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Next Issue Focus:

Production and Inspection

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EM Products

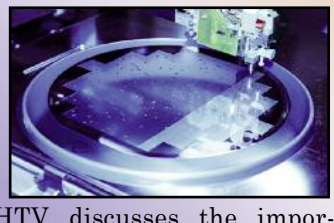
SHENMAO has launched a new no-clean flux for fine-pitch assembly and LED die attach. Electronics manufacturing products begin on... *Page 24*

EM Services

Beckhoff's EtherCAT I/O modules boost the speed of VMEK's vision sorting systems. EMS section begins on... *Page 18*

This Month's Focus:

Test and Inspection



HTV discusses the importance of proper encapsulation for component reliability; Nordson SONOSCAN demonstrates the versatility of acoustic imaging; Tanaka offers strategies for firms recovering from the COVID-19 pandemic. Special features begin on... *Page 48*

Koh Young Inspection Systems Essential to Qualitel's Growth

DULUTH, GA — From prototype to production, EMS provider Qualitel's business model is designed to be flexible and responsive to customers, while meeting strict quality requirements. To verify the quality of its products and to prove it to clients in the aerospace, medical and other mission-critical industries, Qualitel relies on Koh Young automated optical inspection (AOI) and solder paste inspection (SPI) systems.

Celebrating a quarter of a century this year, Qualitel operates a 71,000 ft² EMS facility with state-of-the-art equipment, located north of Seattle, Washington. The company builds complex, high-reliability PCBs and turnkey assemblies. Qualitel is ITAR-registered, aligned to NIST 800-53 and holds ISO 9001/AS9100 and ISO 13485 certifications.

With more than 200 employees, the company offers both series production and prototype services, referred to as Qualitel Corporate and Qualitel Express, respectively. Each facility has its own equipment and dedicated teams.

With more than 200 employees, Qualitel offers manufacturing services from prototype to production.

When Failure is Not an Option

Qualitel applies its core values of responsiveness, reliability, respect, teamwork, and care to its team, as well as to its suppliers, customers and the products it builds. The company is a supplier of choice for OEMs seeking a partner specializing in a full range of high-mix, and low- to medium-volume manufacturing of high-reliability products.

When it came time to invest in 3D SPI and 3D AOI solutions, Qualitel looked for real-time, inline inspection solutions that could offer closed-loop feedback to ensure the quality of each product. The company needed

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In-Mold Electronics (IME) Adoption Projected to Grow

BOSTON, MA — In-mold electronics (IME) promises to enable high-volume production of structural electronics where the electronic circuitry and functionality are part of the 3D-shaped structure itself. This enables innovative and elegant designs and significantly reduces size and weight.

A Transition to Higher Volume

IME is not exactly a new process or technology. In fact, in many ways, it is an evolution of already well-established in-mold decoration (IMD), in which molding and other methods of 3D forming are combined with graphic printing.

The transition from IMD to IME is not straightforward, however, especially at commercial scale. This partially explains why it has taken so long for IME to establish lasting commercial success, despite all the efforts and false starts.

This is now changing. There are already low-volume IME products on the market and the transition toward higher-volume application is not far off. IDTechEx's latest report "In-Mold Electronics 2019-2029: Technology, Market Forecasts, Players," projects that the market will exceed $250 million by 2024.

To enable commercialization of IME, new materials must be developed that can survive new requirements, such as stretching and 3D forming. New processes are required to combine 2D printing, 3D forming and rigid component placement. New design procedures and product concepts must be developed, based on material and process characteristics, as well as market needs.

Functional materials in IME

Continued on page 6

ASM Publishes 2020 Industry Survey

SUWANEE, GA — From mid-September to early October, ASM surveyed roughly 450 companies to see the effects of COVID-19 on business and the ways in which manufacturers are responding to the crisis.

While other industries have been hit much harder by the pandemic, electronics factories around the world are facing great challenges. As expected, 55 percent of the companies surveyed reported that the virus has had a negative impact on their production, with 42 percent reporting concrete declines in productivity.

Becoming More Resilient

One lesson from the pandemic is for companies to take steps to become more resilient. When asked about mid-term plans, companies stated that they are beginning to make their manufacturing operations more durable.

To be more crisis-proof in the future, 75 percent of the respondents are banking on greater levels of automation. Two out of three companies plan to advance the digital

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Cryogenic-Capable Isolators Improve Performance of mmWave Systems

By Dr. Dave Rizzo

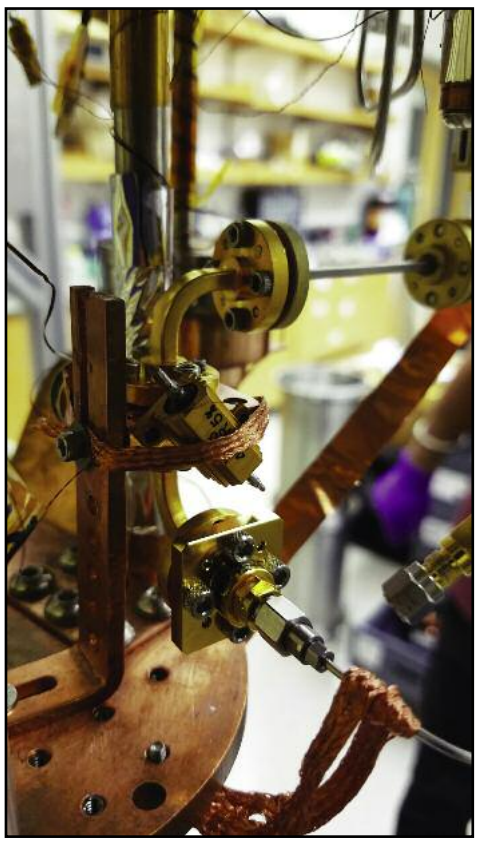
Silence is golden when it comes to filtering out unwanted reflected noise, especially in extremely high frequency, millimeter wave (mmWave) applications. While recent improvements in isolator designs are solving many of these problems, one critical challenge remains — finding isolators that operate optimally under cryogenic conditions.

For manufacturers of ultra-high-frequency wireless applications, such as 5G and 6G communications, stand-off security scanning and military defense products, the issue of mmWave and cryogenics is relatively new. In fact, some system designers may still be unaware that an isolator built to operate at room temperatures will fail to operate optimally when temperatures are reduced to cryogenic levels.

"That happened to us," says Alexander Anferov, a graduate research assistant in the Schuster Lab at the University of Chicago. "We tried using regular isolators from one vendor. We cooled them down and assumed they would work, but they weren't behaving right."

Anferov, a recent Caltech graduate, looked to NASA and its Jet Propulsion Laboratory just outside Los Angeles for a solution. "It turned out they had just commissioned a grant for a company to design isolators specifically for cryogenics," he says. "After talking with them it became obvious from shared experiences that we were actually causing the problem in our setup by utilizing isolators that could not stand up to extremely cold conditions."

Due to the fact that there is no industry standard, mmWave manufacturers often, though unintentionally, make components out of metals that when cooled to cryogenic levels start to superconduct.



Setup to characterize the quantum properties of 100 GHz.

"That completely changes the device properties for the worse," says Anferov. "The real issue is that the results are unpredictable. Surprise resonances and new leakage paths can crop up, and power that used to be absorbed can be reflected instead."

A Universal Challenge

Antenna designers are very familiar with the constant battle of standing waves. Without control, these unwanted waves reflect back into the transmitter to attenuate power output while raising unwanted noise input. Especially in the mmWave bands, which cover the frequencies between 30 to 500 GHz, the reduction of transmitted signal strength jeopardizes the battle — almost literally in military applications.

To reduce the voltage standing wave ratio (VSWR) and help increase the signal-to-noise (S/N) ratio, microwave engineers typically rely on isolators (Faraday rotation isolators). These discrete components allow electromagnetic signals to pass in one direction but absorb them in the opposite direction, reducing noise.

However, Dana Wheeler, CEO of Massachusetts-based Plymouth Rock Technologies, explains how standard isolators often become problematic with next-gen electronics that require components that must withstand more extreme environments.

"We received an SBIR grant from the U.S. Navy to decrease the size of the large satcom antenna systems on aircraft carriers in order to put them higher up onto the ship's superstructures because the jet-blast from the new fighter planes was damaging the radomes," says

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Cryogenic-Capable Isolators Improve Performance

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Wheeler. "The challenge was to lower the weight and size, without losing any performance."

Wheeler says that for any antenna system, if the antenna aperture shrinks, gain (G) drops by a logarithmic amount, which is in contrast to the goal. But if the noise temperature (T) is lowered, then the gain that was lost can be saved. "Our solution was to cryogenically cool the low noise amplifier," says Wheeler.

"We can get down to less than 100 Kelvins with commercially available cryo-coolers," he says. "Our biggest challenge was finding an isolator that could perform at those temps. Fortunately for us, a company called Micro Harmonics had just designed some specifically for NASA."

Micro Harmonics specializes in design solutions for components used in mmWave products. Under a NASA contract awarded in 2015, the company successfully developed an advanced line of isolators for 50 to 330 GHz applications. That successful project led NASA to award the company a subsequent grant to address the issue of isolators at cryogenic temperatures.

"Low-noise integrated circuit amplifiers work, because of the nature of a Schottky diode or a FET transistor, in that as it gets cooler, it has lower noise," says Wheeler. "However, cryogenic low-noise amplifiers are not cheap. With ferrite isolators you get more bang for the buck: a better gain over noise figure at room temperatures, and even more so at cryogenic temps."

There are numerous material issues that must be addressed to ensure that an isolator is able to withstand the rigors of thermal cycling. The substantial temperature dependence of the ferrite magnetization is also a challenge. Ferrite magnetization follows a modified Bloch law, increasing by more than 20 percent when cooled from room temperature down to 4 K. As the temperature decreases there is less thermal energy and it is easier to align magnetic dipoles in the ferrite.

The design used by Micro Harmonics compensates for the change. It also uses magnetic armatures designed to achieve a focused, uniform bias field in the ferrite. This strong magnetic saturation allows the shortest possible length of ferrite — hence the small footprint — while achieving a low insertion loss of less than 1 dB at 75 to 110 GHz and only 2 dB at 220 to 330 GHz.

Proven in Research and Practice

While manufacturers are now realizing the benefits of isolators for cryo' applications, on the research side, Anferov and his team at the University of Chicago are on a mission to see just how low they can go.

"Our lab does experiments at 1 Kelvin, and there are components that can function at temperatures close to absolute zero," he says. "However, at the extremely high frequencies demanded by today's applications, it takes a specialized ferrite isolator to perform consistently under such extremes; a ferrite that won't over-rotate the field and create unwanted issues."

It is essential for any mmWave application that each isolator is tested over the full frequency band on a vector network analyzer to ensure compliance. This includes reliability testing (Belcore) and cryogenic cycling tests. Comprehensive VNA test data should back up every component, since there are often signatures in the data that can be missed.

"Knowing that isolators would now perform in the mmWave bands at single-digit Kelvin temperature was good news for us because that was one less component we had to worry about," says Anferov. For Wheeler's mil-spec work, the cryogenic isolators will help ensure the reliability of Plymouth Rock's technology and products. "In harsh environments, the contaminates on the radome of the antenna can really add to the system noise figure, due to reflections (VSWR)," says Wheeler. "By integrating a cryogenic isolator in front of your low-noise receiver you will realize a reduction in the noise and increase the gain ratio."

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