other parts of your business.

If you can collect data and move it with efficiency and accuracy, or the ability to collect accurate data, it doesn't matter what data you have. It could be on energy, water, people, or processes. The harder part is getting the information, a pathway for getting that information

into some sort of communication system, and then actually communicating it up and down the supply chain.

Johnson: Kelly, what are the long-term implications?

More now than ever, electronics manufacturing companies recognize obligations to enable sustainability through electrified solutions and obligations to be more transparent in their own practices. The risks of not managing sustainability can be severe and are likely now more than ever due to evolving regulatory obligations and expectations for transparency. Requests and requirements are increasing, as is the amount of data regarding a company's environmental, social, and corporate governance aspects and impacts. Information is needed by a diverse and numerous set of stakeholders including customers, investors, regulators and policymakers, employees, suppliers, and the communities in which companies operate. Companies are setting sustainability targets and they are talking about these targets, measuring themselves against their ability to achieve these targets, and looking at their customers and suppliers to ensure they are doing the same.

IPC is building a community of sustainability for electronics expertise. We are expanding existing standards and creating new ones with education and advocacy to be more inclusive of relevant sustainability topics. Sustainability for electronics will not warrant one-size-fits-all solutions. Today, there is not any one checklist that enables compliance or that guarantees all sustainability topics have been addressed. It's just too complex. We respect this complexity and aim for reasonable goals with achievable solutions. We hope to highlight just some of the tools and resources that the electronics industry can turn to now to help your company on its sustainability journey.

Matties: Thanks for your time.

Always a pleasure. **SMT007**

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Christian Wendt
MKTG & COMM. DIGITAL LOGISTICS

Siemens Experts Introduce New Sustainability Podcast

In I-Connect007's inaugural "On the Line with..." podcast, we spoke with six experts in sustainability and electronics manufacturing from Siemens Digital Industries Software: Susan Kayesar, Mark Laing, Patrick McGoff, and Christian Wendt. Other podcasts in the series feature Zac Elliott and Jonathan Fromm. After recording the episodes, we gathered to discuss the series: the content, challenges, potential solutions, and the impact on our industry.

Excerpts from that roundtable conversation are transcribed here, with a link to the audio version. Click here to listen to On the Line with... or follow us on Spotify.

Nolan Johnson: We just all finished recording a series of podcasts on the topic of sustainability with you as our subject matter experts. Sustainability really is a key topic for all industries right now; electronics manufacturing is no exception. Why is sustainability so important

to Siemens, to our shared readers, our shared customers?

Patrick McGoff: Siemens, being a global corporation, takes the lead on initiatives that serve beyond just their commercial interests. They've always been a thought leader and are inspiring other companies to follow with things that not just change industry, but to change the world. They've made it a priority to make sustainability one of their focuses in recent years and going forward. We all try to follow that guidance given there and look for opportunities where we can address that within our areas of domain.

Susan Kayesar: I'm going to go back to something that you touched on in our interview when you were talking about survival of the fittest. We were saying that awareness of sustainability issues is really on the rise globally. Not just in terms of legislation, but also in terms of, ethically speaking, the right thing to do and how we keep our world safe and preserve it for future generations. If we as a global company can be part of that preservation, we have a moral responsibility to do that.

Christian Wendt: We touched on the topic of circular economy, and how we can ensure that we are making the best out of the resources we have on our planet. And this is something that we as a global company are looking at.

Mark Laing: It's about the future, not just today, not achieving our goals for today, but thinking about the future and where we want to take things. How do we hand over this world to the next generation and the people after that? It's in some ways a necessary evil. But if we can make that as efficient as possible, the knock-on effects are significant. For all the technologies that we also need to rely on moving forward, such as electric vehicles, wind, solar panels—all of that is going to rely on efficient electronics.

Johnson: I certainly found these conversations to be very enlightening for me personally, and to interact with all of you as we went through those conversations. We talked about what sustainability means. And in all the different facets that were covered, that was a great process to go through for me personally. I certainly hope the listeners feel the same way.

Kayesar: I say start now, right where you are. Any small thing that you can do to contribute to the effort will be returned ten-fold, a thousand-fold, in years to come.

McGoff: If you're achieving something that makes things more sustainable, you're making it more possible for your clients in the future to achieve success with your solutions. If we do begin now, if we do take the small steps, if we look at each element that we can address and affect, then we do have the ability to have a positive outcome for the future of our companies as well as our children.

Johnson: Thank you very much for joining me to talk about this. It has been a pleasure working with all of you, putting this series together.

Kayesar: Thanks for having us, Nolan. **SMT007**

Electronics Manufacturers Reporting Cautious Optimism

IPC Releases May Global Sentiment of the Electronics Supply Chain Report

Per IPC's May 2023 Global Sentiment of the Electronics Supply Chain Report, cost pressures continue to recede and demand remains positive for now, leading to a cautiously optimistic global electronics industry sentiment.

"Geopolitical factors, along with the continued impacts of inflation and rising interest rates, have led manufacturers to describe the current economy as slow, uncertain, challenging, difficult, volatile, and unpredictable," said Shawn DuBravac, IPC chief economist. "However, despite current conditions, the outlook for 2023 is relatively positive, with manufacturers expressing optimism and expecting growth, especially in the latter half of the year."

> **Nearly three-fifths of electronics manufacturers are currently experiencing a 57% labor and material cost increase. At the same time, ease of recruitment, profit margins, and backlogs are presently declining.**

Additional survey results indicate:

- The majority of respondents are still reporting that labor costs and material costs are rising, but the number of companies experiencing rising costs continues to decline. Only 49% of companies believe material costs will rise in the coming months, the first time this has fallen below 50 percent.
- Ease of recruiting skilled workers has also improved to its highest level since the survey began.
- The Orders Index slipped to 101. This is still in expansionary territory, but it is the lowest level seen since the start of the survey.
- Orders are expected to decline more so for firms operating in North America versus those in Europe, who instead are more likely expecting orders to remain stable.

For the report, IPC surveyed hundreds of companies from around the world, including a wide range of company sizes representing the full electronics manufacturing value chain. View full report.

NEW EPISODE

sustainability in manufacturing

Learn how electronics manufacturers can be more sustainable and have a smaller environmental impact while increasing yield and efficiency. Join Mark Laing of Siemens as he explains strategies in this edition of *On the Line with...* brought to you by I-Connect007.

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iNEMI Develops Tools for Sustainable Electronics

Feature Article by Mark Schaffer
iNEMI

Information and communications technology (ICT) products are essential to modern society and comprise a significant portion of the global economy. They also have a not-so-insignificant environmental impact because they consume large amounts of resources and energy during manufacture, use, and disposal. The short life of ICT products, coupled with increasing demand for products, worsens the scenario.

An initial, but key step in reducing the environmental impact of a product is to measure that impact. Lifecycle assessment (LCA) is the well-recognized methodology to assess environmental impacts through a product's life. However, traditional LCA processes are typically expensive and time consuming. In many cases, a simpler approach can be employed to provide guidance and further enable adoption of LCA to reduce environmental impact.

Given the current climate change challenges, it is necessary for ICT manufacturers to reduce this impact. To that end, the International Electronics Manufacturing Initiative (iNEMI) and its members have developed two tools that can aid the electronics industry in this effort—the Reuse and Recycling Metrics tool[1] and the Eco-Impact Estimator tool[2].

Reuse and Recycling Metric Tool

iNEMI's Reuse and Recycling Metrics (R&RM) project focused on increasing circularity for electronic products. The project team developed a predictive metric that helps

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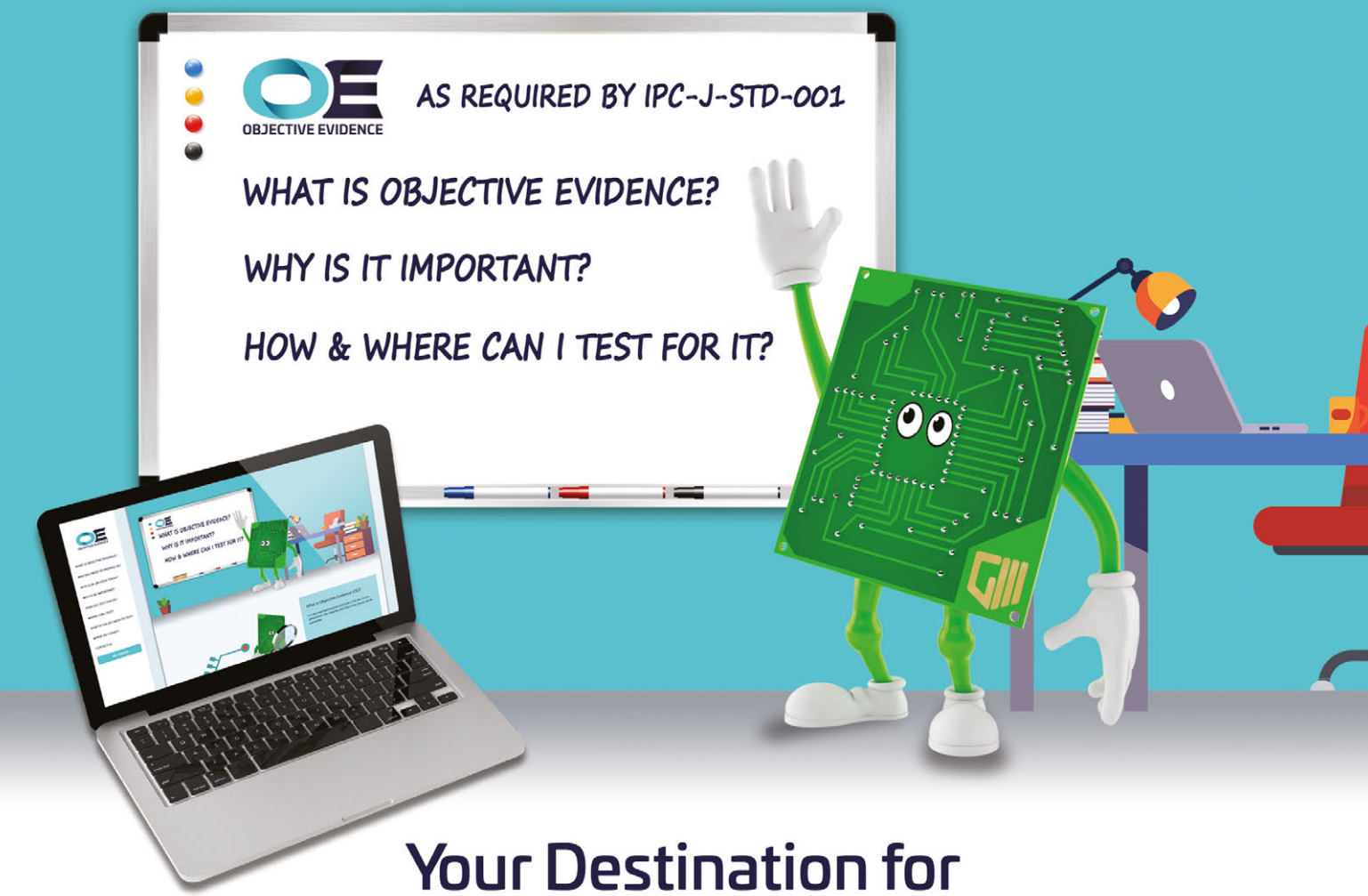

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product designers, recyclers, and refurbishers understand how their choices in design and materials affect the end-of-life performance of their products and identify ways to improve the final outcome.

After evaluating existing recyclability and reusability tools, the R&RM team concluded that the industry had limited means of practically assessing the circular economic value (recyclability, reusability, reparability and refurbish-ability) of ICT products. The team developed the iNEMI R&RM tool as an aid to both product designers and end-of-life providers to provide visibility prior to a product being manufactured as to the impacts of material choices, product design choices, and the region(s) where a product would be recovered at end of life.

Scoring Factors

The R&RM tool incorporates score factors that assign reasonable impact value to product design features along with the ability to recover and return value back to the market. It includes:

- A scoring system (qualitative/semi-quantitative) that assesses the economic feasibility and physical practicality of separating and liberating materials from ICT products (product-category specific)
- A weighting factor that quantifies the quality of the reused and recycled materials (exergy, cumulated energy demand, price, environmental impact)
- A product end-of-life value score, providing a three-tiered system that considers material choice, product design, and regional recovery factors (i.e., the net value of the design/material and the demand for the material in the regions where it will be recovered)

How the iNEMI Tool Differs from Other Tools

Other recycling metrics have fallen short by failing to include the critical economic realities of recycling. A product or material's potential to be recycled or repaired does not mean it is actually recycled or repaired. There are striking differences in recovery rates based on economics. This is driven primarily by:

- Value of the recovered material: Can the material be recovered or sold?
- Cost of liberation/separation: Can the materials be separated into clean streams? What does it take to liberate the materials (hazardous materials included)?

> "There are striking differences in recovery rates based on economics.

Any metric that does not consider these economic realities cannot support informed choices and enable improvement.

The iNEMI tool is configured with a simplified spreadsheet-based interface and includes a product criteria summary in the overview worksheet (Figure 1). Each of the three main R&RM categories (material choice, ease of liberation, and available recovery technology) has a separate input page. Results are summarized in the product criteria worksheet along with sparklines and percent-of-range scores for the three categories.

The current tool is built using Microsoft Excel. It provides data connectivity and interfacing throughout the workbook and allows for logical operations to check and provide feedback to the user depending on the question and other input within the worksheets. Additional updates are planned to focus on improvements to the regional recovery factors with more relevant and timely economic data. The project's final report can be downloaded[3].

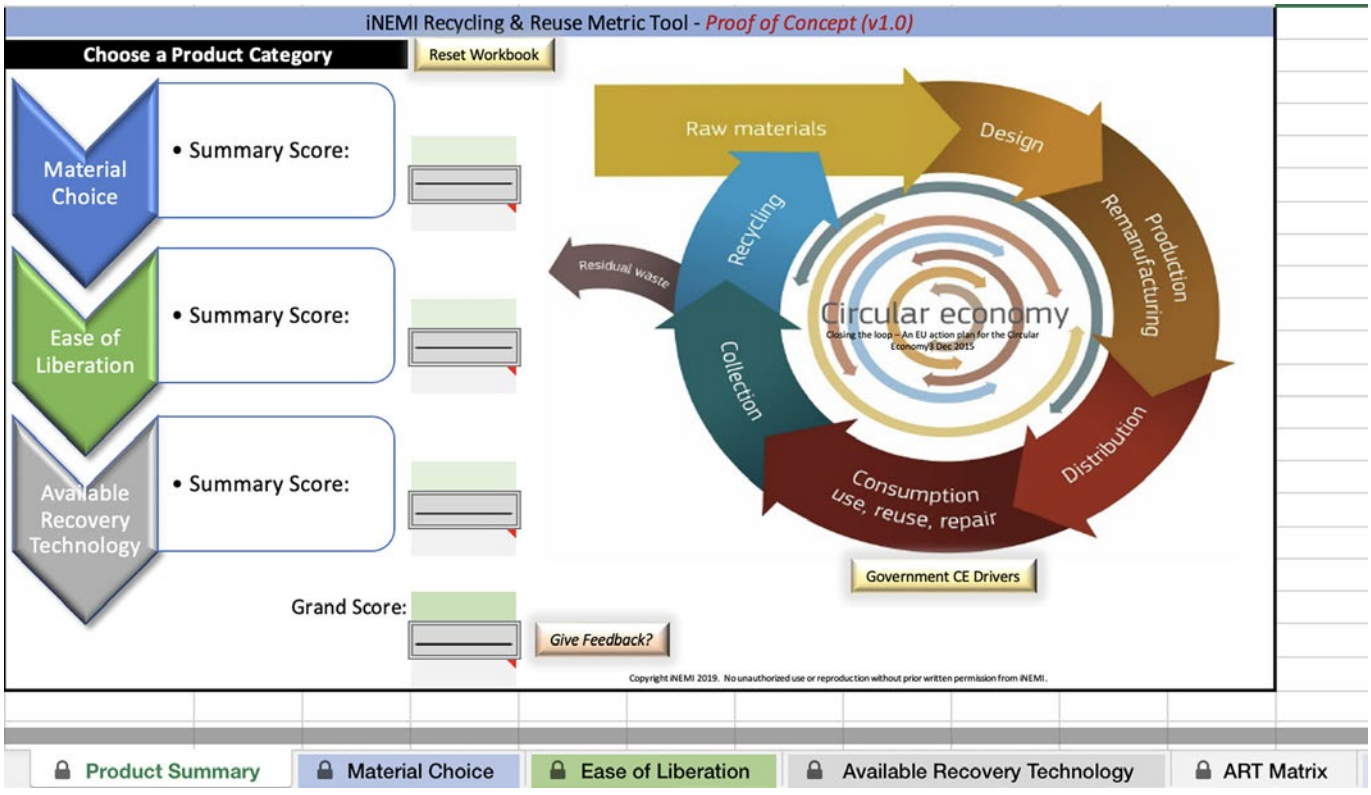


Figure 1.

Eco-Impact Estimator Tool

Over the past decade, several iNEMI members have collaborated to develop and demonstrate the Eco-Impact Estimator (EIE) tool. The approach is based on a methodology developed by Bell Labs (now Nokia Bell Labs) and further expanded through a series of iNEMI projects. The EIE tool only focuses on ICT products. By doing so, simplified estimations that are germane to the industry can facilitate LCA estimations, streamlining modeling and making results most relevant. It provides a means to evaluate product concepts quickly and easily while optimizing design trade-offs. This uses simplified techniques and algorithms for estimating global warming potential (GWP) in terms of carbon dioxide equivalents. iNEMI member companies and their suppliers are using this tool to estimate their products' carbon footprints and make smarter choices at the design stage.

LCA Estimator Framework

The estimator is designed to evaluate a product consisting of individual components and equipment pieces. Products can be classified into distinct categories with common attributes that produce certain levels of environmental impact depending on their component make-up, assembly, usage, and design life. These classifications are sorted into component categories comprised of similar materials and manufacturing processes.

Components are analyzed regarding their respective contributions to the environmental impacts associated with the manufacturing stages. Categorizing these ICT components offers a means of producing a concise list that can be analyzed for common environmental impact attributes, which can then be modeled to derive their level of impact within an LCA estimator tool.

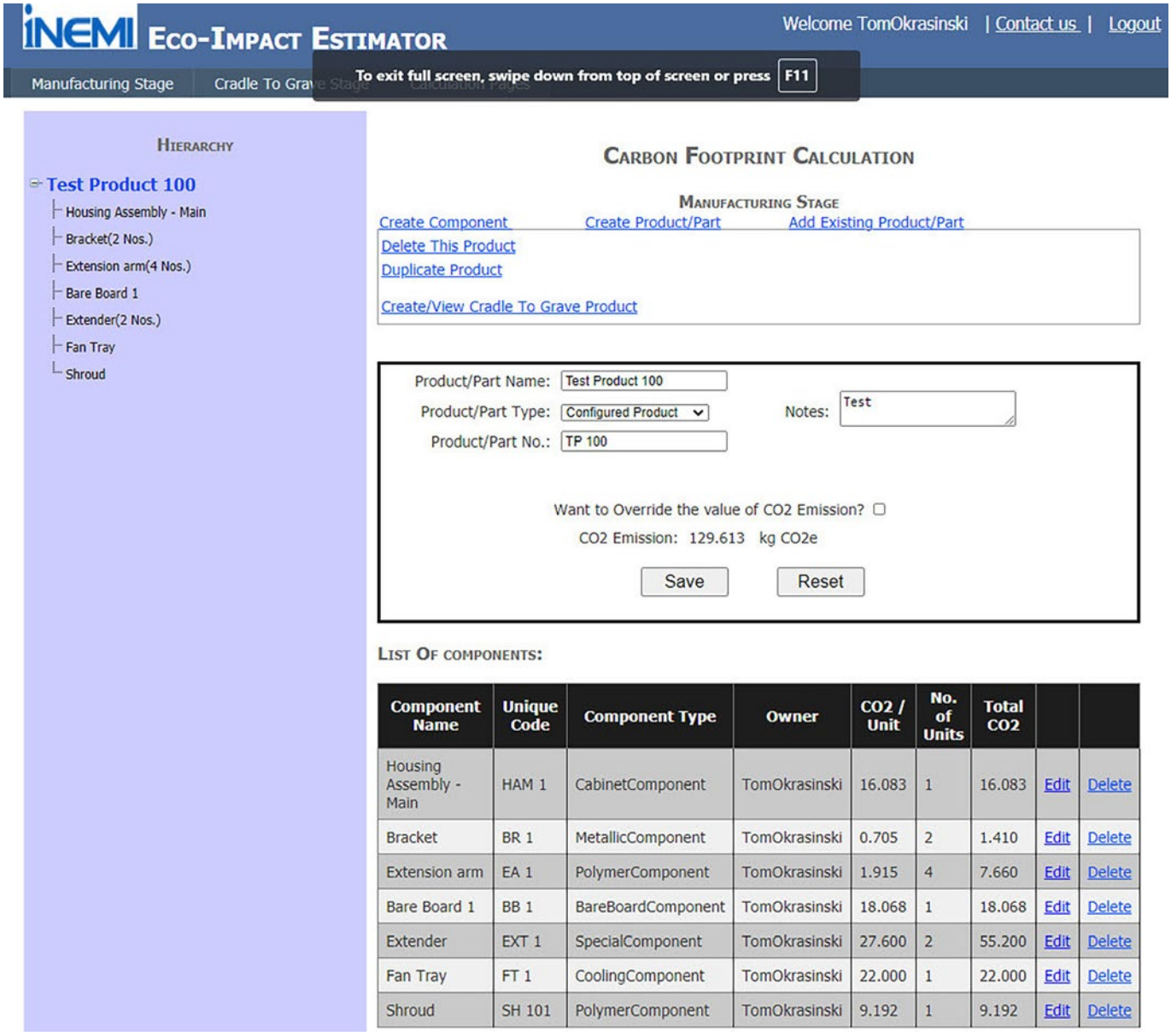
The major component/subassembly categories used by EIE for ICT products include printed wiring boards, integrated circuits, and electro-mechanical assemblies, such as cooling fans, metallic components, polymeric components, and cables. Over a hundred years, GWP has the single largest environmental impact

currently assessed in the estimator since this is one of the most evaluated environmental impact mid-point indicators.

Key parameters and metrics are defined by assessing the environmental impact of the component categories. They represent significant environmental impact contributors based on the analyzed datasets available from within the ICT industry, such as integrated circuits, and from other industry sectors, such as bulk metals and plastics. An associated set of algorithms can then be determined based on the lifecycle impact assessment (LCIA) data available for the key parameters of a given component category.

LCA Estimator Improvement and Modernization

The initial EIE tool used a spreadsheet format and was made available to iNEMI members in 2012. Subsequent development created a web-based tool that provided easier modularization of its component categories—a means to graphically view and configure a product's hierarchy—and easy storage/retrieval of configured products and subassemblies for fur-



Component Name	Unique Code	Component Type	Owner	CO2 / Unit	No. of Units	Total CO2		
Housing Assembly - Main	HAM 1	CabinetComponent	TomOkrasinski	16.083	1	16.083	Edit	Delete
Bracket	BR 1	MetallicComponent	TomOkrasinski	0.705	2	1.410	Edit	Delete
Extension arm	EA 1	PolymerComponent	TomOkrasinski	1.915	4	7.660	Edit	Delete
Bare Board 1	BB 1	BareBoardComponent	TomOkrasinski	18.068	1	18.068	Edit	Delete
Extender	EXT 1	SpecialComponent	TomOkrasinski	27.600	2	55.200	Edit	Delete
Fan Tray	FT 1	CoolingComponent	TomOkrasinski	22.000	1	22.000	Edit	Delete
Shroud	SH 101	PolymerComponent	TomOkrasinski	9.192	1	9.192	Edit	Delete

Figure 2.

ther usage in other product configurations or by other designers (Figure 2).

In 2019, a web-based version of the tool was transferred to Purdue University and made available to select iNEMI members and academic researchers. At the same time, the tool's algorithms, datasets, and methods for estimating environmental impacts for printed wiring boards, integrated circuits, and both metallic and polymeric materials were updated.

Ongoing Development

iNEMI has been holding ongoing project scoping discussions for the next phase of EIE tool development. Discussions have considered a number of elements/foci, including:

- Expansion of environmental impact categories beyond GWP: water use, embodied energy/ accumulated energy
- Development of a standalone ICT-focused dataset that could be used by any LCA tool that includes more primary data (as opposed to aggregated data)
- Incorporation of additional lifecycle timeframes (i.e., multiple reuse cycles) that better show the impact of circular economic principles on the LCA of a product

These planning meetings are not limited to iNEMI members. We welcome industry input.

Scoping efforts for the development of both tools is ongoing at iNEMI. We are also interested in identifying other potential needs and additional tools to help drive sustainability that would benefit from a collaborative approach. Please contact Mark Schaffer, marks@inemi.org, for more information or to participate. **SMT007**

Resources

- Eco Impact Estimator (EiE), Phase 3, Project Close-out Review, thor.inemi.org.
- "Modernizing a Life cycle Eco-Impact Estimator for ICT Products," by Tom Okrasinki, et al, Electronics Goes Green, 2020.
- For more information on iNEMI's sustainable electronics projects:
  - Value Recovery from Used Electronics, Phase 1
  - Value Recovery from Used Electronics, Phase 2
  - Tech Topic Series: Eco-Design for Circular Electronics Economy

References

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Mark Schaffer is a project manager with iNEMI.

Is Sustainability in Manufacturing a Benefit or Burden?

Smart Factory Insights

Feature Column by Michael Ford, AEGIS SOFTWARE

The electronics manufacturing industry has a choice when it comes to sustainability: Be led by incentive and motivation from customers who require it or be forced to comply by governments. If we act together now, we can address sustainability in a beneficial way for our businesses, rather than allowing it to become yet another burden. Let's discover the global challenges and opportunities.

The way that the market and governments currently approach the challenge of sustainability is not too dissimilar: There are pockets of interest and incentives that appear in many different areas. To ensure sustainability, though, is taking a big step forward by creating projects and initiatives. There are hundreds of individual sustainability initiatives, each with a narrowly focused goal and intent, using proprietary point solutions, and developed case by case. Each project interprets the meaning of "sustainability" data differently, depending on its approach and purpose.

In theory, sustainability requirements should be quite simple. For example, one of today's most heavily discussed topics is a company's record of CO_2 emissions use in materials and products. The factors to consider are evolving as they increase in scope and complexity.

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Just one example would be the proportion of CO_2 emitted by a truck which is transporting the materials from the suppliers, in addition to the CO_2 emitted during the materials' manufacture.

Each sustainability project, developed with such a narrow set of attributes, should create some form of sustainability passport that potentially includes:

- Information related to the reuse, repurpose, and recycling of information
- Details of materials and minerals used
- Their origin and transfer of responsibility through the supply network
- Quality assurance and provenance

While it is nice to see immediate results from current projects, many fundamental issues and challenges have arisen related to scalability, and ironically, sustainability. These include:

- ***Costs:*** Each project must develop its own IT infrastructure, perform the necessary software coding, and develop the required data models and data sharing mechanisms, often as customised add-ons to existing solutions.
- ***Ownership:*** Investors in each project may be companies that their peers or competitors may prefer to keep distanced, and which prevents wider adoption.
- ***Dependencies:*** Many companies prefer to avoid uncontrollable dependencies, such as a specific solution provider's technology behind the project.
- ***Interoperability:*** Cost of ownership and operation escalate exponentially as data from different projects and initiatives need to be connected and translated, as required by the many instances of materials in the supply network.
- ***Compatibility:*** The data models within each project are likely not comparable, in terms of both the representation of data and measurement methods, resulting in unreliability and inconsistencies.
- ***Security:*** Projects typically require the mass sharing of data and new storage requirements that risk IP leakage—especially where third parties are involved—to translate data between projects and provide storage.
- ***Privacy:*** Data mandated for sharing may include access which should be held private to the company. This disincentivises expansion beyond the simplistic scope of an initial project.
- ***Greenwashing:*** The sheer complexity of methods of data representation and measurement across different projects lends itself to abuse.

The narrower the scope and scale of each individual project, the less important these points may seem to be. However, let's fast-forward into the future, and consider the potential burden that this activity would represent if left unchecked. Take, for example, an e-mobility product, such as an electric car. Think about the complexity of the supply network, which consists of thousands of materials of different types, each coming through unique paths and processes. They have different origins, hierarchies of complex assemblies, and composite materials that include body parts, electronics modules, batteries, motors, and interior materials.

The methods and requirements for sustainability for each group of materials is likely to be very diverse. When you connect data from these disparate sources you will have a variety of solutions to consider. Combining data with its own measurement methods, terminologies, and methods of data encoding, then trying to extract and contextualize what's useful, will require a case-by-case customization. The sheer IT resources needed to hierarchically "connect" all the potential data points and create a normalized set of reliable and consistent product information is immense.

Alternatively, there are steps the industry can take collectively toward creating an interoper-

able, global sustainable network (GSN). Let's look at what would be required:

1. Create a common set of requirements.

Doing this for the scope and measurement methods for data collection, as well as standardization of terminology and representation of sustainability data, allows for consistency and interoperability. It allows for an open market where solutions from many different vendors work together by sharing, exchanging, and accumulating sustainability data in an automated and reliable way. This is done throughout the supply network with minimal cost of ownership. An essential element of GSN is to respect and preserve existing standards and methods that already apply to each sector or organization within the industry. Rather than replacing or forcing changes related to terminologies and formats, the GSN would feature an IIoT-based connector in which each source/consumer of data natively supports the GSN requirements. This is based on a local data format creation at the source using existing data.

> **The methods and requirements for sustainability for each group of materials is likely to be very diverse. When you connect data from these disparate sources you will have a variety of solutions to consider.**

2. Maintain the GSN definitions.

To avoid competitive resistance and high-risk dependency concerns, the GSN organization should be independent; it should not be under significant control or influence from any one company. Ideally, it should be a distributed organization comprised of entities from different backgrounds.

3. Carefully select raw data.

The technologies used by GSN for a sustainability information exchange must be selected such that the raw data created by each user or consumer does not need to be exposed or moved in volume, for example, to expensive cloud storage under the control of a third-party. The use of W3C Verifiable Credentials may be adopted to provide proofs and facts that are required for exchange of sustainability information without disclosure of the source data. In this way, all existing and future data, including private information and that related to IP, is not exposed and does not need to be changed from its current form. This represents a very significant cost and risk reduction as compared to other methods.

The result of creating GSN brings a very cost effective, low-risk, and low-investment solution for the provision of all forms of environmental and sustainability data, as well as provenance and security for materials and products. Commercial solutions will be created to suit individual needs, which would all be interoperable.

A key need for product sustainability is the accumulation and association of such data related to materials consumed during assembly. Material management and traceability functions within an MES are an essential element in any sustainability initiative. It's essential to adapt existing traceability solutions that will provide material-to-product sustainability data association, as well as add information derived from the assembly operation itself. Solutions will differ depending on the nature and type of material or product, as well as the operation that is being performed. This may range from discrete assembly, harvesting and mixing, to storage and transportation.

The combination of defined measurement protocols, consistent data representation, and interoperability removes most opportunities for casual greenwashing, where excuses—such as lack of knowledge of protocols and methodologies—are removed. Any remaining greenwashing is very likely to receive detailed scrutiny. This makes enforcement easier and brings integrity to the data. Therefore, there is opportunity for the original intent to be satisfied, to wit, with measurable improvement when set against environmental targets.

The notion of a global sustainability network may seem like nonsense and a fantasy. However, the growing need for sustainability throughout the industry is a given. Remanufacturing and recycling are set to become at least as important as original product manufacturing itself and will require a secure information exchange and privacy. These costs must be bearable, and benefits should far outweigh the costs, to make sustainability, well, sustainable. I believe we will see some form of a GSN in the future. Our only choice is how we make that happen so that, rather than a burden, it is a benefit to society. **SMT007**

Michael Ford is the senior director of emerging industry strategy for Aegis Software. To read past columns, click here.

Reduced Speckle on the Horizon

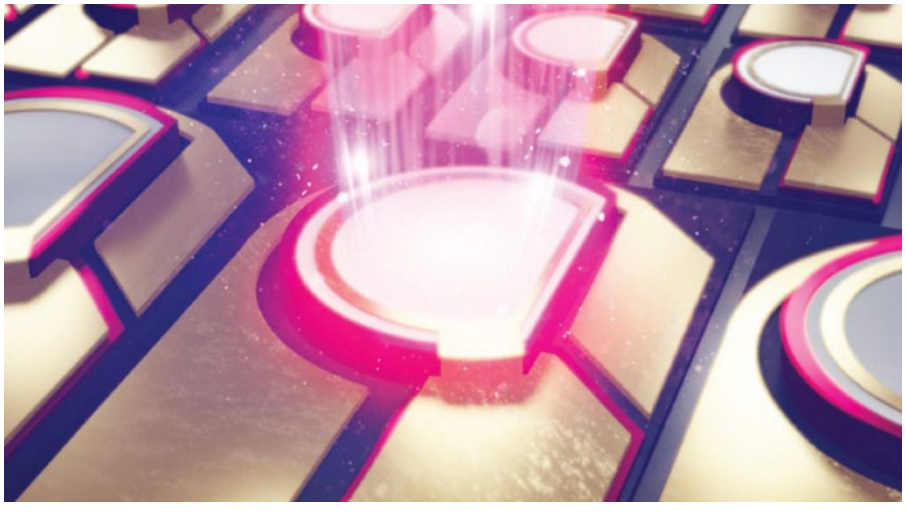
An easy way of altering compact semiconductor lasers to make them more practical for illumination and holography has been demonstrated by KAUST scientists.

Semiconductor technology allows for all elements of a laser to be packed into a micrometer-scale device. This includes an optically active, light amplification region with a highly reflective mirror on each side.

One such device is the vertical-cavity surface emitting laser, or VCSEL. VCSELs are advantageous because hundreds can be created and used on the same substrate at the same time. But the beam is prone to a speckle-like profile, which makes it unsuitable for applications such as lighting, holography, projection and displays. These require uniform light in the plane perpendicular to the direction of beam propagation.

Alkhazragi and KAUST colleagues, together with co-workers from China, have shown that speckles can be reduced in laser light from VCSELs simply by changing the shape of the device to break the symmetry of the cavity. This introduces chaotic behavior in the generated light and allows the emission of more modes.

The team investigated VCSELs with a D-shaped cavity and compared it with those with the standard cylindrical, or O-shaped, geometry. They observed that the D-shaped devices exhibited substantially reduced coherence and a corresponding 60 percent increase in optical power, which is the maximum achievable.



"Machine learning could help design cavities that further maximize the number of modes, lower the coherence and thus reduce speckle density to below human perception," says Alkhazragi.

(Source: KAUST)

Maslow's hierarchy of needs

Needs lower down in the hierarchy must be satisfied before individuals can attend to higher needs.

The Role of 'Sustainable' Automation

Feature Interview by the I-Connect007 Editorial Team

Automation plays a key role in factory efficiencies by lowering cost and improving yields, all of which are good for business and sustainability. Does factory size matter? Can automation be incremental and still be effective? Jeff Forster, SMT product manager at Technica USA, shares his insight on factory automation.

Barry Matties: Jeff, when it comes to automation, what should we be thinking about?

First let me say that Technica is involved in automation in both the PCB fab and PCB assembly markets. I will focus our conversation today on the PCB assembly side of our business.

I like to break down automation into a couple of areas including the assembly equipment hardware and software automation that ranges from the line level to multi-factory level. The assembly equipment line hardware and software have abilities to communicate upstream and downstream of the SMT line to optimize the process "on the fly." For example, inspection equipment now can communicate within the line to optimize the printing and placement processes. From a software perspective you have different levels of automation—multi-factory, individual factory, line level, and the actual equipment level (discussed previously) of automation. For multinationals that have manufacturing facilities here in the U.S., as well as in Mexico, China, India, etc., factory level automation comes into play because these facilities are building products for each of these markets. In many cases, these compa-

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Jeff Forster

nies develop a product or process here in the U.S., maybe with the correct equipment automation, then feed it off to another site, such as Asia or Europe, to fit those market requirements or needs.

Multilevel factory automation gives you a simple way to replicate the product here in the U.S., and then send it to a factory of choice overseas. You can build in those regions where the products are to be used. Streamlining the manufacturing process keeps it simple. You can send the product you develop (programs, processes, materials, etc.) here in the U.S. and replicate it to anywhere in the world; there you go, you have an instant factory.

The next level is the factory, for instance, one in the U.S. that has a manufacturing execution-type system (MES) where the software is communicating and directing the equipment to assemble a particular product or products within an individual factory; this could include single or multiple SMT lines within the factory. Additionally, the factory level of software will optimize to minimize changeover times between product builds, including moving products within the factory for the best possible product output.

At the line level, you have the full line going from the solder paste screen printer process, solder paste inspection, component placement, solder reflow oven process, to automated optical inspection. That's acting at what I call the line level. Within this line level process, the machines can communicate with each other to best optimize the board quality. For example, the automated optical inspection machine communicating with the upstream equipment to optimize the process "on the fly" for a better-quality board assembly outcome.

The last or more detailed one is the equipment level where each equipment process has its own means of automation. For instance, a screen printer might have a person manually scanning barcodes on the input side of the printer. Now, it can be automated with the vision systems and cameras that are in the system itself. It keeps the process simple by automating multiple processes within the printer. The program is first downloaded, and the solder paste is printed onto the board. In the next step of the solder paste inspection unit, the board is first barcode scanned and a program is downloaded automatically. The solder paste inspection process begins there. The point is that automation is multi-faceted, whether it's a worldwide multi-factory or something at the local factory equipment level.

Matties: That's a nice, high-level view all the way down onto the factory floor.

Ultimately, from an automation standpoint, these equipment sets are extremely adaptable. On the equipment level, these machines can do both small and large boards—very fine-pitch, accurate requirements. Even more, the machines can optimize products within a line itself. For instance, you can input up to 500 different products for a run into the automation software, and it will automatically optimize the factory production schedule. It was more likely in the past than now, but a factory will have someone using a spreadsheet to figure out their production schedule based upon a

change, such as a scope change within a product. The software tools now allow you to adapt to those changes on the fly, in many cases, without the need to manipulate spreadsheets.

Matties: It's amazing that people are still using spreadsheets for this.

It is amazing. The more sophisticated company will automate as much as they can using software-type tools, whereas many smaller companies are now starting to realize that adding automation means they can better utilize their employees elsewhere vs. spending their time creating spreadsheets. Trying to modify a production schedule is not easy. Some companies, even the larger ones, are a bit reluctant to jump into these new software tools, but there are companies successfully utilizing them. It's just getting past the idea that you need a person to get involved with the schedule to make it run correctly. These days there is automation software that completes these tasks. Ultimately, it is about making the commitment to utilize these tools in the operation, understanding that they will increase the efficiency and productivity with limited personnel intervention once implemented.

> **"Folks have been doing these types of tasks manually for so long that it's hard to break these habits.**

Matties: I've heard fabricators say they're a quick-turn facility, processes are dynamic, and they might need to change on the fly, so a software tool can't manage that. Are they just not fully aware of the tools' capability?

There are third-party software packages that do programming for lines and equipment, but they're not as dynamic as others where you input the update into the production planning software, and it spits out a new production plan—for that line, for the factory, the day, the hour, whatever makes sense. Even more, these production planning tools are very adaptable. For instance, companies frequently get a new product, or a contract manufacturer has a company that needs to produce a board for delivery the following day. These tools are adaptable enough to reschedule the factory or the line to build that new product on the same or next day. Additionally, some software tools are intelligent to the point where they are managing their parts material inventory and automatically managing the ordering of the materials to meet the ongoing changes in demand.

Matties: Are they just not aware of these tools?

I believe they're aware, but there's still some hesitation. Folks have been doing these types of tasks manually for so long that it's hard to break these habits. There's also the cost component of the software tools. However, if you're paying someone just to do production planning using a spreadsheet, you can easily justify a factory level automation software tool based on the time taken to manually create one and manually manage the continual changes.

Matties: When is the right time to bring in automation? What's the motivation?

I'd say the motivation comes from two things. One is cost, where companies don't want to add another person for a particular task, whether it be through software or through pick-and-place on a line. For example, instead of adding a person on a line, they may decide to look at special tooling/nozzles on their existing pick-and-place tool to automate the placement or insertion of a component. They look at the burden rates of those employees and whether it would be more advantageous to use them elsewhere

in the factory. It's not necessarily about replacing people to lower costs in building a product. The means to do that is by automating, whether it be through a machine, software, or the applications to help support that process.

Matties: As you point out, it's not an all-or-nothing proposition; you can step into automation.

That's typically what people do. They invest in the tools to get started and, over time, they gradually automate their factory with more tools that would minimize changeovers and maximize efficiency of the line.

The second motivation right now is that companies are extremely sensitive to the operational efficiency of a line or a factory. For instance, if you have a factory with five lines and the overall efficiency utilization of those machines is 25%, that leaves 75% idle. In those cases, it forces the company to use the software tools that are available to bring the machines to a more efficient rate of utilization. In some cases, you may not need all five lines; maybe you just use three. I see companies going toward the software automation side of things and learning that there are a lot more tools available to best utilize their current equipment sets vs. just buying another line or machine.

Matties: You're describing adding capacity without further investment into lines.

Yes, utilizing what you already have without buying another line. Obviously, as a rep for manufacturers and distribution, I love to sell more equipment, but what's best for the customer? In this case, if they can alleviate inefficiencies of the line or the factory with software, that's a much more cost-effective way to go.

Matties: Do you think having multiple software packages creates a problem? That's a big infrastructure commitment. You make the choice, bring in the software, and then there's some hesitancy in the evaluation process.

Yes, I agree with you. There are many software options, so maybe it's overwhelming. Some companies are very astute about the software. I think the next generation in the workforce will help these companies automate their factories through software tools. The machines will become smarter and more adaptable through these software tools. To increase that efficiency you want to decrease the cost of building a product.

Matties: Often, when we're faced with too many choices, we stick with what we know rather than risk making the wrong choice.

Yes, but it's even more than that with the software tools at the equipment and line levels—and to some extent the factory level—where there are many gaps between the equipment, line, and factory all the way to a company's MES or ERP system. In some cases, that disconnect limits their ability. From an automation standpoint, companies are just starting to recognize it's important to have a very adaptable MES that supports the equipment and the factory using, say, the CFX-type communications or open API—communicating both upward, I call it. You're sending data information up to the corporate MES, and then the MES is feeding data downward to the machines, including programs and other information on the line on how to build a product.

Nolan Johnson: How much integration effort is involved?

It's twofold. You have equipment manufacturers, as well as the MES software from the company's perspective. Most equipment manufacturers have an open interface that gives the MES the ability to either extract the data or bring it down to the equipment, the line, or the factory to communicate. It can get extremely complicated. Many companies want more control, with their MES system controlling the product builds vs. the line level on the equipment where they have their own software pack-

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ages that could control the line as well. So, it's a dynamic where the equipment itself can fix problems on the fly, and all that data gets fed into their MES. It then goes into, say, a database or a file for future reference.

Companies building DoD, medical, or automotive products purposely keep this data archived in case there's a recall of a component or a part. That data is gathered and stored. The communication going "north" to the MES and down to the equipment level is extremely important. With the way manufacturers have open application-specific tools, it's complex but not as difficult as you would think. Most of the time, the complexity is on the company's MES side on how to extract and communicate to the machines using their protocols and data.

> **Eventually, I can even see where robots can take a bank of feeders and then insert them into the machines.**

Matties: All of this obviously will play into increasing yields, less handling, and more information. What can people expect?

You're correct. In the automotive industry, for example, it's reinforced that no one touches a board throughout the process. The moment that happens, the opportunity for error increases considerably. You have to make sure that everything is done correctly up front, from the correct stencil in the printer, all the way to the correct components being placed on the board. Those processes are all traced and tracked, but the direction is to have less manual handling.

Eventually, I can even see where robots can take a bank of feeders and then insert them into the machines. Once that product is complete, the robot will come back, take that feeder bank out, bring it to a changeover area, then bring in a new one for the next job. It's so important to minimize the manual handling of a product. That's not to say it doesn't happen, but you just can't do it, or you have to scrap the board. In the past, people always wanted to see or inspect everything after a printer or after a pick-and-place machine. These days, they don't need to do that because you have inspection tools to automate those processes.

Matties: Labor cost also goes down.

Absolutely. We worked with a company that did a manual spot inspection after pick-and-place and it was all subjective. It depended on the person working on the shift. One person was looking for one thing, another person was looking for something different. With an automated robot and inspection system, it will inspect and make sure that the product is sound before going into an oven or to the next process. There's even post-oven inspection to make sure that the parts get reflowed correctly.

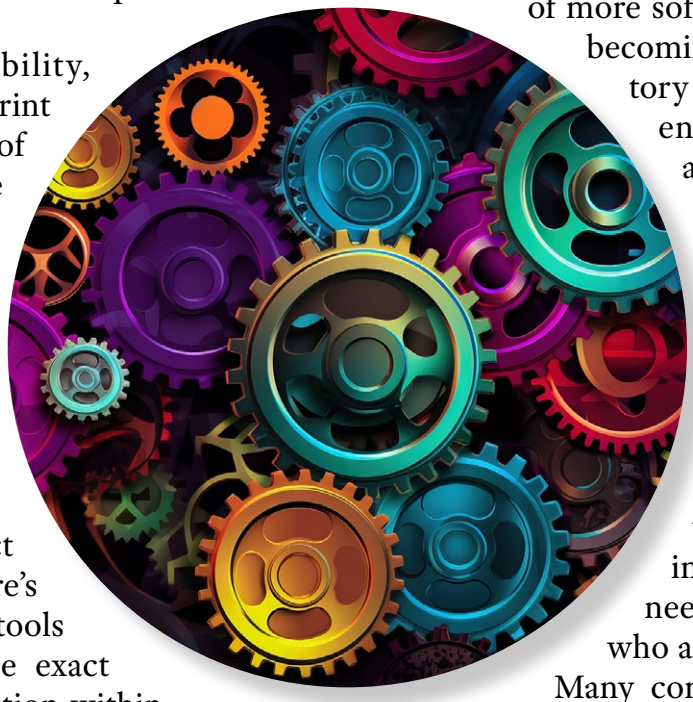
Matties: With automation, all the same parameters are being checked at every inspection.

Correct. With these automation hardware and software tools, instead of having two or three people per line, now you may have only one person who will manage the inspection process on the line. They carry a PDA and there's overhead communication boards that tell them of inspection flags, including trends. It means more efficiency for the factory, and for each individual line. Ultimately, it keeps the machines' operational efficiency high and cost of manufacturing lower. That's

what you want because that's why you're buying the equipment—to get more efficiency, quality, and output.

Matties: Let's talk about sustainability and how automation plays into that. Obviously, sustainability is a big topic in the world today.

Absolutely. A good example of sustainability is in printing solder paste. That machine has a stencil to print the solder paste onto the board, but before that even happens, there are software tools that allow companies to look at the board's assembly and their solder paste options so the process is as efficient as possible right from the start.



Regarding sustainability, you want to get a good print with the least amount of solder paste to create the circuit at the end of the line. The worst case is it's a scrap board because it comes out of the printer with too much paste, and it smudges the stencil. These machines allow you to print the exact amount of paste so there's no waste. Both the tools and software allow the exact amount of print deposition within the printer and, relative to the next step in the process, the solder paste inspection tool gauges how much material is being printed or dispensed. It automatically communicates that back to the printer and adjusts the parameters to optimize that process. You get the exact amount of solder—not too much or too little; circuits are done right the first time. You don't want to run sample board after sample board, having to wipe off the solder paste, start over, and keep repeating that process. These tools minimize troubleshooting a new product right from the get-go.

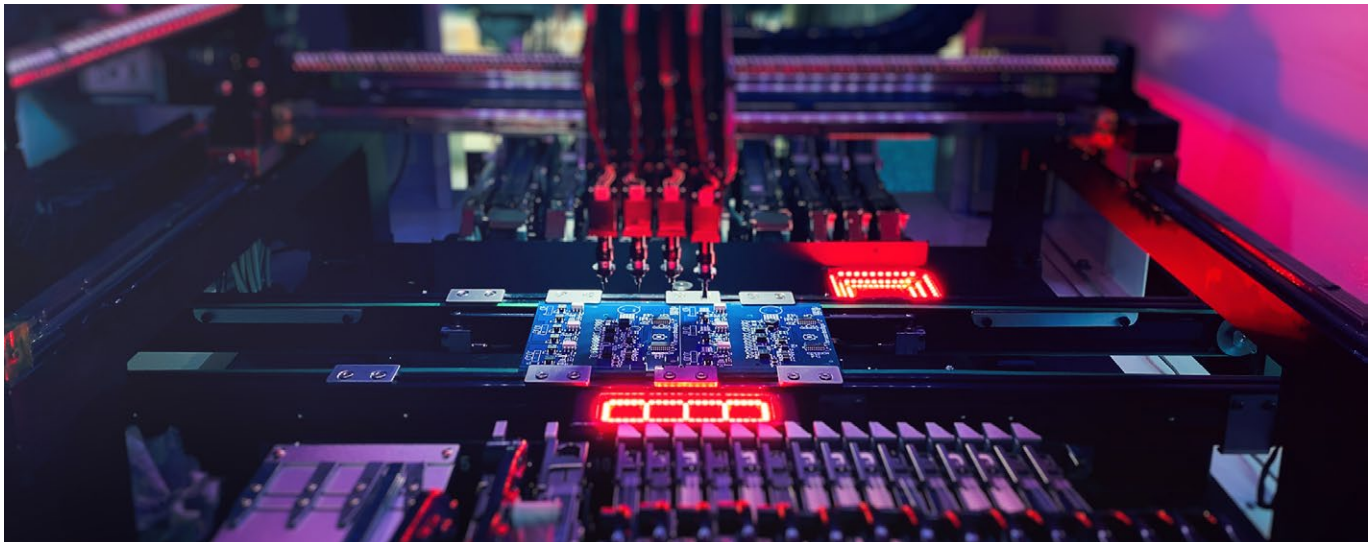
Matties: With this efficiency you're describing it seems that utility consumption would be lower as well.

Oh, absolutely. Having more efficiency of the lines optimizes the power requirements and minimizes the power bill. The machines are set up to best utilize the power.

Matties: How are the roles changing in the factories? Who are we hiring? Are there more software engineers, coders, or someone else?

With this push to software, I see the hiring of more software folks. With MES becoming a major role in factory automation, you need engineers writing code, application interfaces, and APIs to communicate to the equipment throughout the factory, from material handling in your stockroom all the way to your press machine, or your conformal coating line in the back. You need software engineers who are extremely adaptable. Many come out of school with mechanical engineering degrees, and it's important for them to understand software and how it works. With the drive toward and adoption of the Smart factory, it is an exciting time for companies hiring engineering and other technical staff with the drive to improve efficiencies at the equipment, line, and factory levels.

Matties: When you get a software team in place, they start finding new opportunities that you did not even know would exist, whether it be through data analytics or just process tuning.



That's correct. With all the integration of equipment, factories, and multi-factories, there's a lot of data. It must be mined appropriately to make the factories—down to the equipment level—the most efficient they can be to build a particular product or products. Gathering information, then utilizing this data to create KPIs at all levels of the operation, is what moves a factory forward with OEE and quality. It's extremely important.

Johnson: What I'm hearing is that the positive impact to automation is a whole bouquet of small, incremental improvements. There isn't really one big overwhelming change.

I would say the improvements are incremental in most cases. For most of the multinationals, it's more pronounced because they are more apt to afford these high-end equipment sets, MES systems, and the factory software tools that are available. So, I would say it's a mix. For the small- to mid-size companies, it's more of an incremental step at a time.

Johnson: Cabling up the hardware part of the factory could take from days to a few weeks; an MES install could take weeks to months. Determining how to use the data smartly could take longer. What do you say to prospective customers about those incremental changes?

Depending upon the company, especially small- to mid-size, it's how we present the information. Is the equipment scalable? It's extremely important that the software supplier can scale up to more automation as needed. In that case, companies will buy the hardware basics as well as the software basics for an equipment line level. At some point, they will gradually start utilizing some of the line level and factory level software tools as their products grow or as their factory grows.

The implementation of the equipment line level is fairly simple. A line can be installed in a matter of days. The line hardware is not necessarily the difficult part of implementation; the integration side can be more challenging. In a factory environment, an MES system could take up to six months to implement, even when everybody is on board. Some companies have taken years, but those have ERP controlling both accounting and other areas in addition to manufacturing. An MES will no doubt take months, but the equipment level is scalable enough for both small- to mid-size companies, and even the large companies to scale up when they need a simplified implementation.

Matties: Jeff, we certainly appreciate your time today. Your insight has been very helpful.

Well, thank you. **SMT007**

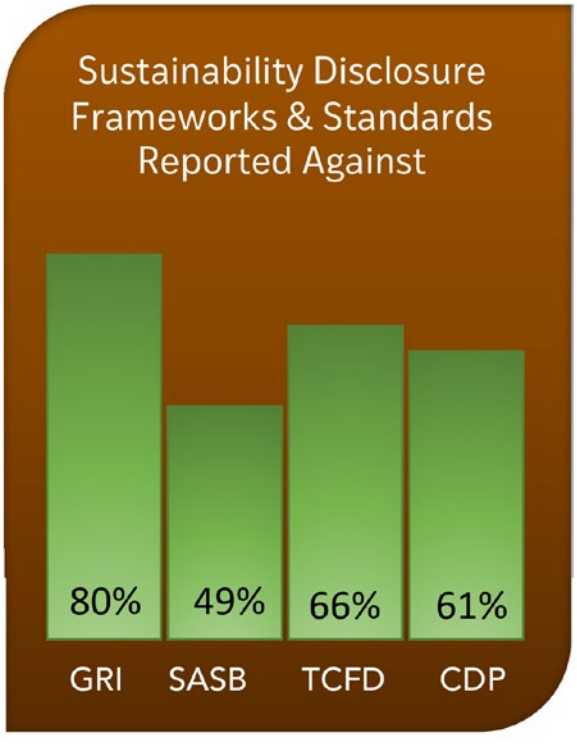
What Does Sustainability Mean for Electronics Manufacturers?

Feature Short by Kelly Scanlon
IPC LEAD SUSTAINABILITY STRATEGIST

In our previous article in *IPC Community* titled, "Sustainability: IPC Leading the Way," we asked, "Which sustainability issues are most likely to impact the operating performance of electronics companies?" While there are a multitude of sustainability topics, not all are material or relevant to electronics manufacturing. The answer, though, can enable companies to manage resources that help them meet regulatory obligations and to identify more sustainable business and manufacturing practices with the most beneficial outcomes for the resources invested.

Here's how we have addressed this question and looked for an answer:

IPC completed an exploratory materiality assessment in Q4 2022 to evaluate the reporting and disclosure drivers causing industry to report and disclose company-specific data and information on various sustainability topics and targets, and the material they have prioritized. The purpose of the exploratory study was to provide a foundation for future industry-specific, sustainability-related studies. However, we were surprised by how useful the results of the study were.



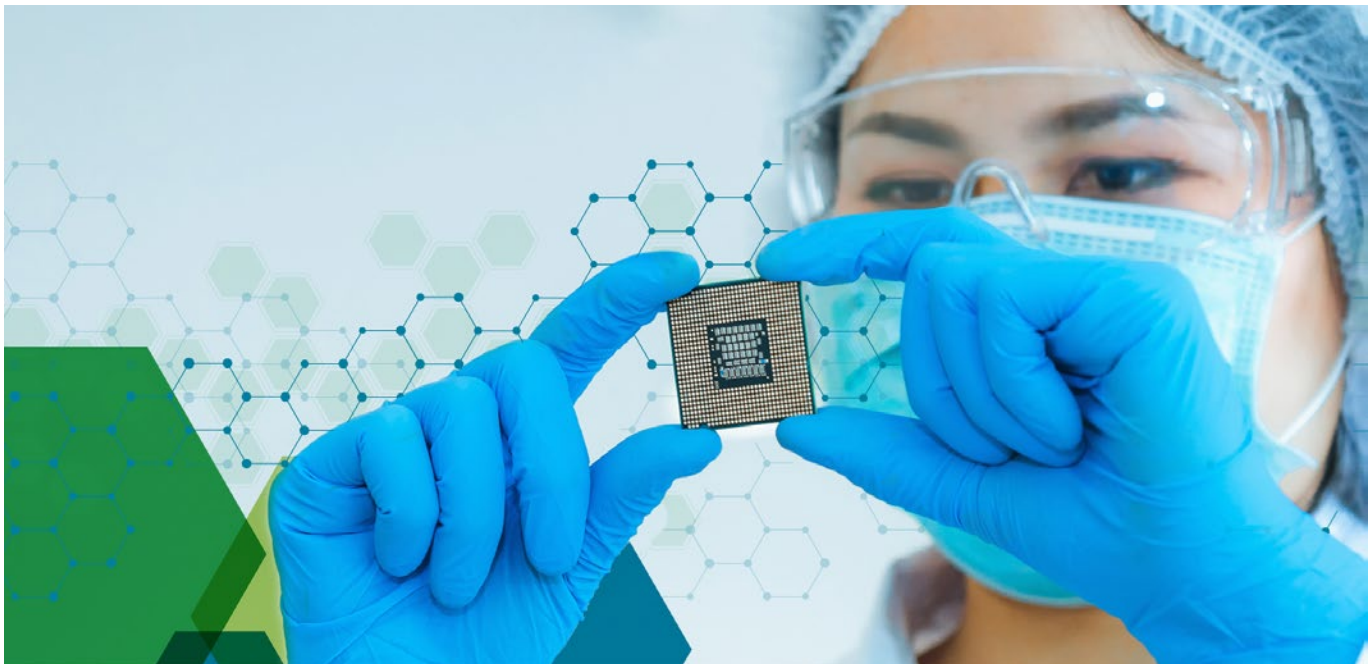
The exploratory study included the following steps:

1. Identify sustainability reports from electronics manufacturing companies.
2. Analyze the results to support consistent review and compilation of data on several parameters.
3. Report to ensure comparability across companies and produce meaningful results.

We analyzed 61 sustainability reports published since 2020 by industry leaders (based on 2021 revenue estimates) using a custom Materiality Framework Tool to support both the consistent review of the reports and the compilation of data. PCB, EMS, and wire/cable companies, as well as OEMs, all from Asia, Europe, and North America, were represented in the study. We recorded data from each report, including:

- Reporting frameworks and standards: The disclosure frameworks and standards reported on in the sustainability report included Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB), Task Force on Climate-Related Financial Disclosures (TCFD), and the Carbon Disclosure Project (CDP).
- Stakeholders and stakeholder engagement tactics and methodology: The companies, organizations, or communities identified as relevant to the company's financial and nonfinancial success and the approach taken to survey or otherwise engage with those stakeholders.
- Sustainability goals: Qualitative, quantitative, or time-bound targets established by the company.
- Material topics and topic boundaries: The sustainability topics presented in the company's sustainability report and the terminology used to define or describe that topic.

To read the rest of this article, which appeared in the Spring 2023 issue of *IPC Community,* click here.



The Right to a Safe, Healthy Work Environment

Feature Article by Pamela Brody-Heine
CLEAN ELECTRONICS PRODUCTION NETWORK

As we enter a new decade characterized by global transparency, companies are increasingly compelled to prioritize the protection of workers, not only within their own facilities but throughout complex multi-national supply chains. Process chemicals are increasingly being viewed as a human rights issue, as millions of workers in the electronics global supply chain are using process chemicals. The U.N. Special Rapporteur on Toxics (2018)[1] reported that there are approximately 160 million cases of occupational disease reported annually across all industry sectors.

After recognizing the significance of safeguarding workers from hazardous chemicals in the manufacturing process, several companies joined forces in 2016 and collaborated with other stakeholders to form the Clean Electronics Production Network (CEPN).

CEPN is a multi-stakeholder innovation network working collectively to address complex workplace health and safety challenges in the electronics supply chain and proactively move the electronics industry toward safer and cleaner production to reduce worker exposure to process chemicals. The network comprises 20 member organizations, including major companies, suppliers, academia, environmen-

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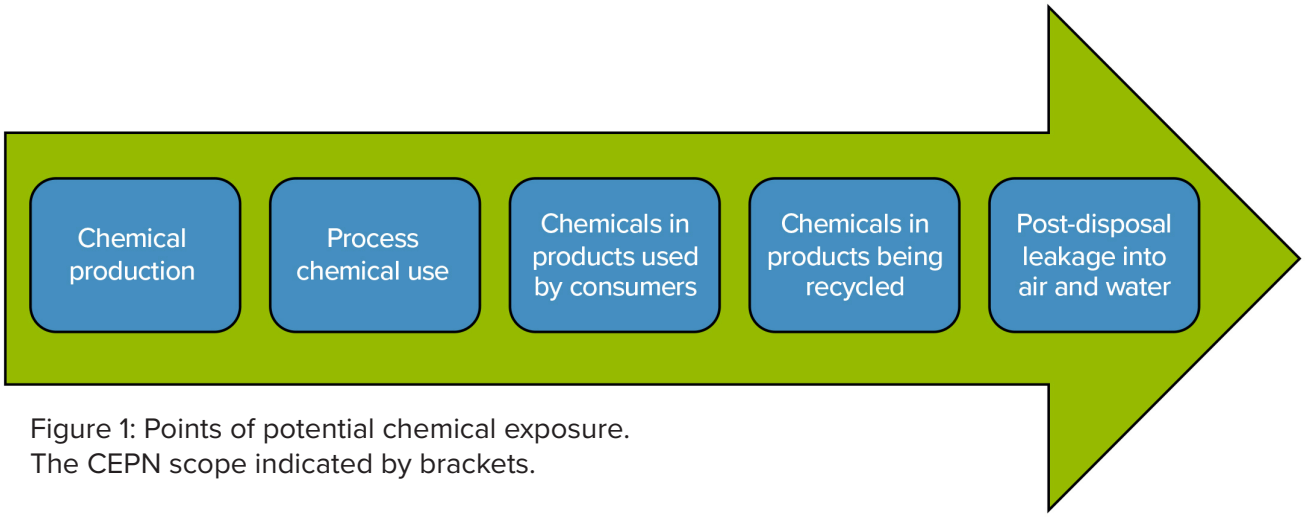

Figure 1: Points of potential chemical exposure. The CEPN scope indicated by brackets.

tal NGOs, labor representatives, ecolabels, and governmental agencies.

Members of CEPN recognize that process chemical management is an industry-wide issue and, given the complexity of electronics manufacturing supply chains, no single company or organization can tackle the issue of worker exposure to process chemicals alone; success requires the collective efforts of industry leaders. Suppliers serve multiple customers, for example, and major companies share many suppliers. Only by working together can companies move toward zero exposure of workers to toxic chemicals. Protecting workers from exposure to hazardous chemicals is a complex, global issue which stretches throughout a supply chain that is shared and globally distributed.

Early in the formation of CEPN, members recognized the need to focus on process chemicals in the electronics industry, as much of the attention to-date—regulations, ecolabels, standards, voluntary efforts, etc.—had been on product chemicals (those chemicals incorporated into final products). Hence, CEPN's primary focus is on reducing exposure to process chemicals, those chemicals used during product manufacturing and the maintenance of related production equipment but are not intentionally fully incorporated into the final product. Examples of process chemicals include cleaning agents, solvents, lubricants, photochemicals, plating agents, refrigerants, hydraulic fluids, adhesives, inks, and coatings, among others.

CEPN welcomes new participants from across the supply chain who are leaders, innovators, and collaborators, as well as experts in their part of the supply chain, and are committed to the goal of CEPN—moving toward zero exposure of workers to toxic chemicals in the electronics manufacturing process.

Tools and Resources

CEPN members have developed publicly available tools and resources to support companies working to move toward zero exposure of workers to toxic chemicals in electronics manufacturing.

Finding safer alternatives: CEPN is providing a single hub of up-to-date lists from organizations certifying safer manufacturing cleaning products and accepted substances for the electronics industry.

Process chemicals data collection (PCDC) tool: CEPN members developed, piloted, and are now using this free and publicly available standardized reporting tool that improves the task of collecting and managing process chemicals data. Network members invite all companies in the electronics industry to use the PCDC Tool.

Alternatives Assessment Guide: This guide is a concise and high-level methodology for identifying and evaluating potential substitutions for hazardous chemicals used in electronics manufacturing processes.

Qualitative Exposure Assessment (QEA): This assessment methodology is designed for facilities where workplace chemical exposure data is not available, to help environmental health and safety professionals without specific chemicals training or expertise in industrial hygiene. The assessment identifies workers' potential risk of exposure to harmful process chemicals and helps determine controls and ways to both reduce exposure risk and improve performance.

The Toward Zero Exposure Program

In the initial years, CEPN members focused on developing processes, resources, and tools for process chemical management and worker safety. As time went on, members sought ways to effectively integrate and expedite the utilization of CEPN's tools and resources throughout the industry. This led to the development of the Toward Zero Exposure (TZE) program, which was launched in August 2021 with founding Signatories Apple, Dell, and HP Inc., and the following year joined by Fairphone.

The Toward Zero Exposure program is designed to support electronics companies in assessing process chemical use, strengthening the culture of worker safety and engagement, and eliminating worker exposure to priority process chemicals both within their own manufacturing processes and deeper into their supply chain. The program provides a framework, credibility, and public recognition for voluntarily improving worker chemical safety in the electronics supply chain.

The program accelerates existing efforts in chemical safety and boosts awareness of the need to improve chemical management practices across the global electronics manufacturing industry to eliminate workers' exposure to hazardous chemicals. TZE represents an opportunity for companies in the electronics industry to meet growing customer and investor pressure calling for transparent and safe supply chains. Expectations on companies to align their brand with best practice in sustainability and authenticity continue to heighten, and participation in leadership initiatives addressing major industry-wide challenges—like chemical exposure—are becoming essential.

The Toward Zero Exposure program guides signatories through clear documentation on progress including benchmarks, milestones, and deadlines for program activities. Company actions are informed by a structured program with researched and pragmatic activities

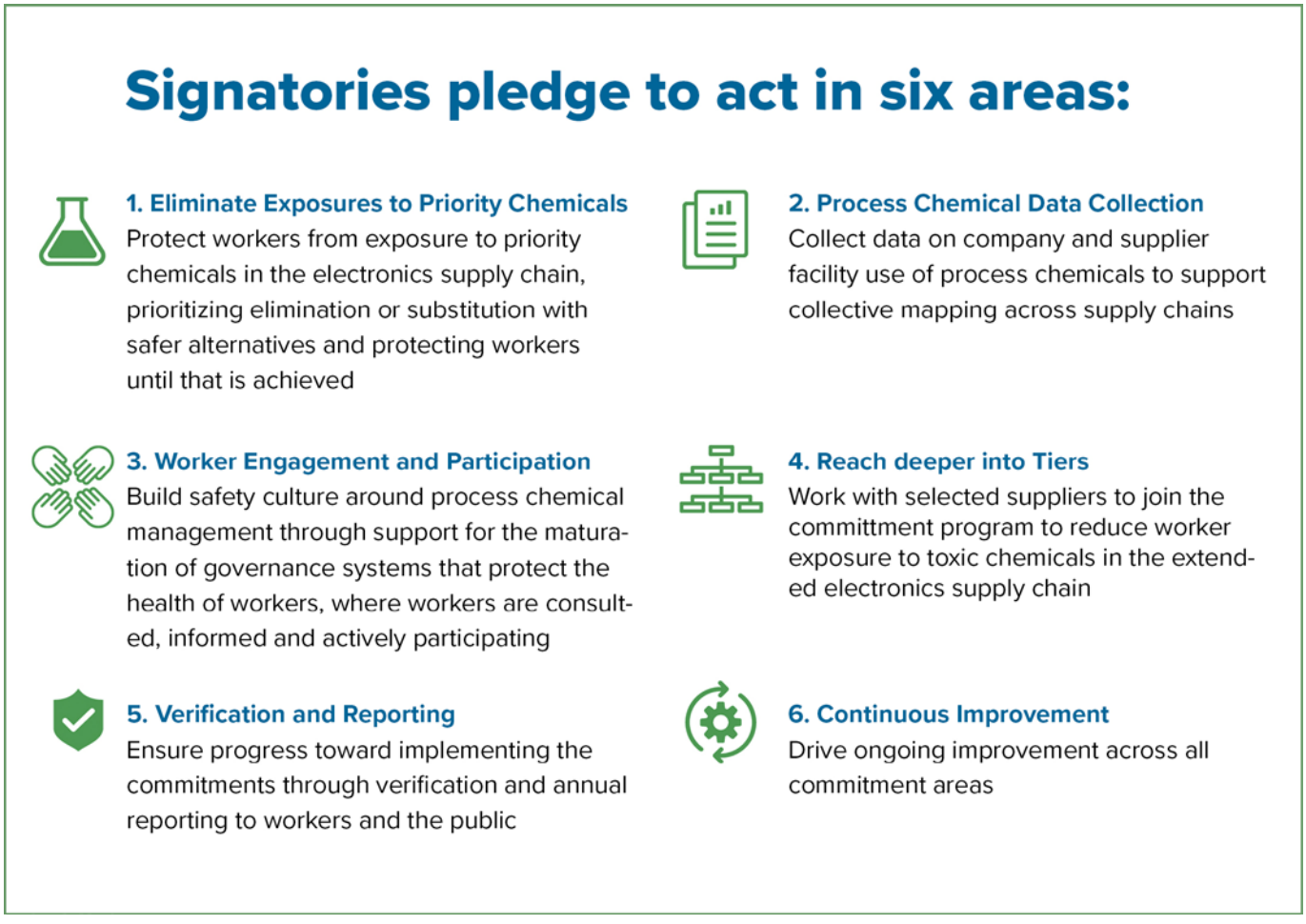

Figure 2: The pledge to take action made by TZE signatories.

backed by the credibility of industry leaders and NGOs. By participating in the program, companies join a forum of leaders to communicate and receive recognition for the work they do to protect workers from hazardous process chemicals.

Toward Zero Exposure signatories pledge to take action in six areas as shown in Figure 2.

To learn about the first year of the Toward Zero Exposure program, see the first annual report, showcasing the impact the program has already had, as well as plans for more progress protecting workers from exposure to hazardous process chemicals in the electronics supply chain.

Toward Zero Exposure welcomes all companies in the electronics supply chain, regardless of CEPN membership, and aims to foster a collective effort to eliminate exposure to harmful substances. Committing to protect workers is the right thing to do, while also building value for companies through reputation, market differentiation, and competitive advantage.

Learn more at cleanelectronicsproduction.org. To become a signatory, send an email to info@towardzeroexposure.org. SMT007

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1. Report of the Special Rapporteur on the implications of human rights of the environmentally sound management and disposal of hazardous substances and wastes, U.N. General Assembly's Human Rights Council.

Pamela Brody-Heine is senior director of the Clean Electronics Production Network.

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MilAero007 Highlights

Nathan Edwards to Lead USPAE as New Executive Director ▸

Effective May 1, 2023, Nathan Edwards will transition into the role of executive director of the U.S. Partnership for Assured Electronics (USPAE). Currently serving as director of government development, Edwards will replace Chris Peters who will continue with the organization as a senior advisor, providing continuity and focus on special projects. As executive director of USPAE, Edwards will be responsible for establishing and growing the organization to help ensure the U.S. government has access to trusted, secure, and resilient electronics supply chains.

North American PCB Industry Sales Up 11.6% in March ▸

IPC announced the March 2023 findings from its North American Printed Circuit Board (PCB) Statistical Program. The book-to-bill ratio stands at 0.91.

Legislation Introduced to Restore America's Printed Circuit Board Industry after Two Decades of Decline ▸

The bipartisan Protecting Circuit Boards and Substrates Act of 2023 introduced by Reps. Blake Moore (R-UT-1) and Anna Eshoo (D-CA-16) finishes the job the CHIPS Act began by incentivizing investment in the domestic printed circuit board (PCB) industry.

Gardien Group Joins USPAE ▸

Gardien Group is pleased to announce its membership acceptance to the U.S Partnership for Assured Electronics.

Trackwise Awarded Prestigious King's Award for Enterprise for Innovation ▸

Trackwise Designs plc, the innovative manufacturer of specialist products using printed circuit technology, is delighted to be recognised with a prestigious King's Award for Enterprise.

Amphenol Reports First Quarter 2023 Results ▸

Sales of $2.974 billion, up 1% in U.S. dollars and organically compared to the first quarter of 2022; GAAP Diluted EPS of $0.71, up 4% compared to prior year; adjusted Diluted EPS of $0.69, p 3% compared to prior year; GAAP and adjusted operating margin of 19.9% and 20.1%; operating and free cash flow of $532 million and $436 million.

FDH Aero Acquires BJG Electronics Group ▸

FDH Aero, a global provider of supply chain solutions for the aerospace and defense industry, has acquired BJG Electronics Group, a leading provider of interconnect and electromechanical products for the defense, commercial aerospace, and space end-markets.

Realizing the Promise of IPC-1791 ▸

IPC-1791, Trusted Electronic Designer, Fabricator and Assembler Requirements, is an electronics standard developed in collaboration with the (DoD) and industry to address some of today's greatest risks to a trusted supply chain. The standard provides traceability and helps protect against counterfeits. In fact, IPC-1791 was specifically cited in the U.S. Department of Commerce response to Executive Order 14017-Securing America's Supply Chains.

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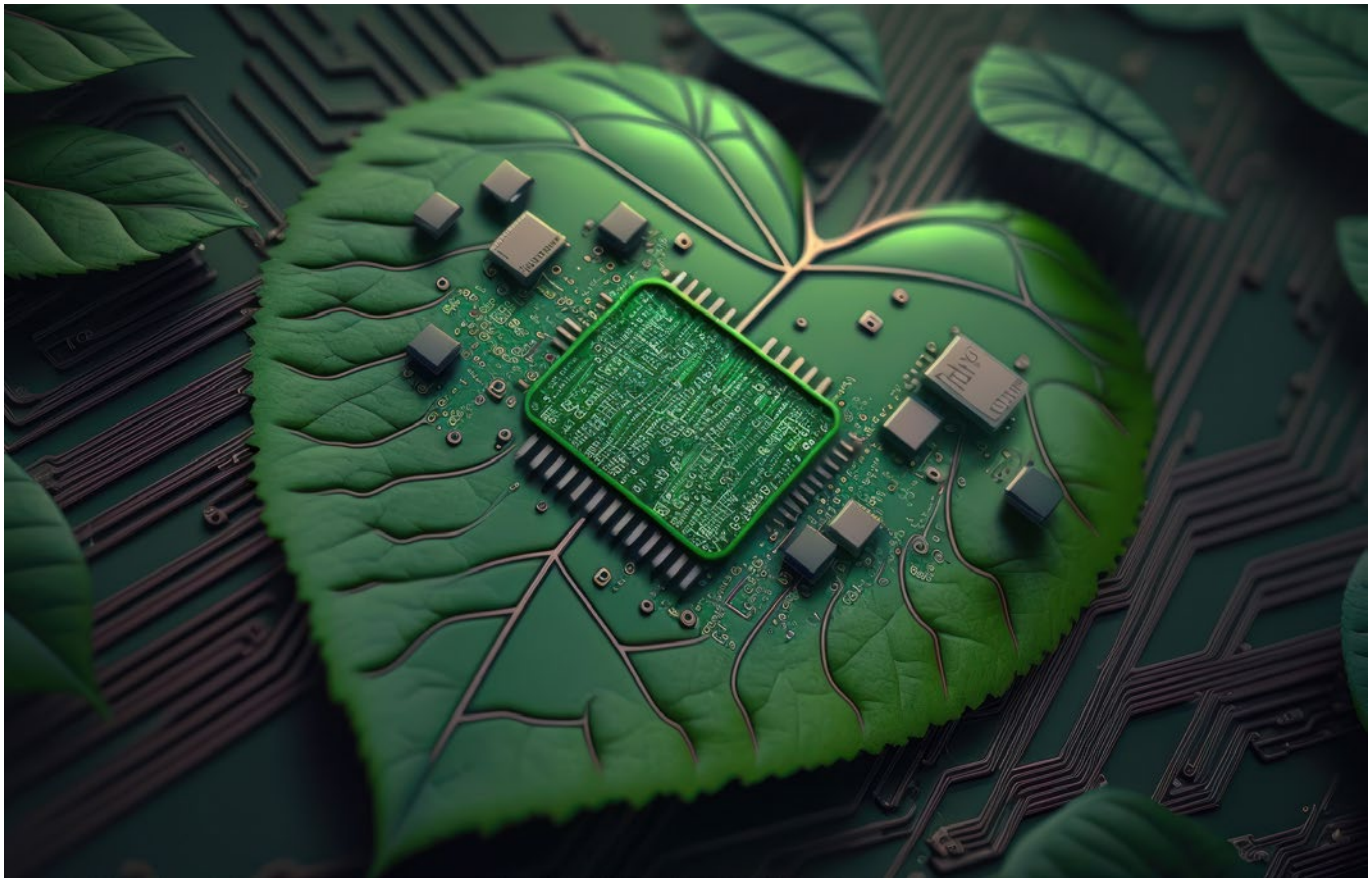

Finding Sustainability in Additive Processes

Feature Article by Art Wall
NEXTFLEX

When you hear about sustainability, odds are that electronics don't come to mind. The manufacturing process alone is riddled with processes that generate large amounts of waste and utilize volatile chemicals and compounds. Consumers dispose of their personal electronic devices, which, added to the waste from the manufacturing process, accumulates into quite a large sum. According to a report from the UN environment program[1], the world produces approximately 50 million tons of electronic and electrical waste (e-waste) a year.

This e-waste is filled with toxic components—such as mercury—that are involved in electronic processes and are often not disposed of properly. The same report highlighted that only 20% of e-waste is being formally recycled each year; the remainder most likely ends up in a landfill or is improperly recycled. Over time, this can have a large impact on environmental surroundings.

What's Being Done

Recently, sustainability has been a hot topic, not only in terms of electronics, but across the broader technology industry. At CES 2023, for example, sustainability was one of its key pillars[2] and the topic of consideration in three panel discussions. The entire electronics community is trying to come together to ring in a new era of sustainable electronics.

To begin working toward a more sustainable workplace, the International Organization for Standardization (ISO) developed the

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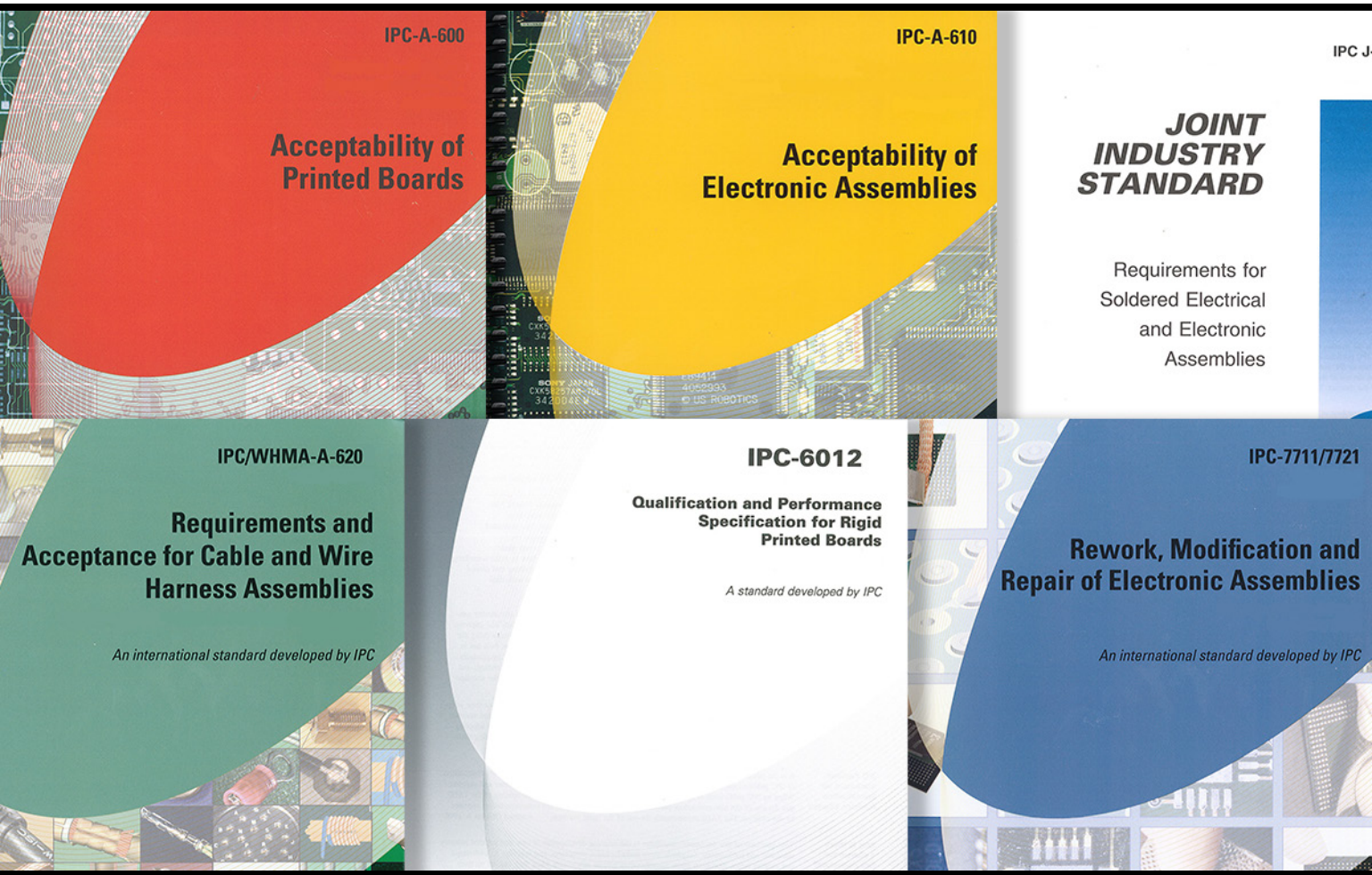

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Art Wall

ISO 14000 family of documents[3] around environmental management. Last updated in 2021, the 14001 standard establishes an environmental management system built to contribute toward sustainability.

Yet, even as these standards are developed and conversations are happening across the electronics community, actionable change is slow to come. Electronics manufacturing, for example, contributed 5.9 million metric tons (MMT) of carbon dioxide equivalent to greenhouse gas emissions in 2020 alone[4]. This casts a spotlight on the unsustainable methodologies currently involved in the electronics industry and begs the question, "Is it possible to be sustainable within electronics manufacturing?"

Introducing Additive Processing

To truly start incorporating sustainability into our manufacturing processes, we need a clean slate. By rethinking how we manufacture and package electronics, including the methods and materials we are using, we can invoke real change. One significant way we have decreased the number of steps involved, while simultaneously decreasing the waste involved, is through additive manufacturing elements.

We commonly see additive manufacturing looped in with basic 3D printing efforts, but it can be applied to a variety of different processes. The basic definition of additive manufacturing is material being deposited, joined, or solidified under computer control, with each material added together, layer by layer.

However, in the electronics realm, "additive manufacturing" seems counterintuitive. At first thought, hearing this term would lead you to believe there are additional steps in the manufacturing process and, inherently, more waste. Actually, the integration of additive processes into our current electronics manufacturing methodologies provides several environmental benefits by eliminating many "subtractive" processing steps that lead to waste.

Printed Patterns

One common practice for making circuit boards involves lithography to create patterns and then etching away unwanted material. In additive processing, the patterns are simply printed. This eliminates several steps and the waste associated with the removal. We've demonstrated this through our assembly of flexible hybrid electronics (FHEs) and wrote about this from a packaging perspective[5]. In that article, we established how a circuit board can be additively printed on a low-cost, flexible substrate. If we analyze this shift in advanced packaging from a sustainability perspective, we see that the integration of additive manufacturing also makes it more sustainable.

Unnecessary Packaging

Another advantage of additive manufacturing is found in eliminating unnecessary packaging of individual components or chips and attaching them directly to a printed circuit. Imagine adding the raw component within the layers of the board which can offer never-before-seen interconnectivity opportunities and miniaturization for electronic components. This system-level packaging also means you are eradicating unnecessary steps in the

manufacturing process and cutting down on the waste associated with them.

The introduction of additive processes into our regular electronics manufacturing processes is only one step in making the electronics industry more sustainable. When combined with the implementation of standards such as ISO 14001, we see the industry moving in the right direction. To become truly sustainable, we need to continue coming together as professionals to find innovative ways of eliminating waste associated with electronics manufacturing while providing the complex products today's consumers anticipate. SMT007

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4. "Emission Trends in Electronics Manufacturing," U.S. Environmental Protection Agency, March 13, 2023.
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Art Wall is director of fab operations at NextFlex.

SMTA: Sustainability at the Local Level

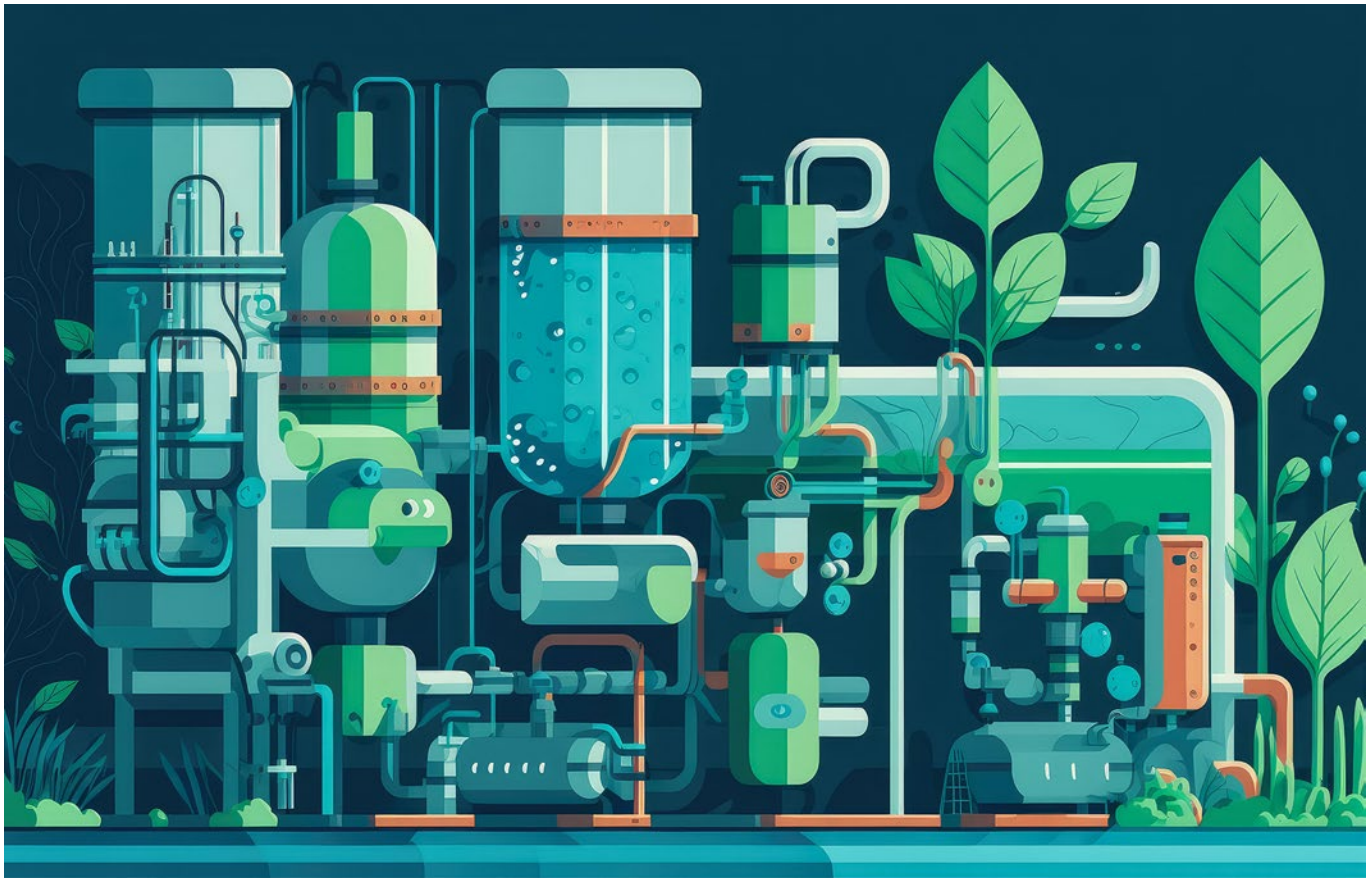
SMTA supports sustainable manufacturing practices through educational programs, local chapter activities, and special events. Here are three examples:

- The long-standing Symposium on Counterfeit Parts and Materials, co-organized with the Center for Advanced Life Cycle Engineering (CALCE) at the University of Maryland, has addressed lifecycle issues as it relates to the threat of counterfeits for over 15 years. The next event is scheduled for June 27–29, 2023 in College Park, Maryland, with several presentations touching on sustainability.
- The 2021 Women's Leadership Program Keynote featured Gayle Schueller, PhD, senior VP and chief sustainability officer for 3M Innovation and Stewardship.
- In 2020 SMTA co-hosted a webinar with iNEMI titled, "Quantifying Life Cycle Impacts for Information and Communications Technology (ICT) Products—A Simpler Approach" featuring insights from Tom Okrasinski, senior manager of the Product Environmental Engineering Group at Nokia Bell Labs' Chief Technology Office.

Lean manufacturing is another topic that has sustainability at its core. SMTA offers Lean Six Sigma certification courses in partnership with the Thayer School of Engineering at Dartmouth College. This program is led by Dr. Ron Lasky with online and in-person options available. Dr. Lasky is co-presenting a three-part webinar series titled, "Solving Real-Life Problems Using the Tools of Lean Six Sigma," along with Jim Hall, ITM Consulting, who has instructed the SMT Processes Certification program since its inception in 2002. The first session of the webinar series kicked off on May 31; the second and third sessions are scheduled for June 7 and June 21, respectively. This webinar series is a joint effort by several local chapters as well as the Students and Young Professionals committee.

Dr. Ron Lasky Phil Zarrow

SMTA empowers members to educate themselves on these important topics and more through participation in the programs like those previously mentioned, as well as through exclusive access to technical papers and archived webinars posted in the SMTA Knowledge Base. Over the years, SMTA has conducted numerous programs educating members about lean practices, environmental protocols, product lifecycle, and other ways to reduce environmental impact through controlled processes and manufacturing best practices and will continue to support these efforts into the future.



Sustainably Clean

Feature Interview by Barry Matties
I-CONNECT007

As the definition of sustainability evolves in the industry, one thing is clear: Process control plays a large role in any definition. Creating a stable process reduces the potential overuse of cleaning materials and it increases yields, thereby reducing scrap and helping the sustainability effort. I recently spoke with Tom Forsythe, executive vice president of KYZEN, about the cleaning process and automated bath control.

Tom, what has my attention once again are your process control systems for the cleaning process. I'm sure you have installed hundreds of these since I first learned about it a few years ago.

Yes, we have. Years ago, when sophisticated aqueous cleaning was born, it required the aqueous cleaning machines of the day to evolve, which meant a need to control a blend of two things—cleaning materials and water. That was a new concept. We all do it at home when we wash the dishes, but it was new for the industry. We originally developed those automated control systems because our customers were having a difficult time keeping their process operating properly.

Without automated control and the water coming in and out, it can easily go from a stable to an unstable process or outside control limits in a matter of hours.

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It's interesting because it shows the difference in dynamics between batch and inline cleaners. Batch systems, for the most part, are very self-contained—they wash, rinse, and dry in the same chamber—but they don't turn on the exhaust until they're doing the drying. Those tend to be much more stable. They don't drift much, and it's a very gradual change over days.

Inline systems have air knives at the end of the wash section to "scrape off" the cleaning material for continued use. That's a value-adder and good for the customer. But now I'm pumping in a few hundred CFM of air with that air knife. What goes in must come out. It would compromise drying if all that moist air were to come out the drying end. Of course, we don't want a cloud of exhaust coming out the input end either. So, the inline system wash chamber dynamics of the spray action is somewhere between 40 and 100 PSI (actually doing the washing), and proper exhaust to balance out that air knife input gets you a very dynamic environment. You can be out of your desired constraints in less than an hour.

> "Those automated control systems are worth their weight in gold.

Those automated control systems are worth their weight in gold. More importantly, beyond the substantial chemical savings, you get a rock-solid process. If you're supposed to be at 10% or 12%, you're at 10, not at 11% or 14%; and the corrections are small, not large, gross adjustments. It's kind of like driving your car down a straight highway, lightly touching the steering wheel as you move it back and forth a little bit. The adjustments are quite modest, but it's a big part of reduced consumption and a better process that delivers quality operations.

What trends do you see? Are people looking for the inline or batch process, or is it still application specific?

It tends to be driven by the tempo in the individual shops. What percentage of your production requires cleaning? This is not about using no-clean technology, but whether your clients require their assemblies to be cleaned. It is worth remembering that no-clean is actually the only modern technology. Barry, what is your guess about how much R&D money has gone into a solder paste that's not named no-clean in this century?

I'm guessing it's a fairly small number.

Everyone, whether they clean or not, uses no-cleans because solder technology has improved this century. It performs better and has a better user experience due to the great features the solder developers have invented and brought to market. But it's a case of who chooses to clean and how much of their production requires cleaning. For example, the aerospace segment never really stopped cleaning but isn't known as a high-volume crowd. They tend to be more batch oriented. Medical devices are changing. Many have gone mass market, such as diabetes implants and other devices employing all kinds of sensors. Those are more often high volume and inline-oriented, but they can still be cleaned in batch systems. The military tends to like inlines, but they also use many batch cleaners.

It's really a function of what you do. Contract manufacturers often use inlines because, of course, they're about bundling business together to gain volume efficiencies. It's not

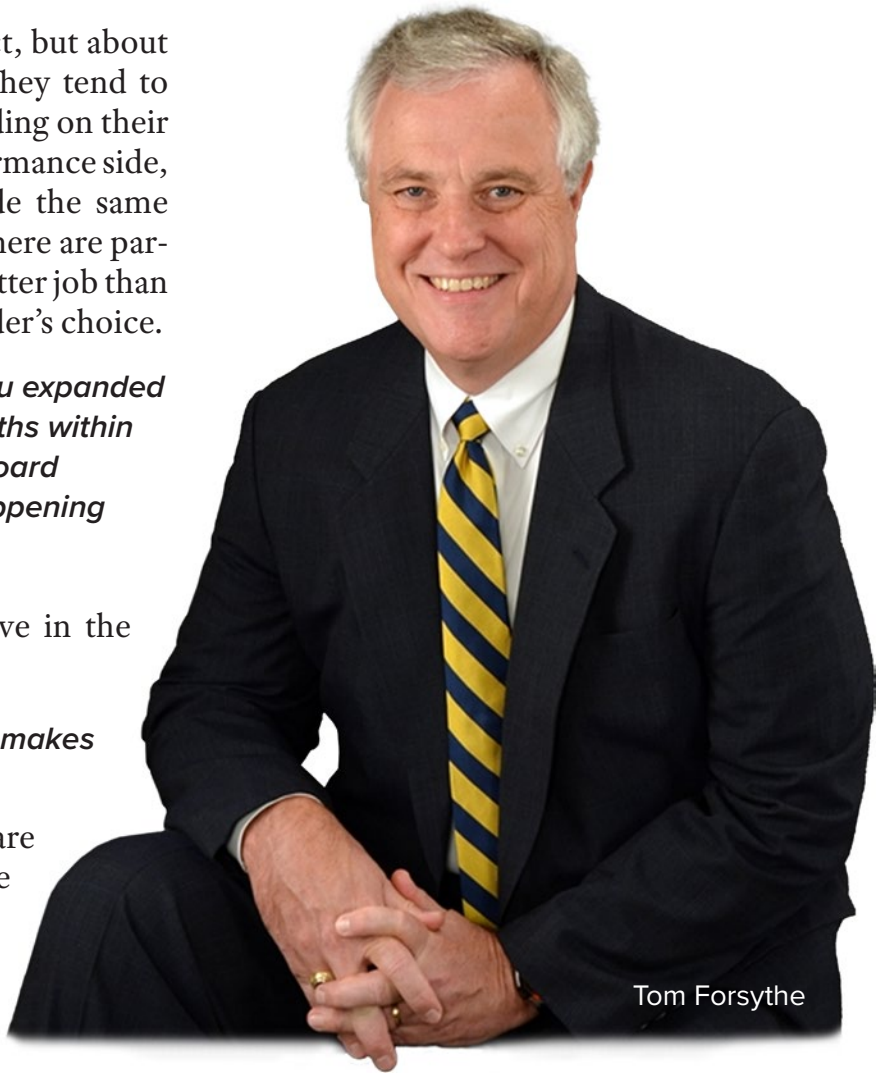
really about any particular contract, but about what the "portfolio" looks like. They tend to be inline guys, but it varies depending on their basic capacity needs. On the performance side, both batch and inline can provide the same level of cleaning for most PCBs. There are particular days where one may do a better job than the other, but on average it's a fielder's choice.

With your control system, have you expanded into other controls for different baths within facilities? For example, the bare board fabricators have a lot of baths happening in their facilities.

They do, but we're not very active in the world of board fab.

If it would adapt, your technology makes a lot of sense.

It does. It's a case of what we are trying to control and whether we can control it. Control technology begins with sensors that are aligned with what you want to measure. It's a case of aligning the sensor with the process. We use several different sensors, which gives us some flexibility. We use this technology in other industries that we support, such as metal fabrication, where we're still cleaning, but the cleaning products are very different because the contaminants are very different. The cleaning materials tend to match the soils.


Tom Forsythe

In today's world, I would consider that an economical solution to a potentially large problem. A bare board plating facility can have so many baths that, honestly, finding a process engineer is quite difficult. Do you have an increased demand for that sort of employee "replacement," if you will?

In part, this tool helps minimize the need for a technician because the materials are automatically being moved into and monitored inside the machine. No one needs to go inside the machine to take a sample and do a manual test. They don't need to handle the materials. Not only does that eliminate a "task," but it also eliminates the potential for a spill or handling accident. That is a real value-adder.

Process control makes things safer, more precisely, and automatically decreases the workload on those operators. Back to your point about the engineers, the system has an advantage because it keeps the historical data on the system, and you can download it as well. Now, if there's a question about whether it was a field return or, "Gee, something weird happened yesterday," they can access that data very rapidly and either confirm or deny whether there's a cleaning process issue.

The system is always on, measuring, recording, and adjusting when necessary to keep the

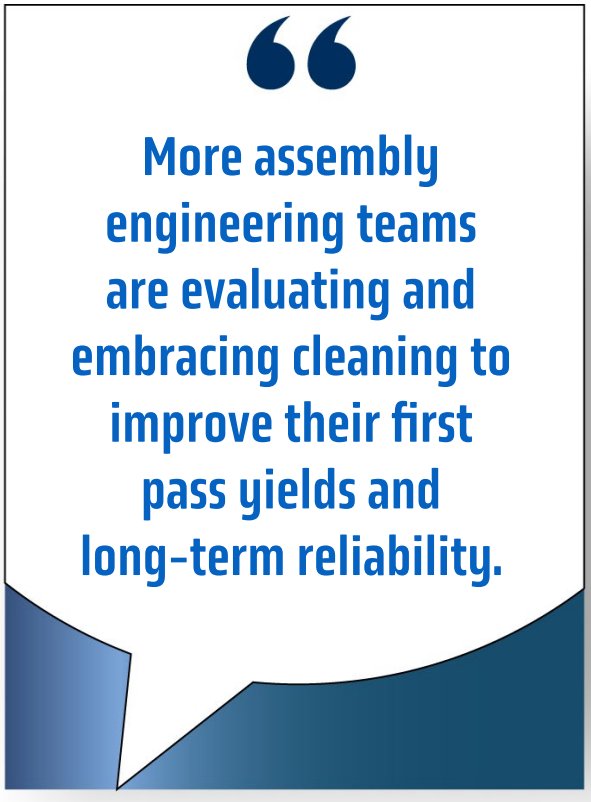
process within the pre-defined control limits. This includes checking that there is cleaning material available to add when needed, and sending alerts from a flashing light on top to digital alerts as the barrel starts to get low. When everything works well, which is most of the time, it prevents problems and saves on time, labor, and trouble. That's a winning combination these days.

What demands are being placed on the cleaning processes? What are people most concerned about?

What's changing are the designs and materials our customers employ; today's cleaning process must be responsive to those new designs and materials. Let me share an example. If you work in your garden, you're most likely to wash your hands when you come back in the house. But if you sit down to read a book, you probably don't wash your hands afterward. Those are different activities with different "contamination" risk factors, and we make a choice to either wash our hands or not. As we look at the evolution of devices that our industry is producing for the world, whether it be the components or SOICs—along with increased density and increased power in smaller packages—more often, cleaning is a value-adder, improving yields and reliability. Of course, cleaning technology must continue to evolve to meet these new challenges. The reason the medical and the military people never stopped cleaning was because they always understood the value that cleaning provided.

They know that by eliminating residues, you can improve the performance of your designs. There's a never-ending drive toward denser, more powerful, and valuable devices and assemblies. Cleaning is a powerful process tool that facilitates that success for many of those new designs. More assembly engineering teams are evaluating and embracing cleaning to improve their first pass yields and long-term reliability. That's what we're seeing, and there's a continuing education need because so much of the industry has not really considered cleaning a solder paste since it has been called "no-clean" for a very long time.

Many of the younger engineers don't consider cleaning as a process option. That's why we do so many technical talks, one-on-ones, and team education with clients and potential clients. We want to help them understand the benefits that cleaning can bring to some of these assemblies. It can solve problems that they're scratching their heads trying to do in other ways.



When you're out teaching and sharing your knowledge, what comes up most often from the customers or prospects?

Forsythe: It starts with the emotional response, "I feel a little silly cleaning something called no-clean." In all honesty, that's not a technical hurdle per se, but it's very much a real hurdle, especially for purchasing people.

They look at the engineers and say, "You guys are nuts. What are you doing?" That's where it begins, and it's a case of the customers sharing information, such as, "We're seeing these kinds of issues today, and we have data that shows this will help." That's where we dive in.

It starts with the focal point of a design that's been created by the Ops team trying to make it a reality, but they're having issues. It could be a yield issue or field failure. Inherently, both are failure issues. Our whole industry is based on improving yields and making things better.

Yes, exactly. Tom, do you have any final thoughts around this topic or another you would like to share with the industry?

One thought is a recommendation not to get hung up on emotions regarding labels. That's more common these days than in previous years. We should try to do that in many parts of our lives, including cleaning in electronics assembly. It's all about the data. When value-added processes make things better, they improve yields and long-term reliability. As we make more sophisticated, higher-volume devices in North America and Western Europe, these cleaning process will be a plus. Data-driven evaluations are always the best approach. When the data says cleaning helps, it can really change the game in a positive way. So, keep an open mind and consider cleaning as another tool in the toolbox that, when appropriate, can save the day.

Thank you. We always appreciate your time and your expertise.

You're welcome. **SMT007**

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Environmental health and safety engineers are responsible for facilitating environmental safety, health and strategy in an organization and also ensure compliance with all Federal, State, and Local SHE policies and standards relevant to the organization.

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EHS engineers actively contribute to establishing company-wide best practices and standards for EHS and help champion a culture that promote environmental health and safety focusing on leading indicators that can deliver world class EHS culture.

They also entails providing support in the identification, analysis, and control of occupational hazards requiring the application of engineering knowledge, skill, and abilities. They seek to identify pre-injury trends during audits, verify compliance with established safety/health procedures, and recommend appropriate actions.

After performing audits, EHS engineers are also responsible for a follow-up on suggested corrective actions, and must also use injury exposure and incidents as parameters to measure progress toward the attainment of factory safety goals.

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Data Collection and Analysis

The Knowledge Base

by Mike Konrad, SMTA

This month, I am speaking with Ryan Gamble, CEO and founder of Intraratio, about the collection and analysis of big data. What are the common misconceptions, does artificial intelligence play a role, and what are some of the biggest mistakes for assembly companies when it comes to big data collection?

Historically, the collection of data was associated with a high price due to the cost of early memory chips. Technology has advanced to the point where memory is cheap, and most assembly process equipment can collect data. Now that we can collect large volumes of data (so-called "big data"), how can we make that data useful?

Early in my career I recall analyzing test data in a binary file format called STDF, and wondering why on earth you would painfully use 4 bits to represent a complex test result. Turns out this file format was created back in 1984, and it was a genius way of compressing data because of the high costs of memory at the time.

With data now flowing freely from test and assembly equipment, it's not unusual to see gigabyte files generated just from a single test operation. The huge challenge now is that this data has no context in terms of correlating to any other equipment in the line, let alone inventory supplier data and other things critical to driving reliability, quality, and cost improvements.


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Ryan Gamble

Exacerbating this are machine vendors themselves that are selling data collection and analytics tools that only address their specific operations—disconnected islands of data perpetuating the need for engineers to waste valuable time manually aggregating it into ad hoc spreadsheet tools. At least 80% of engineering time is wasted on manually aggregating and cleaning up data[1]. Think about what this 80% is costing you in pure dollars, time to market, and more.

The solution is to implement a modern traceability software system that automatically catalogs and contextualizes data from every test and assembly operation across the entire line. Interpreting and storing data from all the different formats and protocols is a complex undertaking, and so best suited for modern software built on web-scale technologies. This breed of software can be configured to be format and protocol agnostic, able to capture all requisite data from all machines, whether it's file or network HTTP/HTTPS data interchange. It will catalog and contextualize it in real time for immediate data-driven insights.

Don't get locked into machine vendor specific data collection solutions—they are just another data silo. Above all, avoid legacy solutions providers; they are still sitting atop software written decades ago, based on older approaches to manufacturing that result in costly customizations, technical debt, and the inability to scale without more costly upgrades.

Modern solutions using web scale technologies are the future because they require lower support costs, plug-and-play type data connectivity via APIs (application programming interfaces), and enable enterprises to be nimble and adaptable amidst the growing complexity of today's supply chain markets.

What are the common misconceptions with data collection and data management?

The first misconception is that it's complicated and costly, therefore only accessible by large corporations who can afford to spend hundreds of thousands of dollars on the endeavor.

Data collection and an effective data management system are a fairly straightforward and cost-effective endeavor to take on. You just need to roll up your sleeves and audit the data collected at every step and every machine in your factory line. Look at where the gaps are against the overall production traceability requirements, so that you have a full picture of the needs. Now you'll be armed to find the right data collection and traceability software solution.

The second misconception is that you should start small, such as with only one machine cell, and that this will somehow translate and scale to the rest of the factory line.

The biggest (and often the costliest) misconception is thinking your ERP can somehow be made to double as the factory data collection and traceability system. Not even a Netsuite Oracle system out of the box can do serialized traceability, let alone track the 30+ process steps of an SMT production line.

ERP is based on a general ledger architecture, not a factory data collection and management architecture. Bring in a system such as an MES (manufacturing execution system) to provide you with true factory line level visibil-

ity and control, with output data reporting that drives better accuracy of your ERP.

With all the buzz surrounding ChatGPT and other online AI-based technologies, how has AI made its way into data analysis and how does that improve the customer experience?

Applications such as ChatGPT don't have direct application to manufacturing. These types of tools are just high-powered chatbots at the end of the day, creating responses to questions based on massive amounts of text content from the web, statistically aggregated to be the most probable response to provide.

Obviously, they will not be able to solve a solder printing process issue or help with that 0.5% yield improvement that is a function of all process settings going back to the semiconductor chips on the PCBA.

However, the underlying technology (a subcategory of AI called machine learning), is a game changer for the electronics industry. Today, anyone with a strong engineering background, coupled with good scripting/programming skills using Python, can implement a machine learning algorithm to hunt for patterns in data. These algorithms can be used for outlier detection, which is incredibly useful for catching quality and process issues in the line, as well as predictive machine maintenance.

Machine learning algorithms can also be leveraged to do virtual product testing based on process data measurements from earlier in the line, thus removing the need to do 100% testing of products going out to customers. The quality, throughput, and overall margin improvements are incredible. But you need well-cataloged contextual data to do this. Otherwise, your engineers will spend most of their time aggregating and cleaning data, and you'll get nowhere.

Based on your experience, what are the biggest mistakes made when collecting or analyzing data?

The biggest mistake I see is not embedding basic traceability attributes in the data at the point it's generated—for example, part number, test program or machine recipe, lot number or board serial number, and date+time of execution should be there as a minimum.

The idiocy is that many common data standards don't specify these fields as required. Just look at the SEMI E142 specification, for example. Machine vendors and third-party data software providers are notorious for violating standards because these standards are inherently overly complicated.

> **"The biggest mistake I see is not embedding basic traceability attributes in the data at the point it's generated…**

Often, engineers try to get around this by embedding information in the file name. But file names get overwritten, and even worse, have you tried to generate analytics by reading in file names?

With today's access to scripting languages, such as Python, which is open source and free, coupled with simple modern web/network APIs (application programming interfaces) approaches, this information can be injected into the data as it's being generated. All you need is an API accessible source of routing information, such as an MES, and you've got it solved.

Where do you see the future of your industry in general, and data analysis specifically?

It's an exciting time for the electronics manufacturing industry, with engineering becoming more and more data centric. With improving

data collection and management, the ability to automate manufacturing lines becomes more attainable, from automated inventory control and dispatching of automated guided vehicles on the factory floor, to advanced outlier detection and improved quality control.

With increased data utilization, there is opportunity for tremendous job growth. I have seen companies grow over four times within the first two years of implementing a modern MES because it frees up engineers to focus on the technical things needed to improve the line, while enabling operators to take on more complex and higher value tasks. All this leads to better product, faster time to market, greater margins, and growth.

Data collection and analytics are key to navigating today's supply chain challenges and market demands. With the ever-increasing electronics complexity of products manufactured today, it is now a requirement for maintaining a competitive edge.

Today's engineers are coming out of college with basic programming and data analytics skills. It's an exciting time with so many new paths to be taken on this technical journey. **SMT007**

Reference

1. "Cleaning Big Data: Most Time-Consuming, Least Enjoyable Data Science Task, Survey Says," by Gil Press, Forbes.com, March 23, 2016.

Mike Konrad is founder and CEO of Aqueous Technologies, and vice president of communications for SMTA. To read past columns, click here.

The World's First Wood Transistor

Researchers at Linköping University and the KTH Royal Institute of Technology have developed the world's first transistor made of wood. Their study, published in the journal PNAS, paves the way for further development of wood-based electronics and control of electronic plants.

"We've come up with an unprecedented principle. Yes, the wood transistor is slow and bulky, but it does work, and has huge development potential," says Isak Engquist, senior associate professor at the Laboratory for Organic Electronics at Linköping University.

The researchers used balsa wood to create their transistor, as the technology involved requires a grainless wood that is evenly structured throughout. They removed the lignin, leaving only long cellulose fibres with channels where the lignin had been.

These channels were then filled with a conductive plastic, or polymer, called PEDOT:PSS, resulting in an electrically conductive wood material.

The researchers used this to build the wood transistor and could show that it is able to regulate electric current and provide continuous function at a selected output level. It could also switch the power on and off, albeit with a certain delay—switching it off took about a second; on, about five seconds.

Possible applications could include regulating electronic plants, which is another strong research area at Linköping University. One advantage of the transistor channel being so large is that it could potentially tolerate a higher current than regular organic transistors, which could be important for certain future applications. "We didn't create the wood transistor with any specific application in mind. We did it because we could. This is basic research, showing that it's possible, and we hope it will inspire further research that can lead to applications in the future," said Isak Engquist.

(Source: Linkoping University)

Credit: Thor Balkhed

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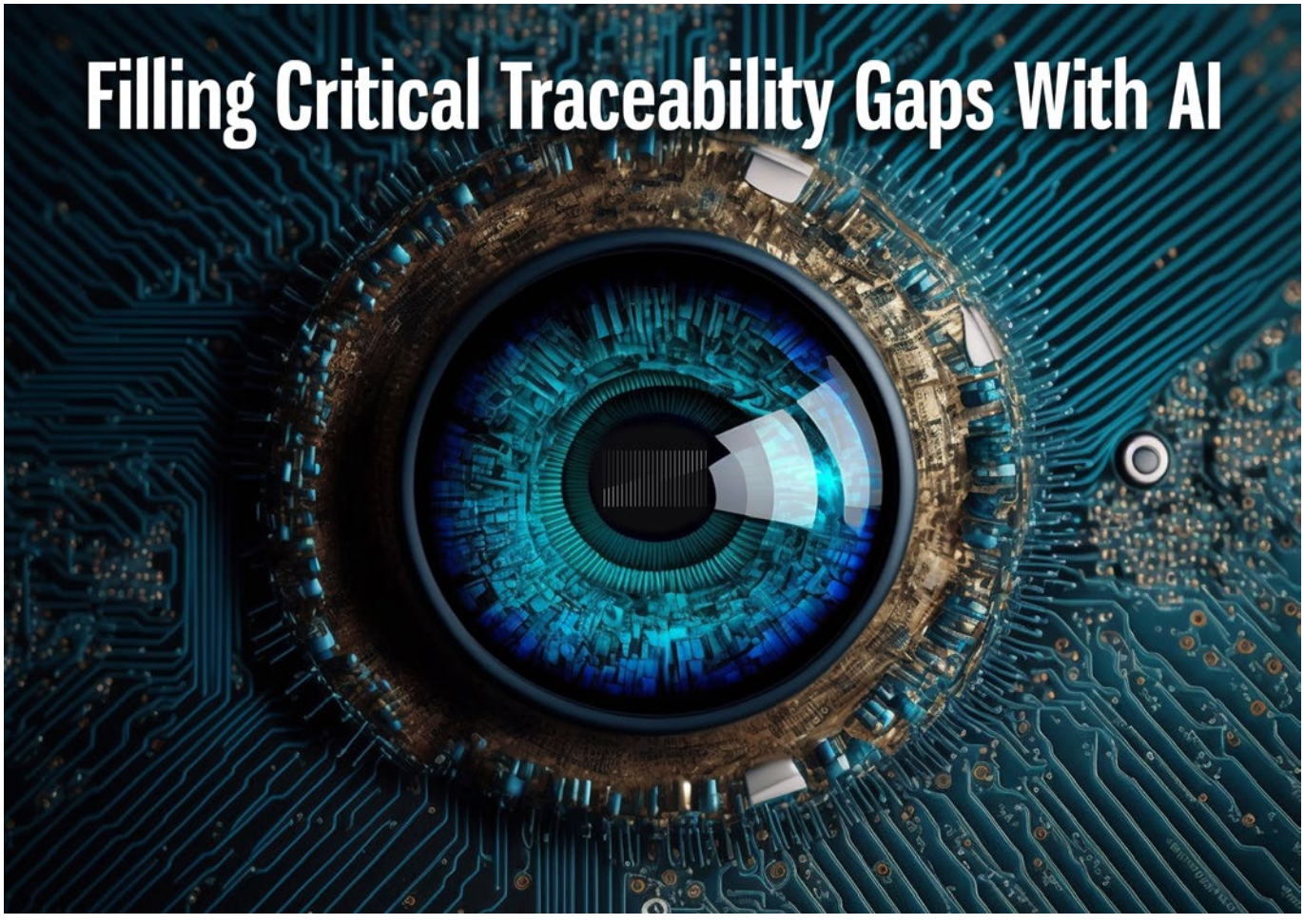
Filling Critical Traceability Gaps With AI



Article by Dr. Eyal Weiss
CYBORD

Traceability means being able to track the origin of any given electrical component throughout the supply chain. For OEMs, this is no longer optional or "nice to have." Yet industrial traceability capacities are sorely lacking throughout industries.

Today, the most widespread standard for traceability is "batch traceability," which aside from tracking the production lot, serial number, and exact board placement for components, fails to analyze the individual components themselves, thus jeopardizing the quality of the goods they compose.

Faulty components are unavoidable. For components that make it into circulation and harbor some kind of defect, the result can easily cascade into sweeping recalls that waste time, money, and resources.

Instead, electronics manufacturers need to be able to facilitate recalls much more surgically. But that can only be achieved through exploratory traceability: new processes that employ precise, detailed, and exacting visual identification of every electronic component placed on a PCBA.

Original equipment manufacturers have an opportunity to improve traceability with AI tools and big data, closing the information gaps that plague tech products across the supply chain.

Where Lies the Fault?

Because eight out of 10 failures are attributed to faulty components rather than faulty workmanship, most manufacturers view traceability as essential. After all, it allows them to oper-

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ate in markets that demand a detailed trail for every part on every board. Consider military defense systems, automotive software, and medical technologies, where consequences of a malfunction can be dire.

Unfortunately, supply chain disruptions, especially in the wake of the pandemic, muddied the waters. Average manufacturing lead times increased from three and a half months to nearly a year, forcing OEMs to circumvent their standard suppliers and source components from alternative suppliers, often with improper storage standards and subpar materials, as well as mixed lots and ambiguous traceability information.

Although the negative impacts of supply chain slowdowns on electronic components have diminished, assuming there are zero defects across thousands upon thousands of components would be wrong-minded. Given that defective and counterfeit components remain, manufacturers should raise their traceability standards to boost quality, output efficiency, and financial clarity, all of which help strengthen the bottom line. Leveraging AI to do this offers the path of least resistance.

The Root of the Problem

Many industry leaders appreciate AI's capacity to improve various phases of the manufacturing process, but often miss its potential impact on the traceability capabilities of individual components.

Presently, there are several levels of traceability across various industries. In the first level, monitoring relevant equipment parts in the manufacturing value chain is conducted inconsistently. The next two levels involve the use of serial numbers to match PCBs to their associated batch. The fourth and highest level monitors the actual placement of the components onto PCBs. However, this maximum level of traceability incorrectly assumes that all components within a reel are exactly the same, and therein lies the root of the problem.

Level Up

Though Level 4 reflects the highest industry standard, many companies have yet to upgrade traceability beyond the first and second tiers; this leads to troublesome gaps in their visibility. Moreover, current lab testing processes are woefully ineffective in identifying compromised material, as they rely solely on sampling a smattering of components out of thousands.

OEMs should strive to extend their traceability standards beyond Level 4 to attain complete exploratory traceability. AI-powered visual technology can enable this heightened level of traceability, offering a far more efficient and cost-effective solution than lab testing batches of components. Regardless of where components are sourced, visual recognition powered by AI can rapidly analyze every component on every board for authenticity and component integrity without concern for human error. When implemented, manufacturers can pinpoint any problematic component and conduct rapid surgical recalls on an individual basis with minimal disruption to the manufacturing process.

Just as doctors administer blood tests to assess a patient's health, OEMs need to take the same approach to each and every electronic component. Luckily, AI can transform this otherwise Sisyphean task into one that is far more efficient and manageable.

No Extra Hardware Necessary

The manufacturing industry needs to embrace AI tools if they truly wish to pioneer air-tight 4A traceability toward a more intelligent, efficient, and cost-effective future. All it takes is a SaaS integration with their existing SMT hardware to gain true visibility into what is going on in their products. **SMT007**

Dr. Eyal Weiss is CTO and founder of Cybord.

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A Solution to the Cost-Estimate Problem

Maggie Benson's Journey

by Dr. Ronald C. Lasky, INDIUM CORPORATION

Editor's note: Indium Corporation's Ron Lasky continues this series of columns about Maggie Benson, a fictional character, to demonstrate continuous improvement and education in SMT assembly. The story continues with Andy and Sue, who both worked at Ivy-Benson Electronics, but have been taking on other projects for Professor Patty Coleman at Ivy University.

At Hartman Electronics, Professor Patty asked owner Matt Harman to describe his new project to Andy and Sue. He had just explained how much he pays his operators and engineers but had concerns about whether this was the right amount.

Andy and Sue had been through a similar exercise at an auto mechanic's shop, where Professor Patty recommended they learn the true cost of operating a business.

"We've been asked to perform final assembly of some units for the FAA," Matt said. "It involves taking PCBs that we assembled on our SMT lines and connecting the PCBs together with wiring in a housing about the size of a small refrigerator. We estimate we will need 20 operators and five supporting engineers."

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Cultivating Connections

Matt then gave Patty, Sue, and Andy a tour of the facility and answered their many questions.

"I pay the operators about $20 per hour and the engineers $40 per hour," he said. "I figure a 40% premium is fair. So, I plan to charge $28 per hour for the operators and $56 per hour for the engineers. Does that seem about right?"

Sue and Andy stared in disbelief at Patty, who then suggested that the two join her in a small conference room to analyze the situation. As she closed the conference room door, Sue said, "Is Matt kidding? Can't he see right off the bat that he'll lose his shirt if he charges so little?"

Andy shared the same sentiment, so Patty explained the situation. "Matt charges his PCB assembly customers per board assembled using a formula the previous owner used, so he is unfamiliar with current charges for this type of work. Let's help him by suggesting what he should charge, and back it up with analysis. But I want you two to take the lead on this." She then left the room to chat with Matt.

"Sue suggested that they put all the data they were discussing in a spreadsheet."

Andy repeated what Matt had said about 20 operators and five engineers being paid $20 per hour and $40 per hour, respectively.

Sue said, "I think it will make our calculations easier if we consider that he also has 20 operators and five engineers doing SMT assembly. Overhead costs will be split between the two operations. He has one person in marketing, one in sales, and two people in procuring and purchasing of PWBs, components, etc."

"He also has two managers—one for SMT and one for the new project—and an administrative assistant. He also has an accountant," Andy said. "He told us that he personally wants to make $250,000 annually."

Sue suggested that they put all the data they were discussing in a spreadsheet. After about 90 minutes of work, Sue and Andy were quite confident they had a reasonable estimate of how much it would cost Matt to keep his operators and engineers employed. Just then, Patty returned, and they reviewed the final numbers together.

Patty thought their answers were spot on. "Okay, let's discuss your analysis with Matt."

Andy suggested that Sue kick off the meeting because she had developed the spreadsheet." Once they convened in the conference room, Sue said, "Matt, it is true that you pay your operators $20 per hour and pay your engineers $40 per hour. However, with all overhead costs, we estimate that the operators actually cost about $44 per hour and the engineers $74 per hour. So, you need to charge at least this amount."

Matt felt shaken and flustered, and his face grew red as he spoke directly to Patty, "You said these kids knew what they were doing. This is laughable. Why do I need to charge this much?"

Patty appeared angry and said firmly, "Matt, I told you not to over-react, and to listen to the analysis they performed. What you said was insulting."

Clearly chastened, Matt replied, "Okay, you're right. Proceed." Still, he appeared very skeptical.

Sue resumed. "Your operators and engineers have a health care benefits package and a 401K. In addition, you have to pay Social Security, Medicare, and a few miscellaneous things. Your accountant confirms that this alone is a 45% adder."

"Wow, that's already beyond my 40% adder," Matt said sheepishly. "I feel like a big dummy."

"You have two purchasing agents, and these add $1.74 to each worker per hour, and a

marketing and sales adder at 87 cents each," Andy said.

After Sue explained that his managers and accountants add $2.90 and $1.02, respectively. Andy added with a chuckle, "Your three administrative assistants add $1.74 and the one personnel manager 87 cents."

"Your requested salary costs $1.83 per hour per worker and we added 10% for a modest profit," Sue said.

"Okay, you win," Matt replied. "I'm embarrassed that I never really thought about the fact that the only people earning money for the company are those that make the product. Their efforts need to financially support the many people who are obviously important but don't generate revenue."

"You finally get it, Matt," Patty said gently.

"Professor Patty, one of your cardinal rules is that doubling what an operator is paid approximates what they will cost," Sue said triumphantly. "Twice $20 per hour equals $40 per hour, quite close to our estimate of the cost of $44 per hour."

Patty felt warmly toward Sue for having called her Professor Patty.

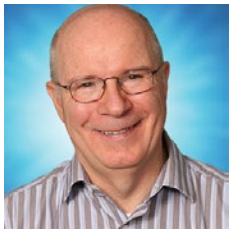
Epilogue: Matt charged $48 per hour for the operators and $80 per hour for the engineers. He explained this to his customer using a cost analysis similar to the one that Patty, Sue, and Andy recommended. Both the customer and Matt's company benefited from the relationship.

The Board of Advisors of the engineering school at Ivy U asked for an example of engineering students solving practical, engineering/business-related problems. The Dean asked Patty for help, and she suggested that Sue and Andy give a presentation on their project.

At the end of the presentation, even very senior members of the Board of Advisors referred to Professor Patricia Coleman, PhD, PE, as "Professor Patty."

Note from Dr. Ron: I'm sure many readers will think that this post is just a work of fiction. After all, no one could be as clueless as Matt. As with all my posts, this one is based on a true story.

Would you like the Excel spreadsheet Sue used to make the calculations? Send me an email at rlasky@indium.com. **SMT007**



Ronald C. Lasky is an instructional professor of engineering for the Thayer School of Engineering at Dartmouth College, and senior technologist at Indium Corporation. To read past columns, click here.

TOP TEN

EDITOR'S PICKS

Anaya Vardya

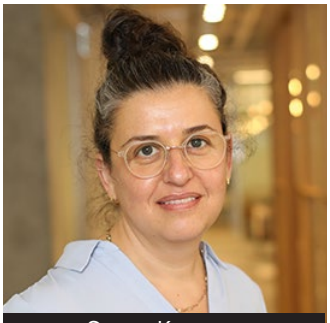
Standard of Excellence: Hey World, Our Products Matter

One of today's biggest challenges is finding, hiring, and retaining good and solid employees. Some people blame the times, while others blame the workforce, especially millennials. If that's the way you want to go, then fine, but I must warn you that with that mindset, you will never find what you're looking for. Instead, let's shift the paradigm and become better ambassadors for our industry.

Knocking Down the Bone Pile: Package on Package Rework—Skill Required

Package-on-package (PoP) is an electronic component-stacked package type consisting of vertically stacked ball grid arrays most commonly in a two-high stack. The package closest to the board is the logic/CPU component and is more commonly known as the "bottom" package. The "top" package sits on top of this module and is the memory module. These packages are generally found in consumer electronics (mobile devices) such as smartphones, tablets, and netbooks. These packages tend to be high IO count, fine pitch, very thin packages.

Sustainability Podcast: Episode 2, 'Sustainability Through Cloud Applications', Now Available



Susan Kayesar

Now available on Spotify, Episode 2 of I-Connect007's new podcast, On the Line with... features an interview with Susan Kayesar of Siemens. Kayesar addresses cloud applications and sustainability, as well as some key, new best practices that emerge from using a cloud-based platform for business operations software systems.

Doug Holtz

Taking Charge of ESD

At the recent SMTA Boise Expo & Tech Forum, Barry Matties spoke with Doug Holtz, national sales manager of Conductive Containers, about challenges related to ESD and where manufacturers are most vulnerable. It's a growing concern, Doug says, and there are important lessons to be learned. Doug also reviews his presentation, and he points out how reducing touchpoints in the supply chain can make a world of difference for both customers and manufacturers.

North American EMS Industry Down 3.1 Percent in March

IPC announced the March 2023 findings from its North American Electronics Manufacturing Services (EMS) Statistical Program. The book-to-bill ratio stands at 1.28.

Maggie Benson's Journey: Calculating Operating Costs

Editor's note: Indium Corporation's Ron Lasky continues this series of columns about Maggie Benson, a fictional character, to demonstrate continuous improvement and education in SMT assembly. In this episode, Sue and Andy have just returned to the Upper Valley of Vermont and are out for a walk. Let's look in on their conversation.

Micross Acquires Technograph Microcircuits

Micross Components, a leading provider of high-reliability microelectronic product and service solutions for aerospace, defense, space, medical, energy, industrial and other applications, announced the acquisition of Technograph Microcircuits Ltd, a leading provider of hybrid integrated circuits, RF & microwave products, optoelectronics, and PCB assembly.

Critical Manufacturing Recognized Leader in 2023 Gartner Magic Quadrant for MES

Critical Manufacturing, a leading provider of Manufacturing Execution Systems (MES), has been recognized as a Leader in 2023 Gartner Magic Quadrant for Manufacturing Execution Systems for the third consecutive time.

Nolan's Notes: Ready to Hire?

Staffing issues remain a top concern for electronics manufacturing companies—a ripple effect of the pandemic, to be sure. No sooner did supply chain issues soften than we realized nobody wanted to come work for us, and if they did, could we train them quickly enough? Therefore, what are today's best practices in on-the-job training? Are local technical schools recognizing the need and meeting the challenge set before them?

SMTA Atlanta: No Rain Delay For This Event

The SMTA Atlanta Expo & Tech Forum couldn't stop the rain, but the chilly, rainy weather didn't deter the technologists who came out for this annual event yesterday. Held at the Atlanta Tech Park small business incubator in Norcross, Georgia, the show drew a crowd primarily from the SMT segment, along with a number of designers and fabricators.

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IPC Instructor
Longmont, CO

This position is responsible for delivering effective electronics manufacturing training, including IPC certification, to adult students from the electronics manufacturing industry. IPC Instructors primarily train and certify operators, inspectors, engineers, and other trainers to one of six IPC certification programs: IPC-A-600, IPC-A-610, IPC/WHMA-A-620, IPC J-STD-001, IPC 7711/7721, and IPC-6012.

IPC instructors will primarily conduct training at our public training center in Longmont, Colo., or will travel directly to the customer's facility. It is highly preferred that the candidate be willing to travel 25–50% of the time. Several IPC certification courses can be taught remotely and require no travel or in-person training.

Required: A minimum of 5 years' experience in electronics manufacturing and familiarity with IPC standards. Candidate with current IPC CIS or CIT Trainer Specialist certifications are highly preferred.

Salary: Starting at $30 per hour depending on experience

Benefits:
- 401k and 401k matching
- Dental and Vision Insurance
- Employee Assistance Program
- Flexible Spending Account
- Health Insurance
- Health Savings Account
- Life Insurance
- Paid Time Off

Schedule: Monday thru Friday, 8–5

Experience: Electronics Manufacturing: 5+ years (Required)

License/Certification: IPC Certification–Preferred, Not Required

Willingness to travel: 25% (Required)

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Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB manufacturer located in Tucson, AZ, is looking for sales representatives for the Utah/Colorado, and Northern California territories. With 35+ years of experience, our PCB manufacturing capabilities reach far beyond that of your typical fabricator.

Reasons you should work with Prototron:
- Solid reputation for on-time delivery (98+% on-time)
- Capacity for growth
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- 5-day standard lead time
- RF/microwave and special materials
- AS9100D
- MIL-PRF- 31032
- ITAR
- Global sourcing option (Taiwan)
- Engineering consultation, impedance modeling
- Completely customer focused team

Interested? Please contact Russ Adams at (206) 351-0281 or russa@prototron.com.

apply now

Career Opportunities

KYZEN
Where Science and Care Converge.

Regional Manager

West Region — Two Positions

General Summary: Manages sales of the company's products and services, Electronics and Industrial, within the Pacific Northwest or Southwest Region. Reports directly to Americas Manager. Collaborates with the Americas Manager to ensure consistent, profitable growth in sales revenues through positive planning, deploy-ment and management of sales reps. Identifies objectives, strategies and action plans to improve short- and long-term sales and earnings for all product lines.

DETAILS OF FUNCTION:

- Develops and maintains strategic partner relationships
- Manages and develops sales reps:
  - Reviews progress of sales performance
  - Provides quarterly results assessments of sales reps' performance
  - Works with sales reps to identify and contact decision-makers
  - Setting growth targets for sales reps
  - Educates sales reps by conducting programs/ seminars in the needed areas of knowledge
- Collects customer feedback and market research (products and competitors)
- Coordinates with other company departments to provide superior customer service

QUALIFICATIONS:

- 5-7+ years of related experience in the manufacturing sector or equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Business-to-business sales experience a plus
- Good working knowledge of Microsoft Office Suite and common smart phone apps
- Valid driver's license
- 75-80% regional travel required

To apply, please submit a COVER LETTER and RESUME to: Fernando Rueda, Americas Manager

fernando_rueda@kyzen.com

apply now

EMA Design Automation®

Technical Marketing Engineer

EMA Design Automation, a leader in product development solutions, is in search of a detail-oriented individual who can apply their knowledge of electrical design and CAD software to assist marketing in the creation of videos, training materials, blog posts, and more. This Technical Marketing Engineer role is ideal for analytical problem-solvers who enjoy educating and teaching others.

Requirements:

- Bachelor's degree in electrical engineering or related field with a basic understanding of engineering theories and terminology required
- Basic knowledge of schematic design, PCB design, and simulation with experience in OrCAD or Allegro preferred
- Candidates must possess excellent writing skills with an understanding of sentence structure and grammar
- Basic knowledge of video editing and experience using Camtasia or Adobe Premiere Pro is preferred but not required
- Must be able to collaborate well with others and have excellent written and verbal communication skills for this remote position

EMA Design Automation is a small, family-owned company that fosters a flexible, collaborative environment and promotes professional growth.

Send Resumes to: resumes@ema-eda.com

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Career Opportunities

pluritec®

MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

Pluritec North America, ltd., an innovative leader in drilling, routing, and automated inspection in the printed circuit board industry, is seeking a full-time field service engineer.

This individual will support service for North America in printed circuit board drill/routing and x-ray inspection equipment.

Duties included: Installation, training, maintenance, and repair. Must be able to troubleshoot electrical and mechanical issues in the field as well as calibrate products, perform modifications and retrofits. Diagnose effectively with customer via telephone support. Assist in optimization of machine operations.

A technical degree is preferred, along with strong verbal and written communication skills. Read and interpret schematics, collect data, write technical reports.

Valid driver's license is required, as well as a passport, and major credit card for travel.

Must be able to travel extensively.

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KOH YOUNG AMERICA

Technical Service & Applications Engineer

Full-Time — Flexible Location

Koh Young Technology, founded in 2002 in Seoul, South Korea, is the world leader in 3D measurement-based inspection technology for electronics manufacturing. Located in Duluth, GA, Koh Young America has been serving its partners since 2010 and is expanding the team with an Applications Engineer to provide helpdesk support by delivering guidance on operation, maintenance, and programming remotely or on-site.

Responsibilities

- Provide support, preventive and corrective maintenance, process audits, and related services
- Train users on proper operation, maintenance, programming, and best practices
- Recommend and oversee operational, process, or other performance improvements
- Effectively troubleshoot and resolve machine, system, and process issues

Skills and Qualifications

- Bachelor's in a technical discipline, relevant Associate's, or equivalent vocational or military training
- Knowledge of electronics manufacturing, robotics, PCB assembly, and/or AI; 2-4 years of experience
- SPI/AOI programming, operation, and maintenance experience preferred
- 75% domestic and international travel (valid U.S. or Canadian passport, required)
- Able to work effectively and independently with minimal supervision
- Able to readily understand and interpret detailed documents, drawings, and specifications

Benefits

- Health/Dental/Vision/Life Insurance with no employee premium (including dependent coverage)
- 401K retirement plan
- Generous PTO and paid holidays

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Career Opportunities

ARLON ELECTRONIC MATERIALS

Arlon EMD, located in Rancho Cucamonga, California, is currently interviewing candidates for open positions in:

- **Engineering**
- **Quality**
- **Various Manufacturing**

All interested candidates should contact Arlon's HR department at 909-987-9533 or email resumes to careers.ranch@arlonemd.com.

Arlon is a major manufacturer of specialty high-performance laminate and prepreg materials for use in a wide variety of printed circuit board applications. Arlon specializes in thermoset resin technology, including polyimide, high Tg multifunctional epoxy, and low loss thermoset laminate and prepreg systems. These resin systems are available on a variety of substrates, including woven glass and non-woven aramid. Typical applications for these materials include advanced commercial and military electronics such as avionics, semiconductor testing, heat sink bonding, High Density Interconnect (HDI) and microvia PCBs (i.e. in mobile communication products).

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2015 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customers' requirements.

For additional information please visit our website at www.arlonemd.com

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INSULECTRO

Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers to build better boards faster. Our nationwide network provides many opportunities for a rewarding career within our company.

We are looking for talent with solid background in the PCB or PE industry and proven sales experience with a drive and attitude that match our company culture. This is a great opportunity to join an industry leader in the PCB and PE world and work with a terrific team driven to be vital in the design and manufacture of future circuits.

apply now

Career Opportunities

MivaTek Global

Field Service Technician

MivaTek Global is focused on providing a quality customer service experience to our current and future customers in the printed circuit board and microelectronic industries. We are looking for bright and talented people who share that mindset and are energized by hard work who are looking to be part of our continued growth.

Do you enjoy diagnosing machines and processes to determine how to solve our customers' challenges? Your 5 years working with direct imaging machinery, capital equipment, or PCBs will be leveraged as you support our customers in the field and from your home office. Each day is different, you may be:

- Installing a direct imaging machine
- Diagnosing customer issues from both your home office and customer site
- Upgrading a used machine
- Performing preventive maintenance
- Providing virtual and on-site training
- Updating documentation

Do you have 3 years' experience working with direct imaging or capital equipment? Enjoy travel? Want to make a difference to our customers? Send your resume to N.Hogan@MivaTek.Global for consideration.

More About Us

MivaTek Global is a distributor of Miva Technologies' imaging systems. We currently have 55 installations in the Americas and have machine installations in China, Singapore, Korea, and India.

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eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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Career Opportunities

American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

The CAD/CAM engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creating manufacturing data, programs, and tools required for the manufacture of PCB.

Essential Duties and Responsibilities

- Import customer data into various CAM systems.
- Perform design rule checks and edit data to comply with manufacturing guidelines.
- Create array configurations, route, and test programs, penalization and output data for production use.
- Work with process engineers to evaluate and provide strategy for advanced processing as needed.
- Itemize and correspond to design issues with customers.
- Other duties as assigned.

Organizational Relationship

Reports to the engineering manager. Coordinates activities with all departments, especially manufacturing.

Qualifications

- A college degree or 5 years' experience is required. Good communication skills and the ability to work well with people is essential.
- Printed circuit board manufacturing knowledge.
- Experience using CAM tooling software, Orbotech GenFlex®.

Physical Demands

Ability to communicate verbally with management and coworkers is crucial. Regular use of the telephone and e-mail for communication is essential. Sitting for extended periods is common. Hearing and vision within normal ranges is helpful for normal conversations, to receive ordinary information and to prepare documents.

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APCT
Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

APCT, a leading manufacturer of printed circuit boards, has experienced rapid growth over the past year and has multiple opportunities for highly skilled individuals looking to join a progressive and growing company. APCT is always eager to speak with professionals who understand the value of hard work, quality craftsmanship, and being part of a culture that not only serves the customer but one another.

APCT currently has opportunities in Santa Clara, CA; Orange County, CA; Anaheim, CA; Wallingford, CT; and Austin, TX. Positions available range from manufacturing to quality control, sales, and finance.

We invite you to read about APCT at APCT.com and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

Thank you, and we look forward to hearing from you soon.

apply now

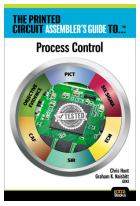
NEW WEBINAR! **On Demand: Free 12-part Webinar Series**

Smarter Manufacturing Enabled with Inspection Data

with expert Ivan Aduna

A smart factory is created from many parts, and inspection systems will play a critical role for process optimization in the next industrial revolution. Accurate, reliable 3D measurement-based data is essential, and a key element for a true smart factory. In this 12-part webinar series, viewers will learn about secure data collection, AI-powered solutions to manage and analyze data, and how to leverage the IPC CFX-QPL to succeed in the transformation to Industry 4.0.

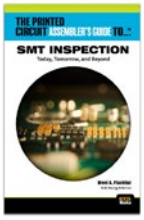
I-007eBooks *The Printed Circuit Assembler's Guide to...*



NEW! *Process Control*

by Chris Hunt and Graham K. Naisbitt, GEN3

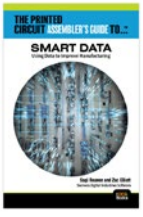
In this book, the authors examine the role of SEC test and how it is used in maintaining process control and support for objective evidence (OE.) Issues, including solution choices, solution sensitivities, and test duration are explored.



SMT Inspection: Today, Tomorrow, and Beyond

by Brent Fischthal, Koh Young America

An in-depth insight into new and exciting true 3D inspection technology is provided in this book, along with a look into the future of leveraging big data management and autonomous manufacturing for a smarter factory.



Smart Data: Using Data to Improve Manufacturing

by Sagi Reuven and Zac Elliott, Siemens Digital Industries Software

Manufacturers need to ensure their factory operations work properly, but analyzing data is simply not enough. Companies must take efficiency and waste-reduction efforts to the next phase using big data and advanced analytics to diagnose and correct process flaws.

Process Validation

by Graham K. Naisbitt, GEN3

This book explores how establishing acceptable electrochemical reliability can be achieved by using both CAF and SIR testing. This is a must-read for those in the industry who are concerned about ECM and want to adopt a better and more rigorous approach to ensuring electrochemical reliability.

NEW PODCAST! *On the Line with...*

...is available now on Spotify and coming soon on all major podcast platforms. In this podcast, we speak with industry experts to get the latest insights and perspectives on the most relevant topics in the electronics industry today. The first series of *On the Line with...* features conversations on sustainability.

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