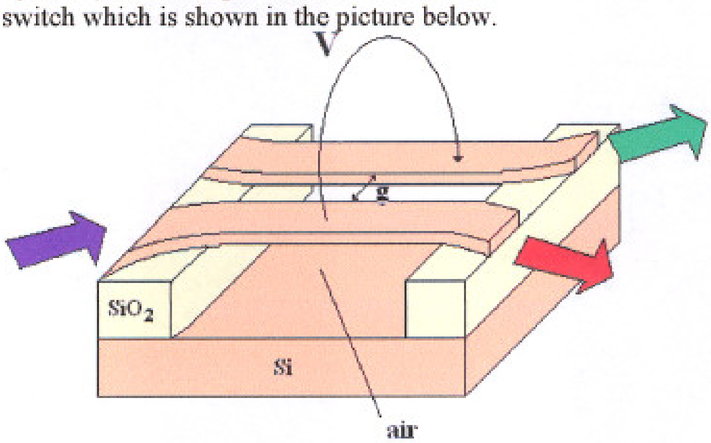
Nanophotonic NEMS modulators in Silicon-on-insulator

During the last decades the research for high-performance optical modulators has been of increasing intrest in both academic and industrial world. To fulfill the demand for increasing performance we are investigating a new promising technology. We expect that the introduction of NEMS (nano-electromechanical systems) into the world of nanophotonics will lead to optical modulators which are relatively fast, cheap, reliable, very compact (only a few square microns) and have an ultralow power consumption (fW) together with a CMOS-compatible processing.

The material system of our choice is Silicon-on-insulator which has proven its convenience for both nanophotonics and classical MEMS (Microelectromechanical Systems). An example of such a nanophotonic NEMS device is a 2x2 waveguide switch which is shown in the picture below.



The working principle is actually quite easy: basically we use a directional coupler with underetched coupling section. By applying a voltage V between the two arms of the directional coupler the gap distance g can be decreased and the coupling coefficient is influenced dramatically. That way we can tune the output power in both output ports (red/green arrows) in a continuous way. Simulations show for example that altering the gap distance g from 270nm to 185nm for a coupler of 46 µm length will result in a complete shift of the output power between both output ports.

The idea of introducing NEMS in nanophotonics is not limited to waveguide switches. It is also possible to create for example a free space spatial modulator using a dynamic zeroth order grating. Silicon wires placed close to each other define a zeroth order (zeroth order means that no diffraction to first and higher orders occurs) diffraction grating. By applying a voltage between the substrate and the wires we can pull the wires to the substrate and influence the diffraction effect.
Simulations show that small vertical deflections (order of hundreds nm) of the wires can result in a total shift from reflecting to transmitting state. Application of this principle will lead to the fabrication of variable optical attenuators and devices for polarization control.

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Optoelectronic Integration
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12-17 March 2006
Pontresina (CH)
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