High-Speed Packaging of Quantum Well Infrared Photodetector for Mid-Infrared Laser Modal Stability Studies

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Much research points to the utility afforded by using comb modal selection for mid-infrared lasers. Quantum Well Infrared Photodetectors (QWIP)⁴,⁶ hold promise for mid-infrared detection in frequency comb-enabled spectroscopic applications. Mode selection through frequency comb generation has been reported to enable greater mode stability for precise molecular spectroscopy, including stand-off detection, using mid-infrared sources.⁵,⁷,⁹,¹¹-¹³,¹⁵,¹⁶ Dual comb spectroscopy uses two frequency combs, which has a small comb pitch difference, to measure molecular absorption or transmission spectra. The two optical comb beating signal produced RF comb can be used to monitor real time measurement results. Recently frequency combs generated by quantum cascade lasers have been reported. QCL based dual-comb spectroscopy has also been demonstrated.¹¹ To study and verify the comb generation principle and modal stability we will need fast mid-IR detectors and mount them with high-speed packaging in cryogenic environment. We report here a method of processing and packaging QWIP detectors for high-speed laser modal stability studies.

Coupling into a QWIP device requires that light enter the gain material off-axis, making alignment challenging. For our study, a three-detector GaAs/AlGaAs QWIP array with 1x1mm top contacts was lapped on a semiconductor wafer lapping wheel to create a 45° face on its long axis. The device was then die-bonded to a custom copper heat-sink via electroplated indium (Indium source in indium sulfamate electroplate solution, 20 mA, 35 min.)¹⁰. The design of the copper component allows the 45° face of the QWIP device to be positioned normal to the ZnSe entrance window of a high-speed cryogenic dewar. An Au-plated SMA connection was mounted directly to the copper heat sink. Manual wire bonding was accomplished using 25 μm x 100 μm Au wire ribbon on a KULICKE & SOFFA 4523 wire bonder. The assembled QWIP device was then secured to an aluminum cold finger (~77 K) inside a four-port cryogenic dewar equipped with high-speed SMA cabling.

Our testing employed a Fabry-Perot quantum cascade laser (QCL), with a center wavelength of 7.9 μm, at 77 K, and a current threshold of 200 mA. Our method of cryogenic packaging and testing holds promise as a robust option for analysis of QWIP performance parameters, including detection speed.

Fig.1 Copper QWIP mount before installation
Fig.2 Basic schematic for coupling into QWIP
Fig.3 QWIP optical path test set-up