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Integrated Optical Nanomechanical Light Modulators and Microphones

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We demonstrate two novel integrated optical (IO) devices, a nanomechanical intensity modulator and a microphone. Both devices are based on an IO nanomechanical effect which works as follows: the width d of a small air gap between a nonabsorbing dielectric plate E (called an "effective-refractive-index-shifting element") and the waveguide is varied by an external applied force K. Since $d \leq \lambda$, where λ is the wavelength of light, the evanescent field of the guided mode penetrates through the air gap into the element E. Because of this interaction, the effective refractive index N of a guided mode depends on d. Gap-width variations Δd of the order of nanometers induce effective index changes ΔN required for operation of IO devices. The IO nanomechanical effect permits the realization of active IO devices without recourse to electro-, magneto-, or elastooptical materials. With an effective-index-shifting element E in an interferometer, light waves were intensity modulated by a varying external force or by the pressure of a sound wave. In our experiments with a "difference or common-path" interferometer, we used planar thin monomode waveguides of SiO_2-TiO_2 on glass or Si/SiO_2 substrates. The effective-index-shifting elements E were either glass or Si/SiO_2 platelets. In the modulator experiments, the force K was generated piezoelectrically; modulation frequencies of up to 550 kHz were reached. The feasibility of an IO microphone which directly transforms sound into light intensity variations was demonstrated.