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Optical Tuning of Terahertz Quantum Cascade Random Lasers

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We demonstrate optical tuneability of terahertz quantum cascade random lasers by illumination with an additional, external 813 nm source. Due to the broadband nature of the multiple scattering feedback mechanism, the unterlying mode structure can be modified. Our results pave the way towards a continuosly tuneable terahertz light source.

1. Introduction

Since their initial demonstration, random lasers have attracted a lot of interest due to their complementary characteristics compared to conventional lasers [1]. In a random laser, the light is trapped by multiple scattering in the gain medium, which has been demonstrated in different kinds of materials, ranging from grinded laser crystals to polymer films and ceramics. Recently we demonstrated [2] random lasers at terahertz (THz) frequencies by making use of quantum cascade laser (QCL) active regions, resulting in broadband surface emission with a highly collimated output beam.

2. Surface Emitting THz Random Lasers

We realized random lasers by etching a random air hole pattern through the active region of a double-metal waveguide. Due to the frequency independent feedback mechanism, broadband surface emission is achieved, covering a bandwidth of more than 350 GHz. This is the distinctive feature compared to previously demonstrated concepts providing surface emission which are designed to support a single lasing mode only. Furthermore, the electrically pumped nature of the used quantum cascade active region allows for highly controllable experimental conditions and is also crucial for potential future applications.

3. Frequency Tuning by Surface Illumination

Here, we demonstrate a tunable broadband terahertz source by optically modulating the random laser with an external illumination source [3] at 813 nm, as depicted in the scheme in Fig. 1 (a). The additional light allows spatially resolved, independent modulation of gain and loss properties. This modulation results in changes in the QCL spectrum. By further optimization of the modulation scheme, our results will pave the way towards a continuously tunable broadband terahertz light source.

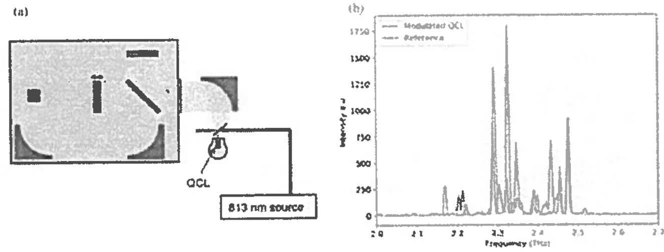

Figure 1: (a) Scheme of the experimental setup. (b) Comparison of spectra recorded with and without additional optical illumination. Occurring modes of the terahertz random laser are modified if an additional 813 nm beam is focussed onto the devices, introducing a spatial loss modulation which favours different modes. This is a caption for a figure.

References

[1] Wiersma, D. S. The physics and applications of random lasers." Nature Physics 4, 359–367 (2008).
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