Subnanosecond multi-stage microlaser pumped OPA system continuously tunable in the VIS and near UV

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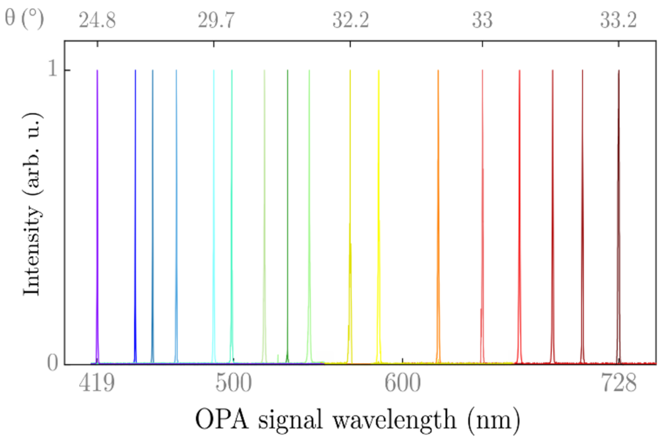
Optical parametric generators (OPGs) and amplifiers (OPAs) in the subnanosecond (300 ps - 1 ns) pulse duration range stand out as both unique and highly promising. Tunable wavelength laser radiation of such duration is of interest in numerous applications such as LIDAR, THz generation, various types of spectroscopy, gas detection, nonlinear optics, etc. [1-6], where sophisticated and expensive ultrashort pulse duration optical parametric systems are not required whereas, nanosecond optical parametric systems have insufficient temporal resolution and output pulse peak intensity. Currently, periodically poled nonlinear media-based OPGs utilizing quasi-phase-matching have emerged as the exclusive solution for the generation of near-to-mid-infrared subnanosecond laser pulses [7-10]. Subnanosecond microlaser-based systems tunable from roughly 1400 nm to 4500 nm with kHz repetition rates delivering microjoule level OPG pulse energies present the advantages of a simple design, low cost, high peak power, excellent robustness, and are currently undergoing development. However, some applications like semiconductor excitation, selective photothermolysis and pump-probe spectroscopy demand tunable subnanosecond laser pulses in the visible (VIS, 400 nm – 750 nm) and near ultraviolet (UV, 400 nm – 300 nm) spectral regions. Despite recent progress of the microlaser pumped OPGs tunable in the infrared (IR), VIS and UV spectral regions remain significantly underdeveloped in the case of subnanosecond OPGs and OPAs due to the additional level of complexity regarding use of periodically poled crystals as nonlinear medium in the VIS and UV.

In this study, we present an effective approach to substantially broaden the tuning range of microlaser-based optical parametric devices into the VIS and near UV spectral range. We demonstrate, to the best of our knowledge, the first subnanosecond multi-stage OPA system continuously tunable throughout the VIS and near UV spectral range. Our BBO crystal-based OPA was pumped by third harmonic (λ=355 nm) from passively Q-switched Nd:YAG microlaser generating 615 ps duration pulses while the seed source was formed from multigrating MgO-doped periodically poled lithium niobate (MgO:PPLN) OPG-based seeder pumped by the second harmonic (λ=532 nm) of the same microlaser. The OPA signal wave was continuously tunable from 419 nm to 728 nm via angular phase matching and maintained high beam quality. We determined that the MgO:PPLN pumping geometry, where the grating vector is at a non-zero angle with the pump, significantly reduced the non-collinear QPM effects in the OPG and decreased the divergence of the seed beam which resulted in up to 4 times higher OPA beam quality. Unlike conventional supercontinuum seeders, the MgO:PPLN OPG seeder achieved much higher spectral power density which was crucial in achieving up to 19% OPA signal to pump conversion efficiencies. The introduction of the upconversion stage (second harmonic generation – SHG) extended the tuning range of the system to 340 nm.



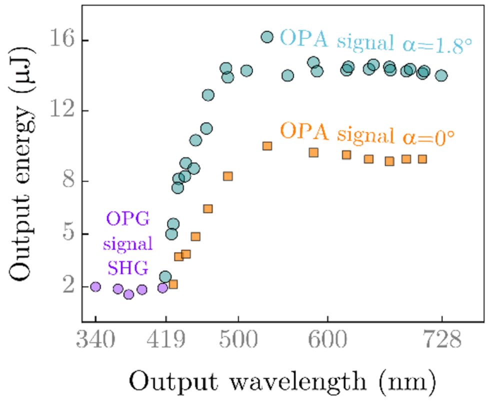


Fig. 1. BBO OPA output spectra at different BBO crystal rotation angles θ when seeder OPG MgO:PPLN grating orientation angle α is 1.8 deg (left); OPA and OPG signal SHG output energy dependence on wavelength at different seeder OPG MgO:PPLN grating vector orientation angles α (right).

A comprehensive characterization of both the seed source and the OPA with upconversion stage was performed including energy, spatial, spectral, and temporal properties (Fig. 1). The showcased multi-stage OPA system is proven to be a reliable and efficient source of tunable subnanosecond laser radiation in the VIS and near UV spectral range.

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