Physics Colloquium

Michigan Technological University

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Layer-Dependent Electronic and Physical Structure of 2D materials

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Abstract

Because of their weak Van der Waals interlayer bonding, certain unconventional semiconductors can be fabricated into atomically thin two-dimensional (2D) crystals. The most studied of these materials has been graphene. In addition, other materials such as transition-metal dichalcogenide (TMDC) with substantial ~ 1-2 eV bandgaps have been explored. One example of this family, monolayer MoS2 consists of a single layer of Mo atoms sandwiched between two layers of S atoms in a trigonal prismatic structure. The TMDC 2D system has attracted great interest because of its distinctive electronic and optical properties, such as a transition from indirect-to-direct band gap in going from the multilayer to monolayer crystal. In addition, a strong spinorbit-coupling-induced split valence bands, due to broken inversion symmetry makes TMDCs interesting for spin-physics physics and devices. In this talk, we describe direct observations of the thickness-dependent electronic-band and crystal structure of these 2D materials. These measurements rely on the use of micrometer-scale, angle-resolved photo-emission spectroscopy (micro-ARPES) and diffraction studies. Our results show an evolution in band structure, which is consistent with an indirect-to-direct bandgap transition in going from few-layer to monolayer TMDC and can be attributed to changes in quantum confinement as the number of layer decreases. In addition, our microARPES and, subsequently, higher resolution nanospectroscopy data provide clear measurements of the hole effective mass, the strain present in the monolayer crystal films, and the valence-band spin-orbit splitting.

BIO

Richard Osgood is Higgins Professor of Electrical Engineering and Applied Physics at Columbia University. He is the inventor of many lasers and microsystem processing methods; and has discovered many new physics and phenomena in chemistry and surface physics, generally connected with light interactions with matter. His research on Optical Devices and Science focuses on the development of next-generation optical devices, their applications, and their basic physics. Professor Osgood served as an associate director of Brookhaven National Laboratory from 2000 to 2002 and its acting Nanocenter Director, 2002. He is a member of the OSA, AVS, ACS, APS, and MRS, and a fellow of the IEEE, OSA, and the APS. He has also served on the DARPA Defense Sciences Research Council and its governing board, the Los Alamos National Laboratory Visiting Advisory Board (Chemical Sciences and Technology Division), and the Brookhaven National Laboratory Science Committee (Vice Chair). Professor Osgood has also served as councilor of the Materials Research Society, as a member of the DOE Basic Energy Sciences Advisory Committee, and chaired the Visiting Committee for all US BES Facilities in 2007. In 1991, Dr. Osgood received the R. W. Wood Award from the Optical Society of America.

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