

Broadband Mid-Infrared Generation at mW-Power Level in Periodically Poled Lithium Niobate Waveguides

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Miniaturization of mid-infrared (MIR) sources for spectroscopy applications has progressed significantly during the past two decades, but a solution able to provide full integration, wide tuneability and relatively high power over the so-called atmospheric window (3-5 μm) in a photonic integrated platform is still missing. In this context, leveraging efficient nonlinear integrated photonic platforms offers a promising approach for generating and amplifying MIR light within a highly compact footprint [1]. In this work, we report the fabrication and characterization of an integrated MIR source able to generate mW-power level continuous wave (CW) light over a broad band relying on difference frequency generation (DFG) in a periodically poled Lithium Niobate on Insulator (LNOI) platform [2,3]. The use of a custom-made tuneable laser emitting at around 1 μm as the optical pump and of a tunable amplified telecom laser emitting at around 1.55 μm as the signal allowed us to fully cover the 3 - 3.45 μm spectral range thus translating the technological maturity of data communication photonic devices to the MIR wavelength band. The waveguides were designed to guarantee efficient input and output optical coupling even using a standard 90°-cleaved optical fiber. They were fabricated by the FEMTO-ST Institute at MIMENTO technology centre. The waveguides are characterised by a ridge structure, laying on a silica substrate (see Fig. 1(a) for the waveguide cross-section). Waveguides with different lengths were fabricated in the range from 2 to 3 cm. The measured losses at 1.55 μm is lower than 0.1 dB/cm and the strong modal confinement within the relatively large waveguide cross-section effectively minimizes optical losses at the MIR wavelengths caused by the silicon oxide substrate and the gold bonding layer. The Lithium Niobate wafer is z-cut and the waveguide is periodically poled with a period of around 25 μm to guarantee the phase-matching. Nonlinear DFG experiments were carried out by sweeping the pump and signal wavelengths and the MIR radiation was measured through an optical spectrum analyzer (BRISTOL 771-B MIR) and a photodiode (Thorlabs PDA07P2). Fig 1(b) reports the idler MIR power as a function of the idler wavelength for different pump wavelengths (λ_p) with a wavelength step of 5 nm. This configuration allows for a fine tunability to fully cover over 460 nm at wavelengths longer than 3 μm . Normalized efficiencies for the generated idler components around 3.24%/W/cm² were measured. Fig. 1(c) reports the idler output power as a function of the pump output power, showing the capability of reaching mW output power levels suitable for spectroscopy applications. Higher MIR idler powers could be achieved by increasing the pump and signal power at the waveguide input, given the high damage threshold exhibited by the Lithium Niobate platform employed in this work.

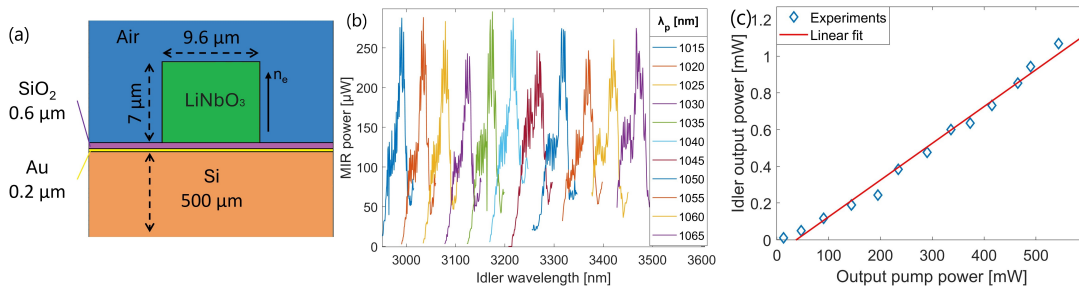


Fig. 1 (a) Cross-sectional view and dimensions of the periodically poled Lithium Niobate waveguide employed in this work; (b) MIR idler power as a function of the idler wavelength for different pump source wavelengths; (c) idler output power as a function of the pump output power with wavelengths set as: $\lambda_p = 1040$ nm, $\lambda_s = 1537.8$ nm.

References

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