Optical Parametric Oscillators Spanning the Ultraviolet to Mid-Infrared

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Abstract: Advances optical parametric oscillators for the generation of coherent radiation from the ultraviolet to mid-infrared and from continuous-wave to femtosecond time-scales, using novel nonlinear materials and solid-state, fiber, and semiconductor pump lasers are described.

The development of coherent light sources in new spectral regions has been a major goal of research in solid-state laser technology for over 50 years. Many approaches to the generation of coherent radiation in difficult spectral regions have been explored using conventional laser techniques, but access to extended bands in the ultraviolet (UV), visible and infrared (IR) has remained difficult, due to the absence of viable solid-state laser gain media.

Soon after the invention of laser, optical parametric oscillators (OPOs) were recognized as attractive alterntatives for the generation of widely tunable radiation in new spectral regions, but practical development of OPO devices was for many years hampered by a number of obstacles, mainly a lack of suitable nonlinear materials. The advent of a new class of birefringent and quasi-phase-matched (QPM) nonlinear crystals during the past decade has had an uprecedented impact on the advancement of OPO technology. Combined with the rapid progress in solid-state, fiber and semiconductor pump sources, as well as the exploitation of innovative techniques based on cascaded frequency up- and down-conversion, a new generation of truly viable OPO devices capable of delivering coherent light from the UV to mid-IR and in all time-scales from the continuous-wave (cw) to femtosecond domain have been realized.

The timely and effective exploitation of QPM materials has led to the realization cw and ultrafast OPO devices with unparalleled performance capabilities in terms of power, efficiency, and spectral coverage. Using MgO:PPLN in combination with Yb fiber laser technology, output power levels up to 17.5 W and specrtral regions from 1.4 to beyond 4 μm in the mid-IR have been achieved with cw and picosecond OPOs in compact, practical and portable configurations. By deploying MgO:sPPLT in combination with cw solid-state, frequency-doubled cw fiber, or optically-pumped semiconductor lasers in the green as pump sources, spectral regions down to 850 nm have been accessed with cw OPOs at multiwatt power levels, while the application of internal upconversion techniques to cw OPOs has enabled wavelength extension to the 400-500 nm in the blue-green spectrum, see Fig. 1 (a). In the femtosecond regime, the exploitation of the birefringent nonlinear crystal, BiB_3O_6, pumped by the second harmonic of the KLM Ti:sapphire laser in the blue has enabled the development of a femtosecond OPO tunable across the full visible spectrum of 500-700 nm, see Fig. 1 (b), (c), while the deployment of internal frequency doubling has made possible the generation of tunable femtosecond pulses in the UV at wavelengths down to 250 nm. These efforts have transformed OPOs from laboratory prototypes to truly practical, efficient, and viable solid-state sources of coherent radiation capable of accessing arbitrary spectral regions from the UV to mid-IR.

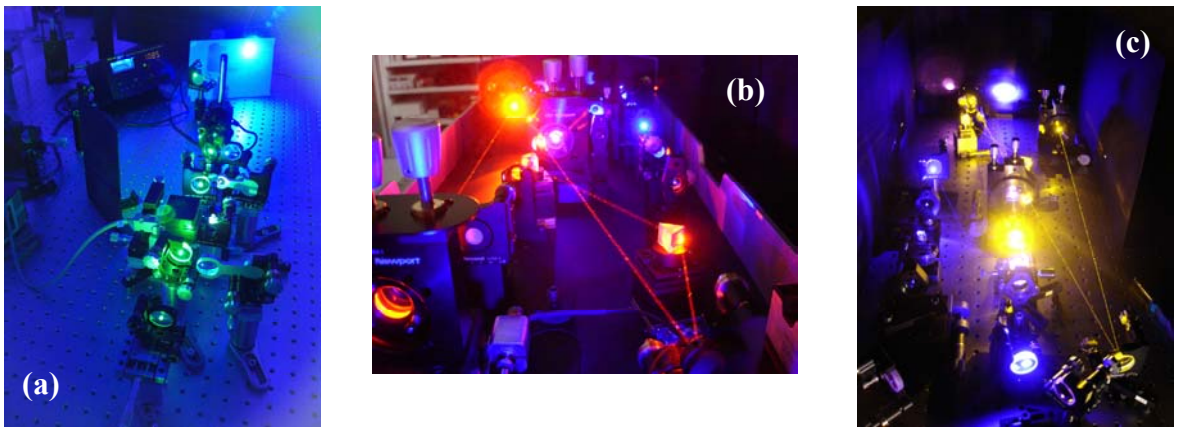

Fig. 1 (a) Continuous-wave OPO tunable in the blue. (b), (c) Femtosecond OPO tunable in the visible.