

Mechanical Engineering Thesis Defense

Hyperbolic Mode Control with Boron Nanotubes and its Impact on Near-field Radiative Heat Transfer

School for Engineering of Matter, Transport and Energy

Vishwa Krishna Rajan

Advisor: Dr. Liping Wang

Abstract

Radiation heat transfer can surpass blackbody limit when distance between the hot emitter and cold receiver is less than the characteristic wavelength of electromagnetic radiation. The enhanced radiation heat transfer achieved is also called near-field radiation heat transfer. Several theoretical and experimental studies have demonstrated enhancement in near-field radiation heat transfer for isotropic materials such as silicon carbide (SiC), undoped and doped Si. The enhancement achieved however is narrow-banded. Significant improvement in radiation heat transfer is necessary to satisfy some of the energy demands. So, there is a growing interest to use hyperbolic materials because of its enhancement due to propagating modes. The main objective of the current thesis project is to investigate the control of hyperbolic bands using boron nitride nanotubes (nanostructure of hexagonal boron nitride) for near-field radiative heat transfer. Optical properties of boron nitride nanotubes are calculated using Maxwell-Garnet's effective medium theory and its corresponding hyperbolic bands are identified. It is observed that the boron nitride nanotubes have only one hyperbolic band located at higher frequencies. Preliminary comparisons of the near-field radiative heat flux calculations with literature are performed using a more general 4×4 transfer matrix method. Due to its high computational time, anisotropic thin film optics is used to calculate near-field radiative heat transfer. Factors contributing to enhancement is investigated. In the end, Spectral allocation ratio, the ratio of heat flux contributed from higher frequencies to the heat flux contributed from lower frequencies is calculated to assess the contribution of each hyperbolic band to total heat flux.



June 17, 2022; 10 AM;

Zoom Link: <https://asu.zoom.us/j/81834951124>