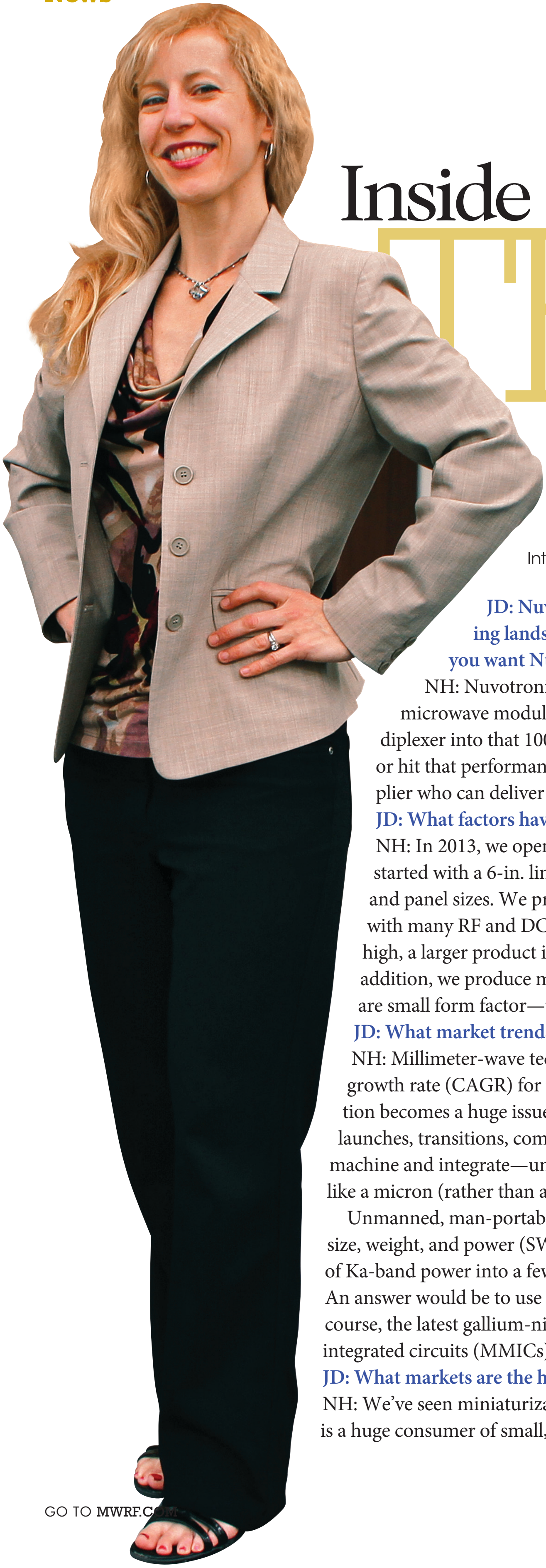

Inside TRACK with Noel Heiks, CEO OF NUVOTRONICS

Interview by JEAN-JACQUES DELISLE

JD: Nuvotronics' goals and identity have been dynamic due to the shifting landscape of grant-based work. What capabilities and technologies do you want Nuvotronics to be known for as the firm comes into its own?

NH: Nuvotronics continues to produce highly advanced 3D architectures for microwave modules and systems. We hope to be known as the ones who can fit a diplexer into that 100x smaller footprint, deliver 500+ RF feed connections in one shot, or hit that performance metric again and again without tuning. We aim to be the supplier who can deliver what no one else can from DC to beyond 300 GHz.

JD: What factors have influenced Nuvotronics' move to a larger-format process?

NH: In 2013, we opened a new facility in North Carolina with an 8-in. wafer line. (We started with a 6-in. line.) This step moved us along our roadmap toward larger wafer and panel sizes. We produce phased-array front ends and other large-format modules with many RF and DC lines currently in scales from 1 to 10 cm. As long as yield remains high, a larger product is more economical because assembly complexity is reduced. In addition, we produce many devices like filters and power modules, where—although they are small form factor—they are made more cost effective as substrate size grows.

JD: What market trends are driving the miniaturization of RF networks?

NH: Millimeter-wave technology is booming with a predicted 63% compound annual growth rate (CAGR) for the industry through 2016.[1] As frequencies go up, miniaturization becomes a huge issue for traditional microwave-system manufacturers. Waveguide launches, transitions, combiners, and antennas all become painfully small—difficult to machine and integrate—unless you have a manufacturing technology capable of tolerances like a micron (rather than a mil).

Unmanned, man-portable, and aerospace platforms also are driving miniaturization and size, weight, and power (SWaP) across all frequencies. Say a customer needs to pack 20 W of Ka-band power into a few ounces. How are they going to achieve their requirements? An answer would be to use innovations in high-density, miniaturized RF networks, and, of course, the latest gallium-nitride (GaN) and gallium-arsenide (GaAs) monolithic microwave integrated circuits (MMICs).

JD: What markets are the highest consumers of miniaturized RF networks?

NH: We've seen miniaturization already in the phones we carry every day. Communications is a huge consumer of small, sophisticated RF devices. For the military alone, communications

is projected to be a $30-billion market by 2019.[2] This demand has driven huge volumes and vast miniaturization in RF networks and will continue to do so in the coming years. In particular, we are looking forward to future volumes in millimeter-wave communications, where hundreds of thousands of millimeter-wave radios will be needed per year by 2018.[3]

JD: What benchmarks is the industry striving for in terms of size, speed, cost, yield, etc.?

NH: Cost and yield benchmarks for commercial applications are more stringent than in defense. But budget constraints in the defense sector also are pushing those targets. For some RF components, yield above 99% is expected. In contrast, more cutting-edge devices have looser constraints. (Think millimeter-wave MMIC dies and anything that uses them.) Regarding size benchmarks, we have customers that need a nearly 10x reduction in footprint, weight, or power, particularly for space applications.

JD: What is enabling miniaturized RF network technology?

NH: Competition between MMIC foundries and design firms has resulted in high-performance, multi-function ICs in dramatically reduced chip form factors. These devices are burdened by numerous RF, DC, and control interconnects in a tight pitch, where signal isolation is difficult to achieve. Novel flat antenna designs have introduced the industry to miniaturized planar beam-steering products. Yet the industry has lacked the feed and interconnect architecture to weave MMICs and planar antennas together, ideally incorporating the feeds, passives, MMIC interconnects, waveguide launches, and hundreds of isolated DC and RF lines all in a compact, low-loss footprint. Nuvotronics has developed a unique additive manufacturing technology for mixed metal-air-dielectric microfabrication to enable this 3D RF miniaturization.

JD: What new applications are being enabled by miniaturized RF networks?

NH: I mentioned millimeter-wave communications as a target application. Not only land-based, but airborne millimeter-wave SATCOM is driving miniaturization. Commercial aircraft and even unmanned drones are being targeted to carry small, lightweight terminals that will need miniaturization throughout. Look at DARPA's Mobile HotSpots program, retrofitting drones with millimeter-wave terminals to make them mobile WiFi hubs.[4] That program is a great example of the need to miniaturize the RF antenna, front end, and power amplifier.

JD: How are miniaturized RF networks helping to advance GaN MMIC technologies in terms of thermal management?

NH: Although the industry is making dramatic advances in GaN, the packaging of such solutions is often an afterthought, while it could mean everything in terms of performance and reliability. Taking a typical PolyStrata power module as an example, we incorporate the combining interconnects, and even filters, in a microfabricated all-metal 3D backplane. A low-loss architecture is provided via air-dielectric transmission lines. We are advancing our solutions toolbox further under a DARPA-funded program called ICECOOL. The goal of that program is to address thermal management for high-power MMIC die.

JD: How do these technologies address yield and reliability?

NH: Let's compare a traditional machined diplexer to a microfabricated component. With the machined part, you get something bulky (a traditional E-band diplexer is 100 times larger than Nuvotronics' version) that is handcrafted, assembled, and tuned. With a wafer-level fabrication technology, what you design is what you get. For higher-level integrated products, microfabrication techniques can still hit commercial-level yields on initial prototype builds without tuning or tweaking. The key parts of the product are simply made at the wafer level. As a result, thousands of parts can be cranked out at one time with micron-level precision and repeatability.

Reliability concerns in new technologies are dealt with the same way they have been in the past—with rigorous qualification testing. We work closely with our customers to develop qualification plans for their particular applications, with space applications being the most stringent. Unlike traditional microelectromechanical systems (MEMS), our structures are primarily made of metal that is often millimeters thick. So, they are quite robust, substrate-free structures. The structures we create are under our control not only electromagnetically, but also mechanically, starting early in the design phase.[5,6]

With any new technologies, there is going to be an initial chasm to cross. That hurdle is no different for miniaturized RF networks. However, the demand piling up in millimeter-wave, mobile, and unmanned systems drives even the most reticent of industries to embrace innovation and work with small companies like Nuvotronics. We are excited to be a part of the solution for this increasingly wireless world. mw

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