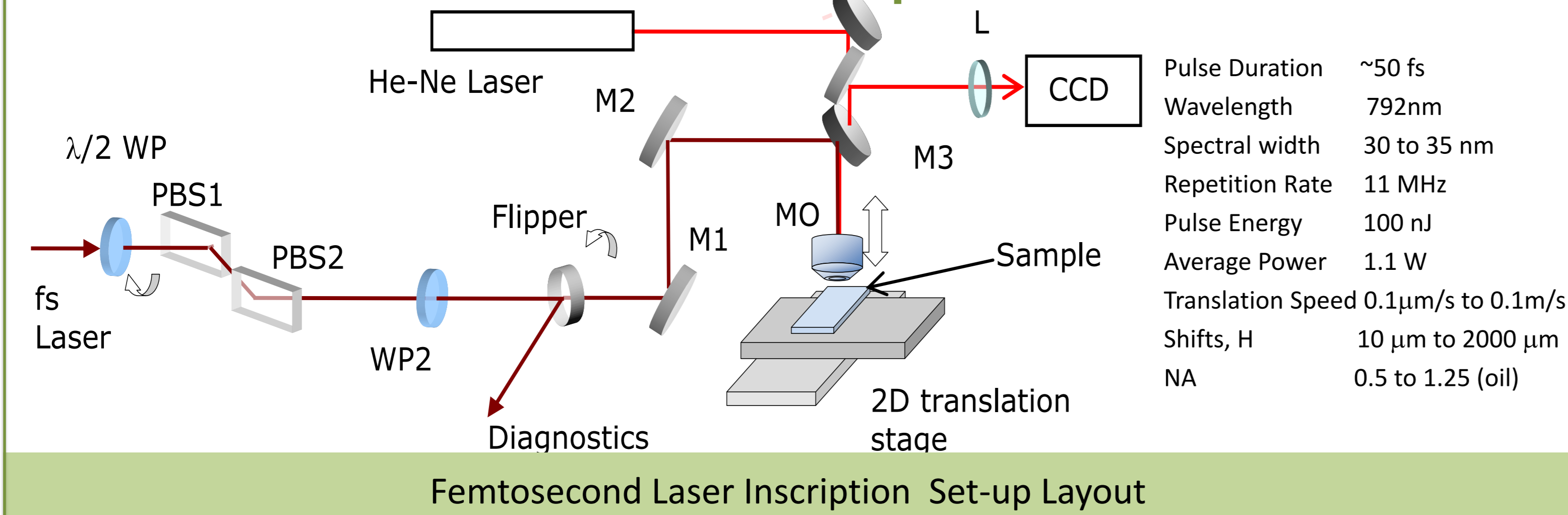
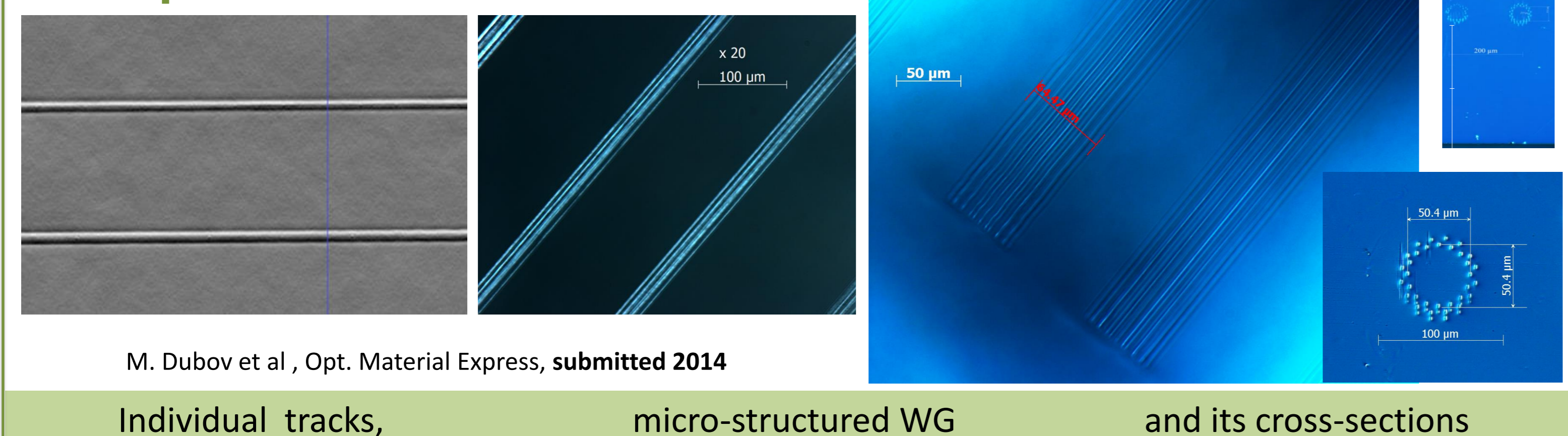


ABSTRACT: We describe how the guiding properties of buried, micro-structured waveguides that can be formed in a lithium niobate crystal by direct femtosecond laser writing can be optimized for low-loss operation in the mid-infrared region beyond 3.5 μm .

1. Direct Femtosecond Laser Inscription

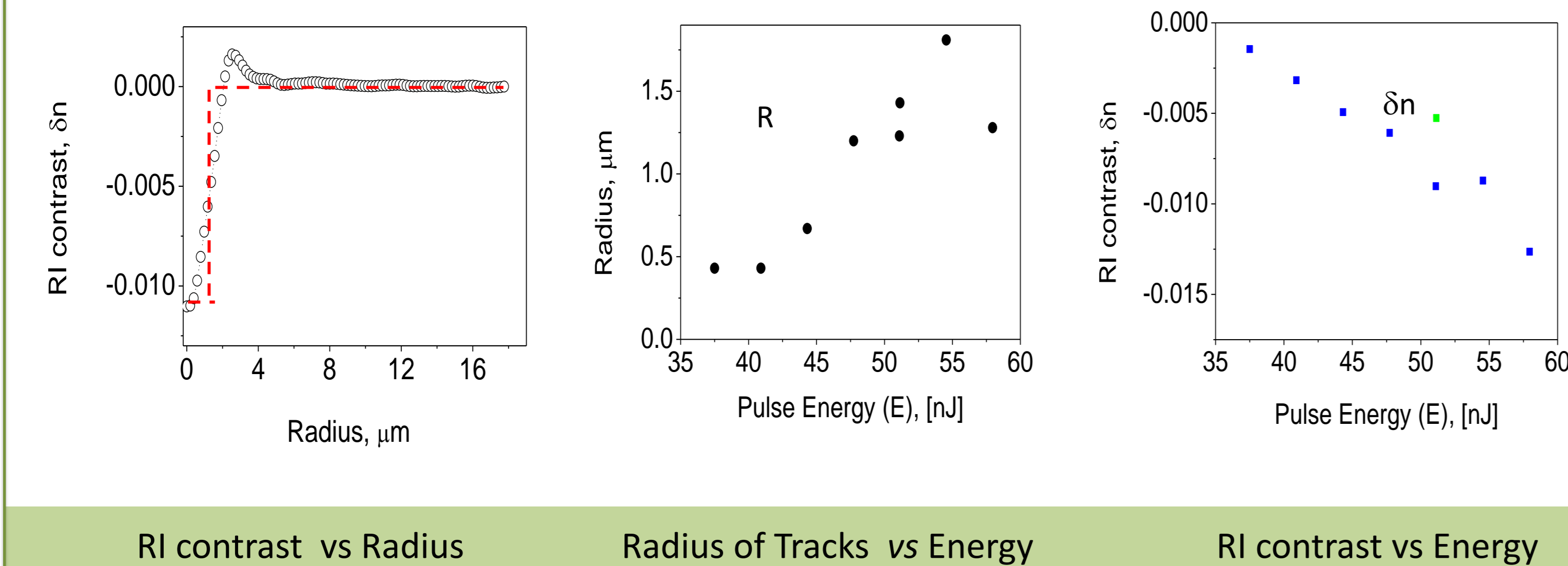


2. Experiment Results

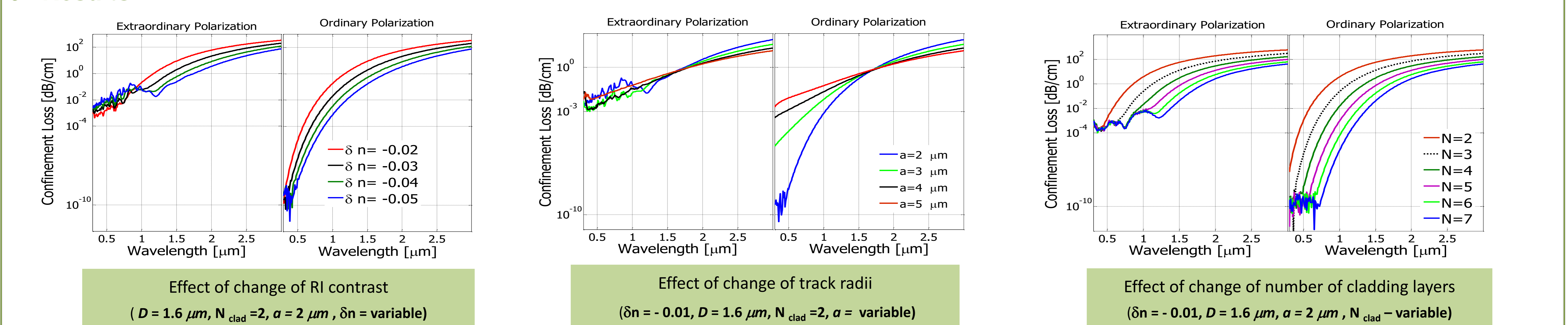


3. Parameters for Simulation

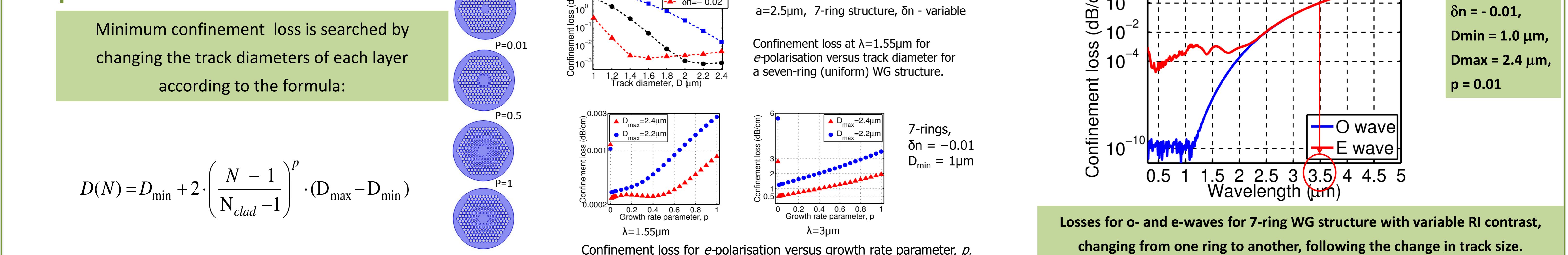
- The parameters measured were used in the simulations
- Step-index RI profile is assumed
- Both Radius and RI contrast of tracks are intra-dependent via Pulse Energy



6. Results

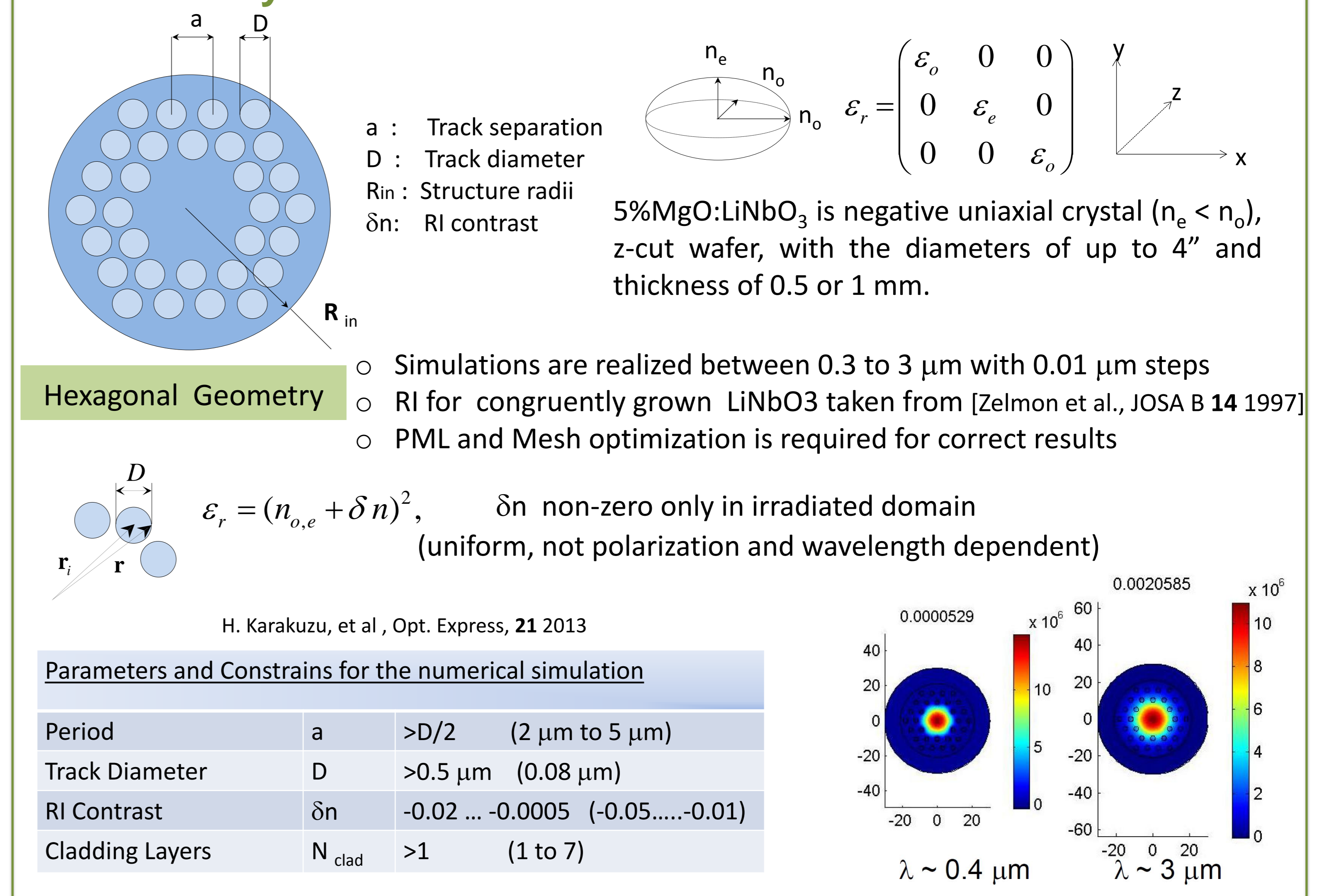


7. Optimization



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.

4. Geometry and Numerical Calculation with Comsol



5. Plane Wave Method vs Finite Element Method

