Investigations of High-Resistivity, Undoped GaP Crystal for Quasi-Phasematched Difference Frequency Generation to Produce Terahertz Frequency Local Oscillators

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We are investigating high-resistivity, undoped GaP crystal as a useful nonlinear optical material for producing terahertz frequency local oscillators using nonlinear optical frequency conversion, a.k.a. laser mixing. Diffusion-bonded stacked (DBS) crystal structures are being developed for quasi-phasematched nonlinear optical frequency conversion from Near-Infrared (NIR) to Far-Infrared (FIR) wavelengths. Sellmeier equations predict coherence lengths for this interaction in GaP to be approximately 960 micrometers. To increase conversion efficiency, a resonantly-enhanced difference-frequency generation scheme is being employed.

At NASA Langley Research Center, a system is being developed whereby a small percentage of the pump and signal laser energy (1064 nm and 1074 nm, respectively) is diverted and used to actively frequency-lock the pump and signal lasers to adjacent longitudinal modes of an ultrahigh finesse Fabry-Perot reference cavity, thereby greatly enhancing their relative stability. Frequency stability measurements made at NASA Langley with low power lasers using Pound-Drever-Hall locking combined with a new cavity locking technique have demonstrated submillihertz linewidths. The majority of the pump and signal laser energy is than coupled into an external cavity that surrounds the DBS GaP structure to build up the field intensity at the pump and signal wavelengths while the idler wave (118 micrometers) is coupled out.

Tuning must be made in increments of the free spectral range of the reference cavity (~3 GHz). Tuning between resonances can be achieved by altering the length of the reference cavity. Depending on the desired system efficiency, frequency-stability, and complexity, the signal laser can either be another Nd:YAG laser operating at 1074 nm (for the 2.5 terahertz OH line), a diode-pumped solid-state laser with a different host material, such as GSGG, or a 532-pumped optical parametric oscillator, operating near degeneracy, which could achieve continuous tuning from 100 GHz to 3.0 THz.