Joint ECE/Physics Colloquium

Title: New Materials for Spintronics

Speaker: William H. Butler

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Thursday September 10, 3:30-4:20 PM, Room: Van Allen 301

Abstract: The young field of spintronics aims to utilize the electron's spin to add functionality to electronic devices. Spintronics began in 1988 with the discovery of Giant Magnetoresistance (GMR) in which the electrical resistance of a magnetic multilayer depends on the relative direction of the magnetic moments in neighboring ferromagnetic layers. GMR was utilized soon afterwards to increase the sensitivity of the read sensors in magnetic hard drives allowing 100% increases in the density of magnetic information storage for several years during the 1990's. In 2001 we predicted that a giant tunneling magnetoresistance could be achieved through a Symmetry based Spin Filtering effect (SSF). This prediction was realized experimentally in 2004. By 2007 all hard drive readers used the SSF approach and the materials set we suggested. In 1996 John Slonczewski and Luc Berger predicted the phenomenon of Spin-Torque Transfer in which spin-polarized currents can affect the relative orientation of the magnetic moments of magnetic multilayers. It has been proposed to combine the SSF effect with the spin-torque transfer effect to make a new kind of solid state memory called STT-RAM (Spin-Torque Transfer Random Access Memory). STT-RAM would be non-volatile like flash memory, but write times would be much faster and endurance would be unlimited. In principle densities could be similar to flash, but initial products are unlikely to compete with flash in density or cost per bit. In this talk, I will introduce spintronics, explain giant magnetoresistance, tunneling magnetoresistance, the symmetry-based spin filter effect and the spin-torque transfer effect. I will discuss how electronic structure theory can be used to design new materials and materials combinations with novel spintronic properties. These effects and materials will be discussed in the context of current and possible future spintronic devices.

Bio: William H. Butler was appointed as the Director of the MINT Center in August 2001 and is a Professor of Physics in the Department of Physics and Astronomy. He also serves as director of the NSF-sponsored Materials Research Science and Engineering Center. He received a BS degree (with Highest Honor) in Physics from Auburn University in 1960 and a Ph.D. in physics in 1969 from the University of California San Diego where he studied under Nobelist Walter Kohn. From 1969 until 1972 he was Assistant Professor of Physics at Auburn University. He joined the Metals and Ceramics Division of Oak Ridge National Laboratory in 1972. He was leader of the Theory Group in the Metals and Ceramics Division of ORNL from 1984-2001. He has received DOE Awards for Outstanding Scientific Achievement and for Outstanding Sustained Research. He was the first recipient of the National Institute of Materials Science Award for Breakthroughs in Materials Science. He has authored more than 170 scholarly papers and is co-author of one book. He is member of the American Physical Society, the IEEE, the Materials Research Society, the American Association for the Advancement of Science. He is a fellow of the American Physical Society. He served as Meeting Chair for the Spring 1990 Meeting of the MRS and as Chair (2009) and Program Chair (2008) for the American Physical Society Topical Group on Magnetism and its Applications.

Dr. Butler's current research interests include: physics of magnetic materials, spin-dependent transport in magnetic multilayers and nanostructures, electronic structure of magnetic oxides and chalcogenides, domain wall switched graded media, electronic structure of half-metals, and precessional damping in magnetic materials.