Northwestern Engineering

2011 Dow Lecture

Department of Materials Science and Engineering

Nanogenerator for Self-Powering Nanosystems and Piezotronics for Microelectromechanical Systems

Presented by

Zhong Lin Wang

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Lecture 4 p.m.

Technological Institute, L211, 2145 Sheridan Road, Evanston

Reception to follow at 5:15 p.m. in the Cook Hall atrium

Robert R. McCormick School of
Engineering and Applied Science

Nanogenerator for Self-Powering Nanosystems and Piezotronics for Microelectromechanical Systems

Wireless devices that are self-powered and do not use batteries are highly desirable. Developing wireless nanodevices and nanosystems is of critical importance for medical science, environmental/infrastructure monitoring, defense technology, and even personal electronics. This is a new initiative in today's research into sustainable self-sufficient power sources for micro/nano energy systems. It is essential to explore innovative nanotechnologies for converting environmentally available mechanical, vibration, and hydraulic energy into electric energy for use in powering nanodevices. Our laboratory has invented an innovative approach for converting nanoscale mechanical energy into electric energy by piezoelectric zinc oxide nanowire arrays. The operation mechanism of the nanogenerator relies on the piezoelectric potential created by an external strain; a dynamic straining of the nanowire results in a transient flow of the electrons in the external load due to the driving force of the piezopotential. We have developed the nanogenerator from fundamental science to engineering integration and technological scale-up. As of today, a gentle straining can output one to three volts from an integrated nanogenerator, allowing us to demonstrate a self-powered nanosensor and to light a commercial LED. A key step for developing a totally nanowire-based nanosystem has been taken.

Alternatively, by substituting the gate voltage in a field-effect transistor with the piezopotential created by an external strain, we have fabricated a series of devices that rely on a coupling between a semiconductor and piezoelectric properties and are controlled/tuned by externally applied force/pressure, such as diode, strain sensor, and strain-gated logic units (a new field called piezotronics). A three-way coupling among piezoelectricity, semiconductor, and photonic excitation has demonstrated the piezo-phototronic effect.

Zhong Lin Wang

Zhong Lin (ZL) Wang is the Hightower Chair in Materials Science and Engineering, Regents' Professor, Engineering Distinguished Professor, and director of the Center for Nanostructure Characterization at Georgia Institute of Technology in Atlanta. Among the world's top five most-cited authors in nanotechnology and materials science, Wang has made original, profound contributions to the synthesis, discovery, characterization, and understanding of fundamental physical properties of oxide nanobelts and nanowires, as well as to applications of nanowires in energy sciences, electronics, optoelectronics, and biological science. He invented and pioneered the in situ technique for measuring the mechanical and electrical properties of a single nanotube/nanowire inside a transmission electron microscope. His breakthroughs in developing nanogenerators established the principle and the technological road map for harvesting mechanical energy from environmental and biological systems for powering personal electronics.

Wang is a foreign member of the Chinese Academy of Sciences, member of the European Academy of Sciences, and fellow of the American Physical Society, the American Association for the Advancement of Science, the Microscopy Society of America, and the Materials Research Society. He has received the S. T. Li Prize for Outstanding Contribution in Nanoscience and Nanotechnology, the Burton Medal from the Microscopy Society of America, and the Purdy Award from the American Ceramic Society.

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