

**Micro/Nano Seminar Series**  
**Sponsored by**  
**U of L Electrical and Computer Engineering Dept.**

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2:00—3:00 pm  
Belknap Research Bldg., Room 139

## Accurately Measuring the Vibrations of Nanotubes and Nanowires

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Our decade long effort to accurately measure the flexural vibrations of nanowires will be summarized. After numerous false starts and dead-ends, I will show how a scanning laser Doppler vibrometer (LDV) can be used to accurately and non-destructively measure the thermal oscillation vibration spectrum of a single multi-walled carbon nanotube (MWNT). Mie scattering calculations suggest the LDV technique can be used to study the vibrations of MWNTs with diameters approaching 50 nm. Measurements of the resonant frequencies from the oscillation spectrum, combined with the dimensions of the MWNT obtained from parallel SEM studies, provide accurate estimates for Young's modulus,  $E$ . For plasma-enhanced chemical vapor deposition (PECVD) MWNTs, we find a wide range of moduli with an average value of  $E = 40.1$  GPa and a standard deviation of 31.8 GPa,[1] considerably less than the 1 TPa values often quoted in the literature. Since the techniques developed are completely general, it is now possible to determine accurately the flexural vibration spectrum from a wide variety of different nanowires. As an example, the new results obtained from  $\text{Ag}_2\text{Ga}$  nanoneedles[2] will also be discussed. The  $\text{Ag}_2\text{Ga}$  nanoneedles are of a sufficiently high quality that the 8<sup>th</sup> flexure vibrational mode has been observed.

[1]. L. Biedermann *et al.*, Nanotechnology (in press).

[2]. M.M. Yazdanpanah, *et al.*, J. Appl. Phys. **98**, 073510 (2005).



Ronald Reifenberger is a Professor in the Department of Physics, Purdue University. He obtained his M.S. and Ph.D. degrees in Physics from the University of Chicago. His research interests span a number of topics that include electron transport, field emission, nanoscale metallic clusters, and scanning probe microscopy.

Reifenberger has been a co-organizer of the European *Trends in Nanotechnology* Conference since its inception in 2000 and is on the Editorial Board of the *Journal of Nanoscience and Nanotechnology*. He has served as a committee member on the “APEC Foresight Committee on Nanotechnology, the Technology for the 21<sup>st</sup> Century”. He received the distinguished Physics alumnus award from his *alma mater*, John Carroll University in Cleveland OH. Between 2000 and 2005, Reifenberger was actively engaged with the design of the nanometrology wing in the Birck Nanotechnology Center at Purdue University.