Topological materials for low-energy electronics

By

Prof Michael S. Fuhrer

ARC Centre of Excellence in Future Low-Energy Electronics Technologies, Monash University, Victoria 3800, Australia
Monash Centre for Atomically Thin Materials, Monash University, Victoria 3800, Australia
School of Physics & Astronomy, Monash University, Victoria 3800, Australia

Date: 26 June 2019, Wednesday
Time: 11.10 am – 12 pm
Venue: SPMS – LT5 (SPMS-03-08)
Host: Prof Xiong Qihua/ Asst Prof Bent Weber

Abstract

During the information technology (IT) revolution global capacity to compute information has grown at an astounding 60-70% per year, enabled by enormous gains in energy efficiency due to Moore’s Law advances in silicon technology. However Moore’s Law is ending, and the sustainable future of the IT revolution is uncertain. A new computing technology is needed with vastly lower energy consumed per operation than silicon CMOS. The recent discovery of topological phases of matter offers a new route to low-energy switches based on the conventional-to-topological quantum phase transition (QPT), a “topological transistor” in which an electric field tunes a material from a conventional insulator “off” state to a topological insulator “on” state, in which topologically protected edge modes carry dissipationless current. I will discuss our work on atomically thin films of Na₃Bi (a topological Dirac semimetal) as a platform for a topological transistor. We study thin films of Na₃Bi grown in ultra-high vacuum by molecular beam epitaxy[1], characterized with electronic transport, scanning tunneling microscopy (STM), and angle-resolved photoemission spectroscopy. When thinned to a few atomic layers Na₃Bi is a large gap (>300 meV) 2D topological insulator with topologically protected edge modes observable in STM. Electric field applied perpendicular to the Na₃Bi film, by potassium doping or by proximity of an STM tip, closes the bandgap completely and reopens it as a conventional insulator. Ultra-thin Na₃Bi on sapphire can be probed by transport experiments, which show topological edge conduction as seen in non-local electronic transport and a giant negative magnetoresistance due to suppression of spin-flip scattering. The large bandgap of 2D Na₃Bi, significantly greater than room temperature, and its compatibility with silicon, make it a promising platform for topological transistors.

Short Biography

Michael S. Fuhrer received his B.S. in Physics from the University of Texas at Austin in 1990, and Ph. D. in Physics from the University of California at Berkeley in 1998. After a postdoctoral appointment at Lawrence Berkeley National Laboratory, Fuhrer joined the faculty at the University of Maryland as an Assistant Professor in 2000, and from 2009-2012 was Professor, and Director of the Center for Nanophysics and Advanced Materials. In 2012 Fuhrer was awarded an ARC Laureate Fellowship, and moved to Monash University as Professor of Physics in 2013. Fuhrer founded the Monash Centre for Atomically Thin Materials, and directs the ARC Centre of Excellence in Future Low-Energy Electronics Technologies. Fuhrer's current research interests lie in understanding the electronic properties of atomically-thin materials (such as graphene and transition-metal chalcogenides), and topological materials. Fuhrer is a Fellow of the American Physical Society and the American Association for the Advancement of Science.

SCHOOL OF PHYSICAL AND MATHEMATICAL SCIENCES
DIVISION OF PHYSICS AND APPLIED PHYSICS
SPMS-PAP-02-01, 21 NANYANG LINK, SINGAPORE 637371
Tel: (65) 6316 2962     Fax: (65) 6795 7981