

# Nanostructures and the control of thermal conductivity

## GUEST SPEAKER

### **Prof David Cahill**

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University of Illinois at Urbana-Champaign

When: **7<sup>th</sup> July 2010, 3.00 p.m. to 4.00 p.m.**

Where: **Institute of Microelectronics, Singapore**  
11 Science Park Road Singapore Science Park II Singapore 117685

## **Abstract**

In recent years, the thermal properties of nano-structured materials have been intensely studied by materials scientists, engineers, physicists, and chemists with the hope of providing improved materials for thermal management and for the conversion of heat to electrical power. I will discuss three examples of this research: i) carbon nanotube nanocomposites; ii) “nanodots” superlattices of PbTe thermoelectric; and iii) ultra low thermal conductivity in disordered layered crystals.

Carbon nanotubes can have extremely high thermal conductivity, as high as diamond, due to their high sound velocities and relative lack of processes that scatter phonons. Unfortunately, these superlative properties of nanotubes have not found immediate application because of difficulties in making good thermal contact with nanotubes, i.e., the thermal conductance of interfaces with nanotubes is very small.

Efforts aimed at improving the efficiency of thermoelectric energy conversion materials often involve the introduction of some kind of nanostructure to reduce the thermal conductivity of the lattice. Nanostructures are intended to scatter the long-wavelength acoustic phonons that carry a significant fraction of heat in semiconductor alloys. In contradiction with previous reports, our work shows that the lattice thermal conductivity of PbTe/PbSe nanodot superlattices does not fall significantly below 1 W/m-K and therefore the figure of merit of these materials is  $ZT < 1$ .

At the low end of the thermal conductivity spectrum, solids that combine order and disorder in the random stacking of two-dimensional crystalline sheets, so-called “disordered layered crystals” such as  $WSe_2$  display the lowest thermal conductivity ever observed in a fully dense material: the thermal conductivity is only a factor of 2 larger than air. The cause of this low thermal conductivity may be explained by the large anisotropy in elastic constants that suppress the density of phonon modes that propagate along the soft direction.

## **Speaker Biography**



Prof. David Cahill joined the faculty of the University of Illinois at Urbana-Champaign in 1991 after earning his Ph.D. in condensed matter physics from Cornell University in 1989, and working as a postdoctoral research associate at the IBM Watson Research Center. His research program currently focuses on developing a microscopic understanding of thermal transport at the nanoscale; the development of new methods of materials processing and analysis using ultrafast optical techniques; and advancing fundamental understanding of interfaces between materials and water. Professor Cahill has co-authored >170 peer-reviewed publications, and has presented more than 120 invited talks. He received the Peter Mark Memorial Award from the AVS; is a fellow of the AVS and the APS; and was named Willett Professor of Engineering in 2005.

## Registration

Pre-registration is required. Closing date is 5<sup>th</sup> July 2010. To register, please log on:  
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## Location Map

