INNOVATION CROSSROADS

OAK RIDGE NATIONAL LABORATORY

INNOVATION CROSSROADS IMPACT

FLEXIBLE ELECTRONICS FOR THE INTERNET OF THINGS

Shane McMahon, Lux Semiconductors

Shane McMahon, Lux Semiconductors' co-founder and CEO and member of Innovation Crossroads Cohort 2, has developed a novel semiconductor processing technology capable of producing high performance thin-film silicon on ultra-thin metal foil.

For the past 50 years, the silicon wafer has served as the backbone of the modern electronics industry, used in over ninety percent of electronic devices. Despite the size of the modern semiconductor industry, a new major class of embedded and flexible electronics is emerging to soon eclipse the modern semiconductor market, including the Internet of Things (IoT), virtual and augmented reality, medical wearables, smart fabrics, and many more. To serve these new applications, devices will need to become more integrated, durable, and flexible, a challenge that the silicon wafer, in its current form, is unlikely to overcome.

By leveraging a half century of innovations in bulk crystal growth and applying them to low cost thin-films for the first time, Lux has developed an ultrathin, flexible version of the silicon wafer to serve as a next generation semiconductor platform.

Accomplishments

McMahon and team have successfully demonstrated the growth of highly crystalline thin film silicon on flexible metal foil substrates. Additionally, Lux has received a purchase order from one of the leading aerospace and defense companies in the United States. The customer has ordered one of Lux's product development kits, which includes a wide range of electronic components patterned directly into Lux's silicon-on-foil substrates.

The Process

Wide scale proliferation of IoT sensor nodes will require low device cost, and thus low sub-component costs for sensing elements, processing circuits, communications, and power. Since energy resources on small IoT nodes are often considerably limited, power consumption must also be minimized during sensor data collection, processing, and transmission.

Integrating all of these low cost, low power components into a single size-limited device becomes a substantial challenge using conventional semiconductor fabrication materials and processes. Research and development

LUX SEMICONDUCTORS

COHORT 2

Milestones

- Developed a flexible alternative to the silicon wafer, enabling a new class of low-cost integrated electronics
- Received first commercial purchase order from a major U.S. aerospace and defense company
- Named to the 2020 Techstars Starburst Space Accelerator
- Funding raised: $510,000

U.S. DEPARTMENT OF ENERGY

TVA

"Working alongside leading researchers in the field, and in world class facilities, will not only further advance and expand a startup's core technology, it will provide much needed credibility when engaging potential investors and customers."

Shane McMahon, Co-founder and CEO, Lux Semiconductors

conducted by Lux Semiconductors attempts to solve this problem.

"Leveraging our thin film silicon, we're able to use a novel 'System-on-Foil' approach to pattern low-power silicon circuitry directly alongside low-cost printed electronics to enable the fabrication and integration of all core IoT functional elements," McMahon said.

The Challenge

One of the larger challenges Lux has faced during the Innovation Crossroads program has been in the design of, and execution against, its technology development roadmap. Lux initially entered the program with the intent of pursuing a semiconductor material supplier business model. However, the company quickly realized the significant market opportunity in expanding downstream into electronic device fabrication.

This major shift not only required a complete redesign of the original technology development roadmap, which occurred in consultation with Oak Ridge National Laboratory (ORNL), but also greatly expanded the technology partnership network that was necessary to effectuate the change. In the span of six months, Lux forged three new partnerships with leading academic and national lab research groups equipped with the expertise and resources to develop technology that leverages Lux's core intellectual property.

The ORNL Advantage

At the onset of Innovation Crossroads, Lux was focused exclusively on advancing the technology readiness level (TRL) of its flexible silicon substrates, rated a three at the time. Nearly two years later, however, the company has added three successive technical components to the core substrate technology, including silicon-based CMOS fabrication, ink-based printed electronics, and device-level packaging. Combined, these components form Lux's System-on-Foil product offering, which has a current TRL rating of four. Equipped with a broader, more mature technology, Lux should be well positioned for follow-on government and private funding at the conclusion of the Innovation Crossroads program.

Lux has advanced both its material and device related research at ORNL in concert with expert staff, operating in state-of-the-art facilities. Through a 12- month user award at the Center for Nanophase Materials Science, Lux has progressed in all facets of material development, including the optimization of thin film semiconductor and buffer layer depositions, as well as pre and post-processed film characterization.

"By working with ORNL, we've also begun qualifying ink-based printing processes on our silicon substrates. These processes will be used to print core electronic components, including temperature and strain sensors, RF antennas, and metal interconnects," McMahon said.

Future Growth

Beyond Innovation Crossroads, Lux will continue its collaboration with ORNL for the development of its first product, a wireless temperature and strain sensor for structural health monitoring applications. To meet expected volume demands of this product, Lux expects to build a manufacturing facility within the next 36 months. Total sales generated over the first five years of production are expected top $17M. By 2030, Lux will have expanded its market position, operating as a circuit design and manufacturing partner for a suite of System-on-Foil solutions.

About Innovation Crossroads

Innovation Crossroads is a fellowship program based at Oak Ridge National Laboratory that matches aspiring energy entrepreneurs with the experts, mentors, and networks in technology-related fields to take their world-changing ideas from R&D to the marketplace.

Through an annual call, up to seven entrepreneurs will be selected to transform their ideas into energy, advanced manufacturing, and integrated grid companies with financial support from the U.S. Department of Energy's Advanced Manufacturing Office and the Tennessee Valley Authority. Innovators will receive a fellowship that includes a personal living stipend, benefits, and travel allowance for up to two years, plus substantial funding to use on collaborative research and development at ORNL.

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