Terahertz sensing and imaging through self-mixing in a quantum cascade laser

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Quantum cascade lasers (QCLs) [1] are compact, semiconductor sources of narrowband terahertz (THz) frequency radiation. Owing to their coherence and high power, they are potentially well-suited for use in a broad range of application areas, including chemical sensing and biomedical imaging [1]. However, their implementation in such applications requires a compact and sensitive detection system. We address this by using the THz QCL not only as the source but also as an interferometric (self-mixing (SM)) detector. SM occurs when radiation from a laser is partially reflected from an external object and injected back into the laser cavity. The reflected radiation interferes ('mixes') with radiation in the laser cavity, producing variations in the threshold gain, emitted power, lasing spectrum and terminal voltage [2]. This technique thus allows simple, self-aligned and robust system to be constructed for measuring displacement and reflectivity [3, 4].

We investigate the use of SM sensing with a THz QCL for three-dimensional imaging and surface profiling. Figure 1 shows a three-dimensional image of a stepped GaAs structure fabricated by wet etching, in which the surface morphology has been extracted from the phase of the SM signal. Whilst the laser SM signals in [3, 4] were obtained by monitoring the voltage variations across the laser terminals, we have also demonstrated that SM signals can also be obtained by monitoring the perturbations in power collected from the back facet of the laser. Figure 2 shows electrical and optical SM signals taken by monitoring the voltage and power variation in response to a moving remote object, and demonstrates the equivalence of these two measurement approaches.

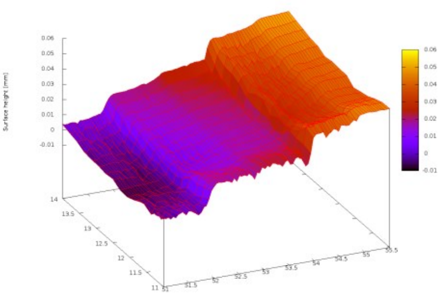

Figure 1 Exemplar three-dimensional image of a GaAs stepped sample.

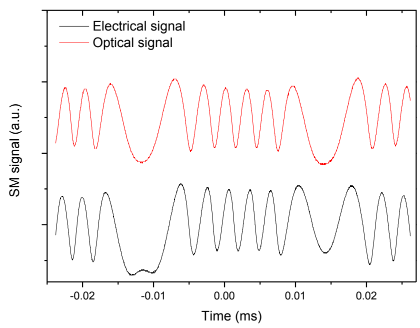

Figure 2 Exemplar electrical and optical SM signals obtained in response to a moving target.

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