Optimisation of Micro-Structured Waveguides in Lithium Niobate (Z-Cut)

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Abstract

We present an optimization procedure to improve the propagation properties of the depressed-cladding, buried micro-structured waveguides formed in a z-cut lithium niobate (LN) crystal by high repetition rate femtosecond (fs) laser writing. It is shown that the propagation wavelength for which the confinement losses of ordinary (O) and extraordinary ordinary (E) polarizations are below 1 dB/cm can be optimized beyond 3 micro meter for hexagonal WG structures with seven rings of tracks.

Micro-structured WGs with low loss, high damage threshold and controlled dispersion in a broad spectral range are indispensable for the present and emerging application areas. The femtosecond (fs) laser inscription method has been widely applied to fabricate optical waveguides in numerous optical materials, including optical crystals, ceramics, glasses and polymers[1]. As one of the most widely used optical crystal due to its acousto-optic, electro-optic, nonlinear optical properties and wide transparency range, LN is of interest on which to establish appropriate design principles and develop suitable fabrication technologies.

The range of track size (D), RI contrast , track period or pitch (a) and number of cladding layers (Nclad) was studied for hexagonal micro-structured WGs in z-cut LN to control the guiding properties[2].

Additionally, a practical approach is applied for optimization of the guiding properties of micro-structured WGs in a z-cut LN crystal, in a pursuit of establishing how experimentally realizable design principles can be used for achieving the propagation of mid-IR wavelengths range. The presented approach is based on those; the proper variation of the track sizes among different track layers, the relationship between track size and induced RI contrast, and the intrinsic losses due to fs laser inscription. Figure 1 shows the cross section of the hexagonally micro-structured WG with its index ellipsoid for z-cut LN.

The results for an hexagonal WG structure with seven rings of tracks are shown in Figure 2. It is clear that such an optimized structure is suitable for mid-infrared applications with a spectral region of propagation, where the confinement losses for O and polarization are below 1 dB/cm, up to 3.5 micro meter wavelength region.

Reference

[1] R. Osellame, G. Cerullo, and R. Ramponi, Femtosecond Laser Micromachining: Photonic and Microfluidic Devices in Transparent Materials: Springer, 2012.

[2] H. Karakuzu, M. Dubov, and S. Boscolo, "Control of the properties of micro-structured waveguides in lithium niobate crystal," Optics Express, vol. 21, pp. 17122-17130, 2013/07/15 2013.

Figures used in the abstract

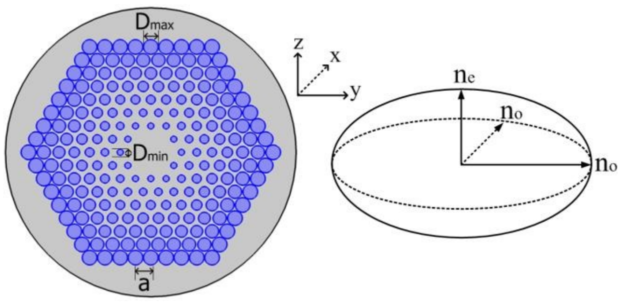

Figure 1: Cross-section of hexagonal micro-structured WG with seven rings of tracks, the size of which increases with growth rate p=0.01, and index ellipsoid of z-cut LN.

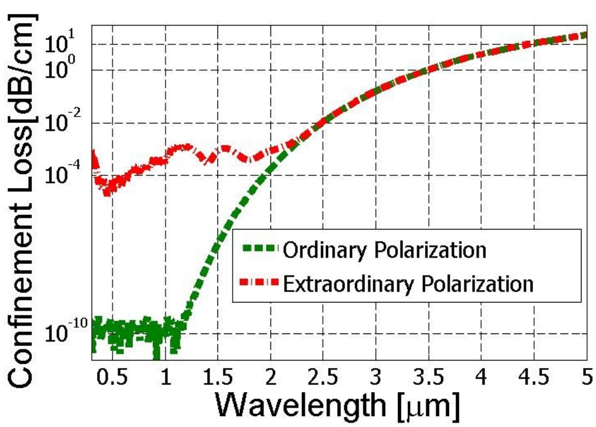

Figure 2: Confinement losses for O and E polarization for a seven ring WG with p=0.01.