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Towards Complex Application-Specific Optical Circuits in $LiNbO_3$

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Advanced material processing technologies allow the development of new integrated optical $LiNbO_3$ devices of attractive properties. They can be combined with the well-known, more conventional devices in optical circuits designed for specific applications in optical communications, instrumentation and sensing.

Enabling Technologies and Devices:

During the last few years several new $LiNbO_3$-specific processing technologies have been developed: periodic poling of ferroelectric microdomains, diffusion-doping with rare-earth ions, laser ablation and photorefractive grating fabrication, selective chemical and ion-beam surface etching and acoustic waveguide definition by Ti-indiffusion and proton exchange. All these advanced material processing technologies can be combined with at least one of the standard waveguide fabrication processes, i.e. Ti-indiffusion or proton exchange, leading to the development of a variety of new integrated optical devices of high performance. Examples are parametric frequency converters for nearly arbitrary wavelengths, optical amplifiers and lasers of high efficiency, narrow-band Bragg-reflectors, ultrahigh bandwidth electrooptical modulators, and tailored acoustooptical wavelength-selective filters, multiplexers and switches.

Devices of Higher Functionality:

By combining two or even more of the enabling technologies and devices mentioned above devices of higher functionality can be designed. Experimentally demonstrated examples are: modelocked, tunable and narrow-linewidth lasers by fabricating rare-earth doped laser resonators with intracavity high bandwidth electrooptical modulator, with tunable acoustooptical filter, and with narrow-band grating reflector, respectively. Proposed examples include nonlinear frequency converters and wavelength-selective acoustooptical devices with internal optical amplification by laser-active ions.

Application-Specific Optical Circuits:

All the devices based on the new technologies enlarge the potential of a future monolithically integrated optics in $LiNbO_3$. In combination with the well-known active and passive devices of excellent performance such as electrooptical phase- and amplitude-modulators, TE-TM-converters, polarization splitters, etc. complex application-specific integrated optical circuits can be developed for optical communications, instrumentation and sensing. Proposed examples are laser-modulator combinations (partly demonstrated), soliton transmitters with a modelocked laser and an encoding modulator on the same chip, lasers with intracavity optical parametric oscillator and a complex heterodyne interferometer with more than 10 devices in the optical circuit (see Fig. 1). The fabricated simple version of the interferometer, operated with a single-frequency semiconductor DFB-laser ($\lambda \approx 1.55$ μm), was used as vibrometer. It was possible to obtain a noise equivalent sensitivity of 45 pm for the measurement of the amplitude of a vibrating mirror.

In conclusion, there is a great potential to develop further application-specific optical circuits in $LiNbO_3$ with attractive properties.

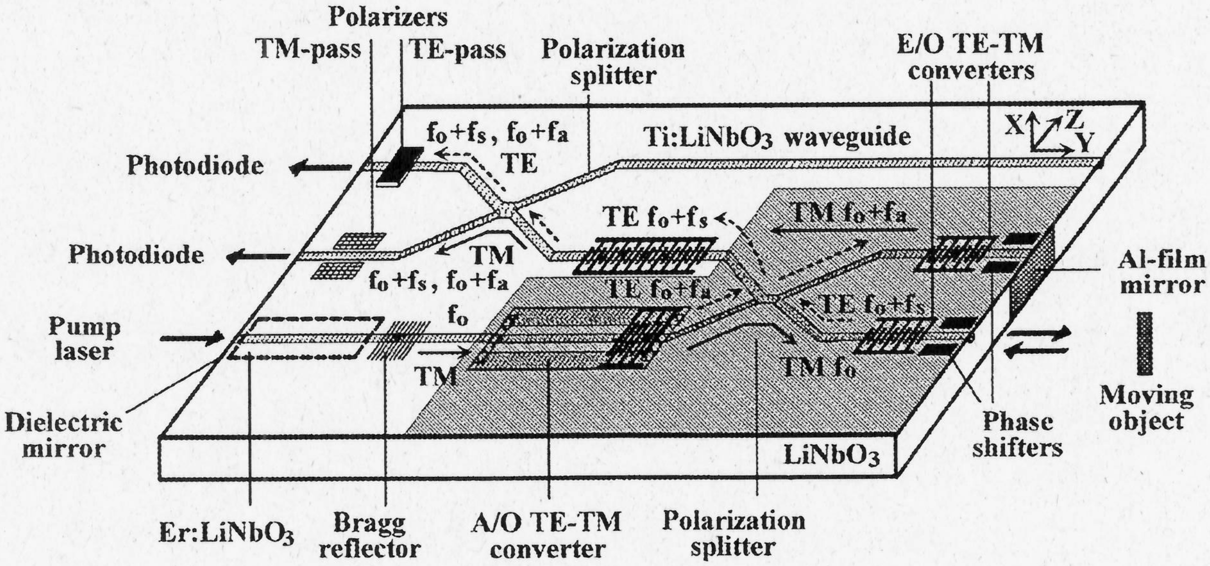

Fig. 1: Monolithically integrated heterodyne interferometer in $LiNbO_3$. Shaded part: experimentally realized.