

NANOBIOTECH NEWS

The global nanobiotechnology intelligence source

Volume 3

Number 11

March 16, 2005

ALD NanoSolutions readying nanocoating technology for commercialization

By Marie Powers

Privately held ALD NanoSolutions, Inc. has quietly been developing a technology based on atomic layer deposition (ALD) coating chemistry and positioning itself to provide both the technology and specific end products that incorporate the technology. With the completion of a dedicated manufacturing facility in Broomfield, CO, the company now has the capability of handling both powders and nanoscale objects, "which feeds into the rest of our business development goals," says Karen Buechler, PhD, the company's president and chief technology officer.

ALD NanoSolutions was incorporated in June 2001 by Buechler, P. Michael Masterson, now the CEO, and two University of Colorado (CU) researchers: Steven M. George, PhD, professor of chemistry, and Alan W. Weimer, PhD, professor of chemical engineering and a former research and development (R&D) executive at Dow Chemical Company (NYSE:DOW). The company's technology platform is based on ALD coating chemistry methods developed by George and Weimer for depositing ultra-thin films on particulate and polymeric surfaces. The technology was still "premature" when the firm was launched four years ago, Buechler admits, "but we wanted to start investigating some commercial applications for the broad technology platform."

While declining to cite the exact amount of capital the company has raised to date, funding has been steady. ALD NanoSolutions has signed confidential materials partnerships with several commercial customers to validate its nano-coating platform in specific markets, enabling it to defray R&D costs.

The company also has won a series of Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) grants -- five in phase I and three now in phase II. The most recent grant, for \$500,000, was issued last November by the U.S. Air Force to study ALD on particles for nanoenergetic, ferroelectric capacitor, and thermal management applications. In July 2004, the company was issued a \$470,000 STTR by the National Science Foundation (NSF) to continue its work on novel

nano-coated ferromagnetic materials.

"We now have meaningful samples that are both materials-specific and product-specific that we hope to turn into commercial partnerships," Buechler says.

ALD technology focuses on conformally encapsulating a fine particle in an ultra-thin layer of a second material to solve any number of critical materials problems, including thermal management, diffusional resistance characteristics, chemical reaction characteristics, surface property mismatches, structural integrity, and electrical properties.

For instance, a simple metal iron particle with a diameter of one micron contains roughly 40 billion atoms, Buechler explains. The outer surface of a particle of this size exposes roughly 60 million atoms, representing only .15% of the entire particle. If the particle size is reduced by a factor of 100 to 10 nm, however, 15% of the particle's atoms are located at the surface.

For any given weight of metal particles, there is an enormous difference in reactivity between those measuring one micron and those measuring 10 nm in diameter, leading to a completely different set of interactions, reactions, and properties from the exact same material, she points out. Particle-ALD technology takes advantage of this order of magnitude increase in relative surface area by controlling surface chemistry at the nanoscale, allowing conformal, pin-hole-free films that are controlled to within a few angstroms of thickness to be chemically bonded to individual primary substrate particle surfaces.

Applications for drug delivery, devices

"By placing a nanothick protective film such as alumina or silica onto the surface of primary nano-sized cobalt and iron particles, it's possible to maintain the strong magnetic moments of these particles, which would otherwise be lost during surface oxidation," Buechler says. Such materials could have significant applications in medical diagnostics, defense, and drug delivery industries, including the development of coated iron nanoparticles as contrast agents for imaging diagnostics.

The company's second fundamental technology is the deposition of inorganic film on polymers using the ALD technique. The process, which involves pre-mixing the inorganic material into the polymer, has applications in nanofluidics and other devices. Last July, the company received a \$750,000 phase II STTR grant from the U.S. Department of Energy to advance this work.

"SBIRs and STTRs require a commercial partner, so each grant has been hard-wired to a particular market," Masterson explains. "We identify a need, reach out to a commercial entity, develop appropriate materials, then move ahead with testing and validation." To date, the company has successfully demonstrated the application of ALD on nanoparticles on metal, ceramic, and polymer substrates in microelectronics, defense, biomedical, consumer products, advanced materials, and other applications.

"The gate to future applications is through the ability to innovate at the surface level, where particles interact with the surrounding environment," Masterson says. "Particle-ALD serves as an enabling technology, potentially providing for the control of ultrafine particle chemical, electrical, optical, magnetic, physical, and other surface properties. We are looking at compelling ALD applications with commercialization potential that can be realized during the next three to five years."

Intellectual property (IP) developed by the CU professors and validated in their labs forms the foundation of the company's processes.¹ ALD NanoSolutions has an exclusive licensing arrangement from CU on broad-based process and composition of matter patent claims for ALD on particles and the first right of refusal on any improvements related to the technology that are developed at CU, including a number of pending patents.² All told, the company holds exclusive rights to practice and license technology based on approximately 100 related claims.

"We came out of the gate with actual granted patents," Buechler points out. "The first covers the deposition of nanothick films on submicron-size particles, which is an incredibly broad statement. The most elemental level is the particle. If you can control and functionalize the particle, you can control and functionalize materials that we see every day."

ALD NanoSolutions' most recent accomplishment is the opening last month of its R&D facility in Broomfield, CO.

"Particle-handling powders have been in wide use for many years," Buechler says. "ALD deposition does not require any special equipment -- just stock parts that are used in a particular way and are quite economical to set up." The coating technology can be performed at or slightly above room temperature, she adds, and no clean-room facilities are needed.

Opening the facility gives the company the ability to produce both powders and objects cost-efficiently, even though they have different handling characteristics. Two systems in the plant -- including one fluidized bed reactor with the capability of pro-

viding kilogram batches of ALD -- will be ready to provide commercial-grade samples by next month, according to Buechler.

"Coated iron nanoparticles are difficult to produce," she points out. "We have one method that works well, but we're looking to develop others and to have our ALD coating system as one of the products. Production, itself, is not our ultimate intention."

Instead, ALD NanoSolutions is looking to "move up the value chain" by identifying industries with small volume, high margins, and expertise in specificity, Masterson points out.

Aiming for contrast agents, fluidics

"Life sciences -- if you can succeed -- is perfect, so that is a tremendous opportunity for the company, even with the inherent regulatory and infrastructure hurdles," he says. Because ALD NanoSolutions is "opportunistic," the company first is seeking to pluck some of the lowest-hanging fruit in nanobiotech, such as contrast agents and fluidics. While other companies have staked a narrow claim in these markets, "we're looking to create a franchise within life sciences," Masterson says.

While the company pursues a stake in nanobiotechnology over the next three years, it plans to exploit its ALD technology in other markets where it has identified "quick commercialization strategies as opposed to getting a molecule to market," he says. Most of the company's existing customers are at the proof of principle stage of development, "so we had to improve our infrastructure to meet demand," he says.

Long term, the company's commercialization strategy includes the potential for an IPO or acquisition by a company with interest in multiple materials markets. For the time being, ALD NanoSolutions is seeking to convert customers from one-shot R&D deals to sustained relationships.

"We're looking to gain three more collaborations, and we have the technology, expertise, management, and financing to do that," Masterson says. "We would like to raise more money from a strategic partner, but we're not looking to go the venture route. This not just a technology looking for a home."

Editor's Note: Contact Karen Buechler at (303) 318-4145 or Michael Masterson at (617) 218-1614.

References

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