Probing size-dependent light-matter interactions and structural phase change properties with nanowires

By
Prof. Ritesh Agarwal
University of Pennsylvania

Date: 19 December 2012, Wednesday
Time: 11.00am to 12.00pm
Venue: Hilbert Space (SPMS-PAP-02-02)
Host: Asst. Prof. Xiong Qihua

Abstract
Semiconductor nanowires offer a unique approach for the bottom up assembly of electronic and photonic devices with the potential of integrating different technologies on a common platform. The one-dimensional geometry allows efficient transport of charged carriers, photons and phonons in a highly directed manner. In addition, the anisotropic geometry and mesoscopic length scales of nanowires also makes them very interesting systems to study a variety of size-dependent phenomena. We will discuss the intriguing size-dependent properties of one-dimensional semiconductor nanowires at the 20-200 nm length scales. At these length-scales not only finite-size effects become important, but also other length-scales such as visible optical wavelengths, strain fields, interfacial, and polarization scales become comparable to the size of the nanostructures. Proper understanding of these phenomena and the effect of different length scales on nanowire properties becomes important, which is also required to rationally design functional devices with tunable and precisely controlled responses.

We will discuss different examples: size-dependent interaction of light within nanowire optical cavities and their very unique waveguiding and slow-light propagation properties; nanowires integrated with plasmonic nanocavities allows precise control over their excited state lifetimes, which can be shortened by more than three orders of magnitude to sub-picoseconds due to strong confinement of the optical fields based on the surface plasmon whispering gallery modes; size-dependent electrical properties that lead to structural phase change phenomena, which are very important for new types of nonvolatile memory devices. None of these phenomena exists in bulk systems or in extremely small systems with sub-10 nm sizes. Our recent efforts to observe the crystalline to amorphous phase change in “real time” via in situ electron microscopy techniques will be discussed, which allows unprecedented insights into the critical events that lead to structural phase transformations. The unique aspects of each size-dependent phenomenon in nanowires will be explained with the help of simple models. The implications of these findings for assembling novel and reconfigurable electronic and photonic devices will be discussed.

Short Biography
Ritesh Agarwal earned his undergraduate degree from the Indian Institute of Technology, Kanpur in 1996, and a master’s degree in chemistry from the University of Chicago. He received his PhD in physical chemistry from the University of California at Berkeley in 2001. After completing his PhD, Ritesh was a postdoctoral fellow at Harvard where he studied the optical and photonic properties of semiconductor nanowires. Ritesh is currently an Associate Professor in the Department of Materials Science and Engineering at the University of Pennsylvania. His research interests include structural, chemical, optical and electronic properties of nanoscale structures. Ritesh is the recipient of the NSF CAREER award in 2007 and the NIH Director’s New Innovator Award in 2010.

College of Science
Nanyang Technological University
SPMS-04-01, 21 Nanyang link, Singapore 637371
Fax: +65 6515 8229 Tel: +65 6513 8459