Nonlinear Optical Frequency Conversion to & from the Mid-Infrared in Ti:PPLN Waveguides for Spectroscopy and Free-Space Optical Communication

Abstract Mid-infrared (MIR) sources and detectors have been of strong interest since decades. Due to shortcomings of existing lasers for this range, frequency conversion using nonlinear optical difference-frequency generation (DFG) is a popular means to generate MIR radiation using near-infrared (NIR) sources. On the detector side, nonlinear-optic frequency conversion can be used to realize a hybrid up-conversion detector (UCD), which converts radiation from the MIR, to the NIR or even visible, where it can be detected using detectors with favorable properties.

Within the scope of this work, such nonlinear-optic devices, based either on DFG or SFG (sum-frequency generation) were investigated, using Ti-indiffused waveguides in periodically poled Lithium Niobate (Ti:PPLN). More than 10 mW of tunable radiation at either 3.4 µm or 3.8 µm could be generated, using pump lasers at 1064/1100 nm and 1550 nm wavelength. Similarly, UCDs based on either DFG or SFG were thoroughly characterized. The UCDs convert radiation within a few nm bandwidth around a design wavelength, and can be temperature-tuned by tens of nm.

The devices were combined in order to realize free-space optical (FSO) transmission lines. With such a transmission line, MIR-spectroscopy of methane was performed with NIR instrumentation only. The devices are also of interest for FSO data transmission, because atmospheric transmission impairments can be minimized by using MIR-wavelengths. It was shown that data transmission through an atmospheric turbulence generator could be improved when comparing transmission at 3.8-µm wavelength with wavelength conversion, to transmission at 1550 nm.