Argonne NATIONAL LABORATORY

News Release

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For immediate release

DARPA funds Argonne-led project to develop technology for advanced radar, communications systems

ARGONNE, Ill. (June 23, 2008) – The Defense Advanced Research Projects Agency (DARPA) is providing $1.4 million to a Phase III research project led by the U.S. Department of Energy's (DOE) Argonne National Laboratory to develop high-performance integrated diamond microelectro-mechanical system (MEMS) and complementary metal-oxide-semiconductor devices (CMOS) for radar and mobile communications using an Argonne-developed and patented Ultrananocrystalline Diamond (UNCD^{TM}) film technology.

Argonne's program partners are Advanced Diamond Technologies, Inc. (ADT), Innovative Micro Technology (IMT), MEMtronics Corp., Peregrine Semiconductor, the University of Pennsylvania and Lehigh University.

The project's principal investigator and project manager is Derrick Mancini, associate division director for facilities and technology at the Center for Nanoscale Materials (CNM) at Argonne. The project's technical leader is Orlando Auciello, a senior scientist in Argonne's Materials Science Division and the CNM, and Anirudha Sumant, an assistant materials scientist in the CNM, is a major contributor to the Argonne's part of the program.

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DARPA, a U.S. Department of Defense organization that supports high-risk, transformational research, is interested in the development of advanced phased-array radar and communication systems for military and commercial applications. The integration of capacitive radio frequency (RF) MEMS and CMOS devices will enable rapid electronic steering of radar beams to substantially improve radar speed and precision. Monolithic RF MEMS/CMOS device integration will also greatly improve the multifunction performance of state-of-the-art wireless devices.

RF MEMS devices like resonators (tiny diving board-like structures at very high frequencies) and switches (tiny membranes that establish or disconnect electrical pathways) may substantially improve the functionality and performance of RF and microwave systems.

"The UNCD film technology," Auciello said, "has the potential to improve the reliability of MEMS switches because of unique combination of properties such as resistance to adhesion between two surfaces in physical contact that can lead to premature switch failure, and because of demonstrated tunability of dielectric properties and leakage current. In addition, UNCD film exhibits the highest Young's modulus – the measure of a material's stiffness under stress – of any material being investigate for MEMS resonators, and is currently the only technology that can produce diamond films at temperatures less than or equal to 400 degrees Celsius. Both characteristics provide critical parameters for producing resonators for very high frequency operations and the integration of diamond MEMS with advanced microelectronics, respectively."

In the DARPA Phase II program, the Argonne-led team achieved several key goals:

- materials integration and processes to fabricate UNCD-based resonators;
- integration of UNCD films with CMOS devices;
- demonstration of UNCD dielectric properties suitable for application as low-charge/low-force of adhesion dielectric layer for RF capacitive MEMS switches; and

- demonstration of UNCD-dielectric-based RF MEMS switches that surpassed one-billion switching cycles with low (approximately 0.17-decibel) insertion losses at about 10 gigahertz.

Argonne is the world leader in the fundamental and applied science of UNCD film technology and works jointly with academia and industry to develop new UNCD-based MEMS and other hybrid technologies, including the integration of oxide piezoelectric and UNCD films that produced the lowest power piezoelectrically-actuated UNCD resonators and nanoswitches demonstrated today. The CNM currently has the world's only microwave plasma chemical vapor deposition system for growing UNCD films at less or equal to 400 degrees Celsius on up to 200-millimeter wafers, located in a clean room environment for nanoelectro-mechanical systems fabrication. The CNM provides the main expertise and infrastructure at Argonne critical for the success of the DARPA Phase III program. UNCD is prized for its exceptionally small grain size of 5 nanometers, which is thousands of times smaller than grains in traditional microcrystalline diamond films.

Argonne's five research partners each bring specific interdisciplinary expertise and capabilities that are critical to the success of the DARPA Phase III program.

- **Advanced Diamond Technologies**, a Romeoville, Ill.-based Argonne spin-off company that commercializes UNCD, is the world leader in the development and application of diamond films for industrial, electronic and medical applications. ADT provides diamond film and materials integration solutions to a variety of industry participants in diverse application areas. ADT has developed a low-temperature process for producing UNCD films and a number of wafer-scale products suitable for integration of UNCD with other materials for MEMS applications, including diamond-on-silicon and diamond-on-insulator wafers up to 200 millimeters in size with unprecedented property uniformity.

Advanced radar technology – add three

- **Innovative Micro Technology** manufactures MEMS devices, and its overriding goal is to partner with companies to develop products based on MEMS technology. IMT has the largest and best-equipped MEMS foundry facility in the world providing full services from MEMS design to high-volume manufacturing of MEMS devices, including drug delivery, biomedical implants, microfluidics, inertial navigation, sensors, telephone/digital subscriber line switching and RF devices (critical to the DARPA Phase III), among many other devices. IMT will fabricate the RE MEMS switches for the DARPA Phase III program.
- **MEMtronics** of Plano, Texas, is a privately held company focused on the development and maturation of RF MEMS switching technology. This technology is being incorporated into phase shifter and tunable filter products targeted at a variety of military and commercial wireless and radar applications. MEMtronics has designed and demonstrated some of the most advanced RF MEMS switches to date—a critical component.
- **Peregrine Semiconductor** is a global leader of high-performance RF CMOS devices. Peregrine's patented UltraCMOS™ process technology — enabled by silicon on sapphire substrates — drives unprecedented levels of monolithic integration throughout a broad portfolio of mixed-signal RF ICs. The UltraCMOS process technology will drive the UNCD-based RF MEMS switches designed by MEMtronics and fabricated by IMT in the Phase III program.
- **University of Pennsylvania** Professor Robert W. Carpick leads a group that conducts world-class research on tribology and mechanical properties of materials using novel atomic-force microscopy and surface science tools. The university group will provide unique expertise and tools to characterize the tribological and mechanical performance of UNCD-based MEMS.

About Argonne

Argonne National Laboratory brings the world's brightest scientists and engineers together to find exciting and creative new solutions to pressing national problems in science and technology. The nation's first national laboratory, Argonne conducts leading-edge basic and applied scientific research in virtually every scientific discipline. Argonne researchers work closely with researchers from hundreds of companies, universities and federal, state and municipal agencies to help them solve their specific problems, advance America's scientific leadership and prepare the nation for a better future. With employees from more than 60 nations, Argonne is managed by UChicago Argonne, LLC for the U.S. Department of Energy's Office of Science.

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