Development of a Novel Twin Collinear Optically Pumped Far-Infrared Laser

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To meet the demand for a high-stability collinear orthogonally polarized light source in far-infrared polarimetric interferometers and Cotton-Mouton polarimeters for tokamak plasma diagnostics, a novel optically pumped twin far-infrared laser based on formic acid (HCOOH) gas is developed in this paper. The laser adopts an innovative integrated design of dual resonant cavities, where the two cavities achieve coaxial optical path layout via an intracavity beam combining technique and share a single output coupler to ensure structural compactness and stability. Through a polarization control mechanism, the polarization directions of the 432 μm far-infrared light emitted from the two cavities are strictly orthogonal, ultimately realizing the direct output of collinearly propagating orthogonally polarized dual light beams. Experimental verification demonstrates that the laser effectively avoids the polarization crosstalk caused by optical path alignment deviations in traditional external beam combining schemes and significantly reduces the systematic error in collinear measurements, with the polarization orthogonality of the output beams being better than 95% and the long-term operating power stability being ±10%. This novel laser provides an integrated light source solution for far-infrared polarimetric diagnostic technologies, and is particularly suitable for high-precision diagnostic scenarios such as the measurements of electron density and magnetic field profiles in fusion plasmas. Meanwhile, it offers a new approach for the miniaturization and integration of multi-beam collinear polarized light sources.