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## **Salem Firm Pushing Forward with Technological Ventures**

By David Brooks

SALEM – If you were forced to describe AmberWave's job in one small sentence, this would do OK: It lines up atoms really, really well.

"When atoms don't align, it's horrific for electrical properties of any device," said Mark Carroll, AmberWave's director of operations, shaking his head at the prospect of lattice mismatch and other nano-scale disasters.

Avoiding disasters a millionth of a meter wide or smaller has been the driving idea behind AmberWave Technologies since it was founded nearly a decade ago to commercialize a method of making faster computer chips.

Despite tech-industry ups and downs, AmberWave continues its venture-capital-funded work in a nondescript industrial park on the Massachusetts border, and is even moving into other industries that depend on electrons or photons zipping quickly between mismatched compounds.

"Traditionally, we've been focused on the semiconductor chip industry . . . but our work has broad applications for other advanced materials, like LEDs and solar power," said Bryan Lord, the company's vice president for finance and licensing.

That kind of potential expansion of business built on cutting-edge work draws attention, including a visit last week from U.S. Sen. John Sununu, who came to help publicize a new partnership with University of New Hampshire. The two institutions were named recipients of the latest Granite State Technology Innovation Grant by the New Hampshire Innovation Research Center, which brings together academic and industry research to generate new business.

The grant will help support work into what is known as aspect ratio trapping, a process that should let manufacturers combine different materials onto a silicon base and create the computer-chip equivalent of fiber optics, with much faster data transmission. It could also lead to more efficient solar cells and better solid-state lighting.

"Our partnership with AmberWave represents an opportunity to apply fundamental research that originated at UNH to real problems in the semiconductor industry," said Dr. Glen Miller, a professor in the department of chemistry and materials science program at UNH, who is also associate director of the Center for High-rate Nanomanufacturing at UNH.

AmberWave has licensing arrangements with a number of other schools, including the Massachusetts Institute of Technology and Purdue University.

Success has also drawn attention to AmberWave's unusual business model, which tries to find profit in the R&D area known as the "valley of death," because it lies in the risky space between blue-sky academic research and short-term industry development.

"We do a lot of work of trying to identify promising university technologies that can be commercialized. . . . One of the causes for lack of participants in that valley of death is that it requires a lot of capital for advanced technology, research tools, more personnel, but return isn't predictable," Lord said.

AmberWave was created in 1998 by MIT professor Eugene Fitzgerald and one of his students, Mayank Bulsara, to commercialize a research discovery known as "strained silicon." In laymen's terms, it increases the distance between electrons on computer chips, producing greater processing speeds without creating additional heat. Other discoveries are designed to integrate photonics (light) on a computer chip.

(The "amber" in the company name refers to a part of the light spectrum that has particular properties when interacting with electrons.) AmberWave's research concerns the surprisingly difficult task of putting very thin films of one material onto another material, usually by growing it in crystal form, to create bonds that conduct electricity or light pulses with great precision – a situation known as epitaxy.

"You can get them to bond like paint on a wall, but not epitaxy," said Carroll.

The process is a combination of chemistry (only materials from certain columns on the periodic table are useful), physics, big-bucks engineering and potential for disaster.

AmerWave's newest machine, as an example, sends bubbles of hydrogen gas through bottles of explosive liquids, trying to make the right molecules float onto a silicon substrate.

The process also reflects the way the once-backwater field of materials science has become cutting edge as it flirts with the edge of quantum mechanics.

"You wouldn't know who is who here, because what we do overlaps each other so much. That's what I like about material science: It's a meeting of many scientific disciplines," said Carroll.

And, apparently, a meeting of many scientific obstacles.

"Folks thought commercialization (of strained silicon) was just around the corner. Turns out, it has required a lot more research and development and investment than anybody realized," said Lord.

AmberWave survived that bleak introduction to the valley of death. It now has 25 employees – down from a peak of around 40, but more than they had in the post-dotcom-bust era – many dripping with advanced degrees.

They work in and around three high-tech clean rooms as strict as ISO 10 (which means the number of minuscule particles floating in each cubic foot of air can be counted on your fingers), using equipment as advanced as a transmission electronic microscope, which has to be operated by somebody with a Ph.D.

Lord said AmberWave had has five rounds of venture capital funding totaling \$91 million. It also has income from licensing some discoveries, including payments from Intel for strained silicon that started flowing only after AmberWave sued the chip giant over patent infringement.

Lord describes the company as "approaching break-even." He acknowledges that this phrase can mean almost anything, but says that with AmberWave these days, it means what it says.

"It's certainly a phrase that we weren't able to use in times past," he admitted.

Down the road, Lord says the company wouldn't be adverse to try small production runs of chips or wafers, albeit of a limited, high-value-added (i.e., profitable) kind, although high-end research and development will continue to be the core of its business model.

In other words, life will continue in the valley of death.