

PhD Thesis Defense JUNXIONG WEI 'Novel nonlinear frequency conversion sources in the mid-infrared'

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December 18, 2018

Tuesday December 18, 15:00 h. ICFO Auditorium

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Optical Parametric Oscillators

ICFO-The Institute of Photonic Sciences

The goal of this thesis has been the development of a new class of advanced solid-state photonic sources for the mid-infrared (mid-IR) spectral regions, where there exists a severe shortage of practical coherent laser sources, and many scientific and technological applications can benefit. The strategy has been to exploit nonlinear optical techniques based on difference frequency generation (DFG), parametric generation and oscillation, in the latest class of mid-IR nonlinear materials, in combination with the most advanced lasers pump

sources based on fiber laser technology, to realize novel, high-power coherent source with broad tunability in the mid-IR.

Accordingly, we demonstrate an angle-tuned MgO:PPLN picosecond OPO, synchronously pumped by a Yb-fiber laser, for the first time to the best of our knowledge. The OPO is tunable from 1413-1900 nm in the signal togerther with idler tunability across 2418-4307 nm providing a total tunability of 2376 nm in the near-to-mid-IR region, simply by angular interrogation of the MgO:PPLN crystal at room temperature. Using a 10% output coupler, we were able to extract up to 2.4 W of signal at 1664 nm together with an idler power of 1.7 W at 2950 nm, corresponding to an overall extraction efficiency of ~45% with good beam pointing stability of better than 30 rad and 14 rad for the signal and idler, respectively. These resul s indicate the potential for rapid and wide tunability of high-power OPOs as compared to t e temperature tuned devices.

In addition, we have demonstrated a novel device based on a tandem configuration, for an injection-seeded pulsed OPO system. Using a 38-mm-long PPLN crystal, we have produced ~0.94 W of average power with 9.7% slope efficiency at 1677 nm, for a pump power of 10 W at 80 kHz repetition rate. The measured optical bandwidth of signal is less than 20 MHz, and the seeding operation is achieved over signal wavelengths ranging from 1510 to 1677 nm, providing a total seeding range of 167 nm in the near-IR region. From a more general viewpoint, the method shownhere will also work at other wavelength range of OPO as well, opening a new path towards injection-seeding or injection-locking of pulse OPOs with full tuning range and high spectral purity.

Finally, we present detailed characterization of optical properties of the recently developed nonlinear material, orientation-patterned gallium phosphide (OP-GaP), by performing DFG experiments in the 2492-2782 nm wavelength range in the mid-IR. Detrimental issues such as thermal effects and residual absorption have been studied and confirmed by performing relevant measurements. Temperature and spectral acceptance bandwidths for DFG in the 40-mm-long OP-GaP crystal have been measured to be 18 ºC and 4 nm, respectively, at 176 nm. Further, we have measured the damage threshold of the OP-GaP crystal to be 0.8 J/cm at 1064 nm, for the first time. The polarization dependence of the input beams on the DF power has also been systematically investigated. To our knowledge, this is the first report o tunable DFG in OP-GaP, as well as the first nanosecond DFG source based on this ne nonlinear material

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