Simulations are realized between 0.3 to 3 μm. RI for congruently grown LiNbO₃ taken from [104]. The radius and RI contrast of tracks are intra-structural. The wavelength [2.1045, 2.1158, 2.15497, 2.1558, 2.11805] for LiNbO₃ is negative uniaxial crystal [2.1045, 2.1158, 2.15497, 2.1558, 2.11805].

Experiment Results

Optimization of micro-structured waveguides in Lithium Niobate (z-cut)
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**ABSTRACT:** We describe how the guiding properties of buried, micro-structured waveguides that can be formed in a lithium niobate crystal by direct femtosecond laser writing can be optimized for low-loss operation in the mid-infrared region beyond 3.5 μm.

1. Direct Femtosecond Laser Inscription

2. Experiment Results

3. Parameters for Simulation

- The parameters measured were used in the simulations.
- Step-index RI profile is assumed.
- Both Radius and RI contrast of tracks are intra-dependent via Pulse Energy

4. Geometry and Numerical Calculation with Consol

**Optical Set-up Layout**

5. Plane Wave Method vs Finite Element Method

6. Results

- Extraordinary Polarization
- Ordinary Polarization
- Extraordinary Polarization
- Ordinary Polarization
- Extraordinary Polarization
- Ordinary Polarization
- Extraordinary Polarization
- Ordinary Polarization
- Extraordinary Polarization
- Ordinary Polarization

7. Optimization

- Minimum confinement loss is searched by changing the track diameters of each layer according to the formula:

8. Conclusions

- We have numerically demonstrated that the guiding properties of depressed-cladding, buried WGs formed in a LiNbO₃ crystal by fs laser writing can be controlled by the WG structural characteristics, even for the relatively moderate induced RI contrasts typical of the direct fs inscription. In particular, the number of depressed-cladding layers has revealed to play a major role in the control of the WG properties. Importantly for practical applications, we have shown that for an induced RI contrast of -0.013, the propagation losses can in principle be reduced by four orders of magnitude at telecom wavelengths by increasing the number of cladding layers from 2 to 7. Minimisation of the confinement loss at mid-infrared wavelengths is realised by varying the growth rate of track diameters.