
A GaAs-based Optical Nanoelectromechanical Device

Personnel

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Optical systems are being developed to reach the functionality and large-scale integration of electronic systems. Strides are being made to develop an on-chip optical system by designing and fabricating an Optical NanoElectroMechanical, ONEM, device structure based in a gallium arsenide material system. Gallium arsenide, a III-V compound semiconductor, was chosen due to its high-refractive index contrast when combined with oxidized AIAs. GaAs was specifically chosen over other III-V materials due to its comparable mechanical integrity to silicon-based electromechanical devices. The ONEM project will address several fabrication issues: nanometer-sized feature fabrication, optical wave guiding and mode-matching, and electronic and mechanical interactions in a GaAs material system.

Developing an optical nanoelectromechanical switch presents a dynamic problem with design trade offs existing in both optical operation and electromechanical operation. Three-dimensional energy modeling simulations were carried out to determine the relationship between optical transmission and the deflection of the cantilever. Frequency-domain and time-domain simulations were used to simulate the optical performance of the various switch designs. Two-dimensional finite difference modeling simulations were carried out to determine the electromechanical operation of a nanometer-sized GaAs cantilever. The variational method and the Rayleigh-Ritz method were used to simulate the optical switch's electromechanical operation. The results of optical simulations and electromechanical simulations lead to an optimal device structure that is currently being fabricated using the equipment in the Nanostructure Laboratory and the Experimental Materials Laboratory.

The completion and testing of the optical switch should give insight on the capabilities of optical nanoelectromechanical devices fabricated in the GaAs material system. Resolving the issues facing nanometer-sized pat-

terns and pattern transfer makes it possible to scale down current MicroElectroMechanical (MEM) structures into the nanometer regime. Characterizing the electromechanical properties of gallium arsenide would lead to the development of more complex ONEM structures. Resolving the issues facing optical confinement in a high contrast medium of gallium arsenide and aluminum oxide would make it possible to transfer the ONEM structure to other III-V material systems. Immediate goals are focused on increasing the on/off contrast of the switch by incorporating additional coupling waveguide elements and photonic crystals into the design with the long-range goal of creating a wavelength filter by the incorporation of photonic crystals.
