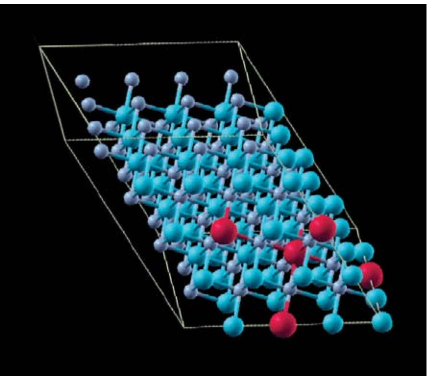
Spintronics adds new dimension to semiconductor development



above: The computer visualization depicts the atomic structure of the rock-salt structure semiconductor scandium nitride, doped with 8 percent manganese. The manganese is shown in red, scandium in light blue and nitrogen in silver.

Spintronics – short for spin-based electronics – may soon provide tinier, faster and more robust components for small electronic devices and computers. The spintronics approach stores electronic data through magnetic properties caused by the spinning of electrons, in addition to the fundamental electrical charge of electrons that is used by more conventional computers. The spin charge is assigned a value of "up" or "down" and, like the electrical charge, can be encoded with binary data.

"In semiconductors, one can possibly have far more detailed control over both the number of active electrons and their spin orientation in a device," said Walter Lambrecht, Ph.D., professor of physics at Case Western Reserve University. "The problem is to find magnetic semiconductors that retain these distinct magnetic properties above room temperature."

These specialized semiconductors are created through a process called doping: manufacturing into the semiconductor small amounts of transition metals or rare-earth elements, which possess distinctive electronic properties. While most work in this field requires a small percentage of the dopant, gadolinium-doped gallium nitride has been found during experiments to exhibit the desired magnetic properties even for part-per-million levels.

"We are accessing the computational resources of the Ohio Supercomputer Center to perform calculations of various possible irregularities in the atomic arrangement and studying their interaction with gadolinium in gallium-nitride to unravel the origin of this mysterious source of magnetism," said Dr. Lambrecht. ■

Project lead: Walter L. Lambrecht, Ph.D., Case Western Reserve University
Research title: Muffin-tin orbital based first-principles calculations
Funding sources: Office of Naval Research & the Army Research Office

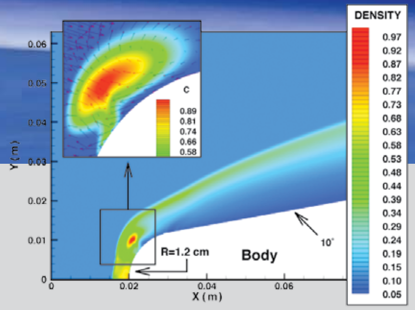


illustration courtesy of NASA

Ablation model measures hypersonic gas plumes

Scientists are developing hypersonic aircraft that can travel at speeds beyond Mach 5 (3,800 mph) and travel from New York to London in less than an hour. In military applications, flight above Mach 8 will be needed for effective homeland security.

Several technical obstacles remain, however. At hypersonic speeds, shock waves created by the compression of air in front of the aircraft increase in strength and number. The aircraft body experiences turbulence, and the air becomes a swarming jumble of hot gases, which transfers heat to the aircraft.

Engineers have addressed the problem by constructing thermal protective shields that slowly burn away — a process called ablation — creating gases that carry heat away from the aircraft and leaving behind a solid material that insulates the craft.

"Extensive research has been conducted that predicts the ablation rates of thermal protective shields due to hypersonic flow," said Alex Povitsky, Ph.D., an associate professor of mechanical engineering at The University of Akron.

"The interaction of small-scale, but high-intensity, plumes can significantly affect the heat transfer between hypersonic gas and the shield. However, the majority of studies based on heating tests or flight test data don't take into account the effects of gas plumes."

Through access to the IBM Cluster 1350 at the Ohio Supercomputer Center, Dr. Povitsky, Dr. Kedar Pathak and graduate assistant Nathan Mullenix are developing a computational methodology for simulating the ablation of carbon shields, complete with local and multiple ablation plumes and subsequent multiple plumes. ■

Project lead: Alex Povitsky, Ph.D., The University of Akron
Research title: Modeling of ablation in hypersonic flight
Funding sources: Dayton Area Graduate Studies Institute, Air Force Office of Scientific Research & Air Force Research Laboratory