



UNIVERSITY OF LEEDS

This is a repository copy of *Terahertz interferometry and imaging using self-mixing in a quantum cascade laser*.

White Rose Research Online URL for this paper:
<http://eprints.whiterose.ac.uk/75469/>

Version: Accepted Version

Conference or Workshop Item:

Keeley, J, Dean, P, Alhathloul, R et al. (4 more authors) (2013) Terahertz interferometry and imaging using self-mixing in a quantum cascade laser. In: UK Semiconductors 2013, 03-04 Jul 2013, Sheffield Hallam University.

Reuse

Unless indicated otherwise, fulltext items are protected by copyright with all rights reserved. The copyright exception in section 29 of the Copyright, Designs and Patents Act 1988 allows the making of a single copy solely for the purpose of non-commercial research or private study within the limits of fair dealing. The publisher or other rights-holder may allow further reproduction and re-use of this version - refer to the White Rose Research Online record for this item. Where records identify the publisher as the copyright holder, users can verify any specific terms of use on the publisher's website.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

Terahertz interferometry and imaging using self-mixing in a quantum cascade laser

J. Keeley^{1,a}, P. Dean¹, R. Alhathloul¹, A. Valavanis¹, L. Li¹, E. H. Linfield¹, and A. G. Davies¹

¹School of Electronic and Electrical Engineering, University of Leeds, Leeds LS2 9JT, UK
^ael08jk@leeds.ac.uk

1. Background

The terahertz (THz) frequency quantum cascade laser (QCL) is a high power (>100 mW) semiconductor source of narrowband, coherent THz radiation, which is well-suited for applications [1] in two-dimensional (2D) and three-dimensional (3D) THz imaging. However, exploitation of THz QCLs, to date, has been limited by the need to use cryogenically-cooled bolometers to achieve high sensitivity detection. We have addressed this through the design of a compact and simplified imaging system, based on a self-mixing (SM) scheme [2] in which the QCL is not only used as the THz source, but also as an interferometric detector. In this SM arrangement, the radiation emitted from the laser is coupled back into the emitting facet after being reflected off an external object. This leads to a perturbation in the QCL threshold gain, emitted power, lasing spectrum and terminal voltage [3], each of which can be monitored. Importantly, unlike when using bolometers, the detection is coherent. This opens up the possibility of sensing displacement, surface morphology and reflectivity with high precision [4, 5].

2. 2D and 3D imaging using self mixing

In our self-mixing experiments, THz radiation is focused onto the sample, which is itself raster-scanned transverse to the beam. At each position, perturbation of the QCL voltage through optical feedback from the target is recorded. Fig. 1 illustrates 2D imaging of a scalpel blade, with adjacent fringes corresponding to a change of $\lambda/2$ in the depth of the surface. To acquire a 3D image, the sample was also scanned longitudinally. The phase of the resulting fringes was used to extract the relative displacement of the sample surface, enabling a 3D image to be reconstructed. Exemplar fringes and a fitted SM function [6] for phase and amplitude extraction are demonstrated in Fig. 2.

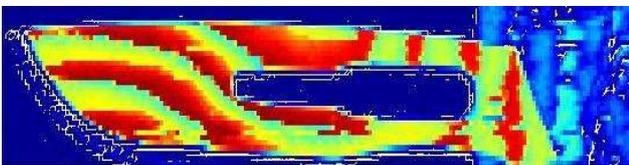


Fig. 1 2D image of a scalpel blade at 2.6 THz

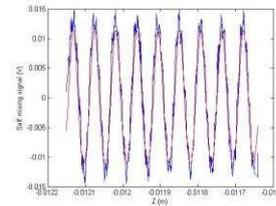


Fig. 2 Data from one pixel of a 3D image, with a fitted curve for phase and amplitude extraction

We acknowledge support from the ESPRC (UK), the Royal Society, the Wolfson Foundation, and the ERC programmes ‘NOTES’ and ‘TOSCA’.

References

- [1] M. Tonouchi, *Nature*, **1**, 97, (2007)
- [2] P. Dean, *Appl. Phys. Lett.* **99**, 081108 (2011)
- [3] R. Lang and K. Kobayashi, *IEEE J. Quant. Electron.* **16**, 347 (1980).
- [4] Y. L. Lim et al., *Appl. Phys. Lett.* **99**, 081108 (2011).
- [5] P. Dean et al., *Opt. Lett.* **36**, 2587 (2011)
- [6] A. Valavanis et al., *Sensors Journal, IEEE*, **13**, 1, 37 (2013)