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Recent Advances in Difference-Frequency Generation Using Single-Mode Diode Lasers

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Recent advances in the development of new nonlinear optical materials, such as $AgGaS_2$ and $AgGaSe_2$, now offer a convenient technique of generating cw tunable infrared narrow-band coherent radiation over a wide wavelength range (3 to 18 μm) by means of difference-frequency generation (DFG). The use of semiconductor diode lasers as pump sources in the nonlinear DFG process is particularly attractive as their compact size and ease of operation allow the construction of a portable and robust infrared laser spectrometer for sensitive environmental monitoring. Approximately 3 nW of cw tunable infrared radiation around 5 μm have been generated by mixing two single-mode diode lasers (808 and 690 nm; total power ~10 mW) as pump sources in $AgGaS_2$. Higher visible-to-infrared conversion efficiencies can be achieved by using optical amplifiers to boost the power output of the low-power diode lasers. We report the generation of 47 μW of cw infrared radiation and 89 μW of pulsed infrared radiation, tunable around 4.3 μm by mixing the outputs of a high-power GaAlAs tapered traveling-wave amplifier at 858 nm and a Ti:Al_2O_3 laser at 715 nm in $AgGaS_2$. The GaAlAs amplifier delivered up to 1.5 W of diffraction-limited cw power into the nonlinear crystal while the Ti:Al_2O_3 laser power was set to 300 mW. Output powers, conversion efficiencies and spectral characteristics of this novel mid-infrared source are discussed.