DEPARTMENT OF MECHANICAL ENGINEERING
Purdue School of Engineering and Technology

SPRING 2005 SEMINAR SERIES

Date: **Wednesday, March 30, 2005**
Time: 10:45 am - 11:45 am
Room: **SL 165**

Everyone is invited

Nanoscale Ultrafast Dynamics in Laser Solid Materials Interaction

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Abstract. Micro-/nano-scale laser materials processing is currently the subject of intense development due to rapid progress in the information technology, microrobotics, medical, and MEMS industries. A femtosecond (10-15 s) laser represents a unique tool for such industries because of its high versatility, reproducibility, and precision. However, the identification of optimum processing parameters has historically relied on empirical experimentation rather than well understood fundamental physical principles. This is because existing classical theories fail to describe the process dynamics occurring under the ultrahigh (1013 – 1018 W/cm2) laser power intensities developed by these lasers at the femtosecond time scale and nanometer length scale. Fundamental studies to understand the governing laws are required to identify and control key process parameters for the laser micro-/nano-scale fabrication.

After a brief introduction on the background of this interdisciplinary area and related research, this presentation will focus on our proposed quantum models for photon-electron-phonon interactions in femtosecond laser materials interaction. The well-known two-temperature model has been successfully extended for ultrashort laser heating by using full-run quantum treatments to calculate significantly varying properties, including the electron heat capacity, electron relaxation time, electron conductivity, plasma reflectivity, and absorption coefficient.

The proposed two-temperature model is beyond the low temperature limit of the existing model and effectively extends the applicable range of the model to high laser fluencies. Also, a new plasma model with quantum treatments has been developed to study the femtosecond laser ablation of dielectrics by using the Fokker-Planck equation for electron density distribution. The proposed plasma model greatly increases the accuracy of ablation depth prediction and for the first time can predict the crater shape. The predicted ablation depth and threshold fluence compare favorably with available experimental data. Shortly after the publication of our results in this area, the prediction of unexpected phenomena, such as the flat-bottom crater, was validated by several other groups.