FEMTOSECOND LASER SPECTROSCOPY STUDY OF ACOUSTIC/THERMAL TRANSPORT IN NANOSCALE MATERIAL

by

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

DOCTOR OF PHILOSOPHY

Major Subject: Physics

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

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Rensselaer Polytechnic Institute
Troy, New York
December, 2010

ABSTRACT

Rapid advances in fabrication techniques have enabled the production of nanoscale electronic devices. Pursuit of faster electronic devices made the size of these devices miniaturized, and the gate size is now well deep in nanoscale. As the transistor density increases, heat generation and its management became a major challenge in these devices. Heat transport in nanoscale materials is a largely unexplored area of research, although pioneering research has been made a decade ago. One of reasons for this, is a lack of suitable experimental methods, and another reason is a lack of nanoscale material suitable for this purpose. Ultrafast spectroscopy provides powerful tool to explore dynamics of electrons, phonons and their interactions in non contact way. In this thesis, thermal transport in nanoscale material is explored from view point of transport of heat carriers: phonon transport in nanoscale materials using ultrafast laser spectroscopic techniques. Electron-phonon coupling process was investigated in freestanding single crystal Cu nanorod with different diameter. Enhancement of electron-phonon coupling constant in Cu nanorod was observed and discussed. Oblique deposition angle dependence of signal intensity and decay time in Cu nanorod was also investigated and explained by the effective surface area model and two temperature model. Vibration response of Cu strip was observed in transient reflectivity measurement. Polarization dependence of strip vibration was discussed qualitatively and vibration modes were discussed using finite element analysis (FEA). Coherent acoustic phonon propagation and acoustically induced vibration were investigated. Spatial confinement of nanorod was observed. We also investigated GHz coherent vibration in complex shape free standing submicron Si spiral. Vibrational modes of spiral ware discussed using finite element analysis (FEA).