

RESEARCH BRIEF

III-V MEMS FOR INTEGRATIVE OPTICAL MICROSYSTEMS

The potential

Indium Phosphide (InP) is a III-V semiconductor with unique properties. In addition to enabling high-speed electronics, it also is an efficient emitter of light. This gives InP unique advantages over silicon when it comes to optical communication systems.

Micro-electro-mechanical systems (MEMS) offer the ability to incorporate many complex optical devices on a single chip. By confining light to small optical pathways, called waveguides, we minimize optical losses. If we free these waveguides from the substrate so that they can be physically displaced by application of a voltage (electrostatic actuation), optical functions including switching and tunable filtering can be achieved.

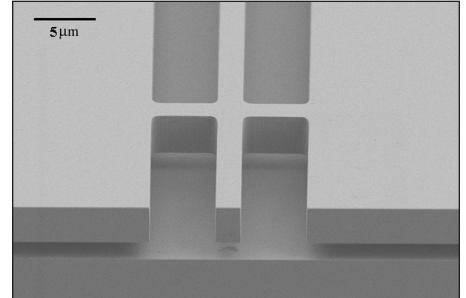
The challenge

Currently, most optical microsystems utilize silicon due to its mechanical robustness and mature processing available through the IC industry. InP is known to be brittle, however, and little prior work on the micro-mechanical properties of this compound semiconductor has been done. This makes the application of InP to optical microsystems difficult, both in terms of processing and materials reliability.

Fabrication processes need to be developed in order to demonstrate InP-based MEMS with moving waveguides. Here, the quality of the waveguides is important: roughness has to be limited to a small fraction of the wavelength of light used (i.e. roughness of less than a few tens of nm) in order to limit optical losses.

Once moving waveguide devices are realized, optical functions can be demonstrated. This includes optical switching by displacing two waveguides relative to each other. Tunable optical filters can also be realized by changing the spacing between two waveguide-integrated mirrors, thereby varying the resonant frequency of the resulting optical cavity. More complex optical systems would include

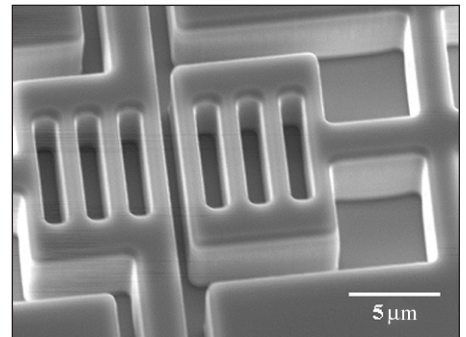
many switches and tunable filters on a single chip. These could be augmented by laser sources or laser semiconductor amplifiers by taking advantage of the unique properties of InP for optical applications.



This InP waveguide is suspended above the substrate by lateral tethers.

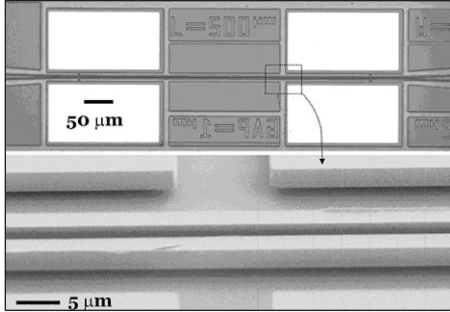
The research

Dr. Reza Ghodssi and researchers have studied the mechanical properties of thin-film InP and have shown it to be sufficiently robust for optical microsystems. More recently, they demonstrated a simple process for realizing suspended and movable optical waveguides made of InP. Additional processing defines metal electrodes for actuating the waveguides via an applied voltage. This has laid the foundation for complex InP-based optical microsystems.



Bragg-Mirrors for tunable filter applications

A low power optical switch utilizing movable waveguides with less than 10V operating voltage has already been demonstrated. Currently, Dr. Ghodssi and his researchers are improving their optical switch by looking at alternate optical coupling schemes. They are also designing and fabricating tunable optical filters that take advantage of the high refractive index of InP. Such tunable filters are an integral component of large bandwidth communications networks.



MEMS evanescent coupler optical switch device

Awards

National Science Foundation CAREER Award (Dr. Ghodssi)

DoD Maryland Procurement Office, Laboratory for Physical Sciences (LPS) of the National Security Agency (NSA)

ARCS (Achievement Rewards for College Scientists) Foundation

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III-V MEMS for Integrative Optical Microsystems
project
www.enee.umd.edu/MEMS/projects_III-VMEMS.html