Efficient difference-frequency mixing of single-mode diode lasers in $AgGaS_2$

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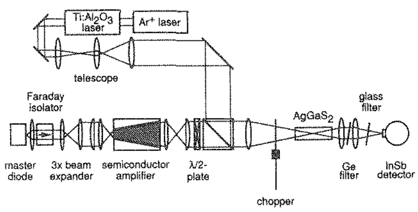
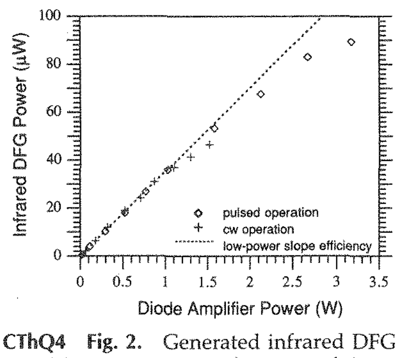
Recent advances in the development of single-mode III–V diode laser technology now offer the possibility of using cw diode lasers as pump sources in difference-frequency generation (DFG). Because of the small size and low power consumption of diode lasers, a robust, portable diode laser based DFG spectrometer especially suitable for environmental and medical applications can be designed.

The generated infrared power of all-diode-laser DFG sources has been limited in the past by the relatively low input power available from commercial single-mode III–V diode lasers.[1] One way to increase the DFG output power is the use of optical semiconductor amplifiers to boost the output power of the diode lasers. We demonstrated difference-frequency mixing of a high-power GaAlAs tapered traveling-wave semiconductor amplifier with a cw $Ti{:}Al_2O_3$ laser in a 45-mm-long $AgGaS_2$ crystal cut for type I noncritical phase-matching (Fig. 1). The amplifier was injection-seeded by a single-mode index-guided master diode laser. As much as 47 μW of cw infrared radiation and 89 μW of pulsed infrared radiation, tunable near 4.3 μm have been generated (Fig. 2). Alternatively, the DFG conversion efficiency can be increased by taking advantage of the high circulating light



CThQ4 Fig. 1. Experimental setup used to mix the outputs of a GaAlAs tapered amplifier and a $Ti{:}Al_2O_3$ laser in $AgGaS_2$ cut for 90° type I phase-matching. The amplifier was seeded by a cw single-mode master diode laser.



CThQ4 Fig. 2. Generated infrared DFG λ ≈ 4.3 μm power as a function of the amplifier power incident upon the crystal with cw and pulsed modes of operation. The $Ti{:}Al_2O_3$ laser cw power was fixed at 300 mW.

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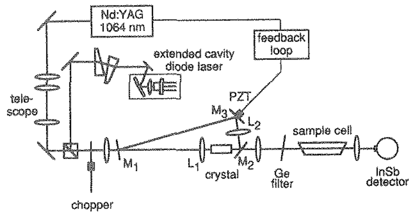

CThQ4 Fig. 3. Experimental DFG setup using a passive buildup cavity to enhance the signal wave (Nd:YAG laser) inside the nonlinear crystal. The pump wave was provided by an external cavity diode laser tunable around 800 nm.

field inside an external (passive) enhancement cavity or in one of the pump laser cavities. We report on the use of an external enhancement cavity built around the nonlinear optical $AgGaS_2$ crystal to resonate the signal wavelength (Fig. 3). As the infrared power generated in the nonlinear three-wave mixing process scales with the product of the signal and pump powers, enhancement of the signal power equally increases the nonlinear conversion efficiency. An extended cavity GaAlAs diode laser near 800 nm and a compact monolithic Nd:YAG laser at 1064 nm were used as the pump and signal sources of the difference-frequency generation process, respectively. Both enhancement techniques, the use of optical amplifiers and the use of an external buildup cavity will be compared and their practical potential for the construction of a compact infrared DFG source are discussed.

1. U. Simon, C. E. Miller, C. C. Bradley, R. G. Hulet, R. F. Curl, F. K. Tittel, Opt. Lett. **18**, 1062 (1993).