Performance of a compact, continuous-wave terahertz source based on a quantum-cascade laser

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Summary

We report on the development of a compact, easy-to-use terahertz radiation source, which combines a quantum-cascade laser (QCL) with a compact, low-input-power Stirling cooler.

Introduction

Terahertz (THz) quantum-cascade lasers (QCLs) are very promising radiation sources for many scientific and commercial applications. Examples are high-resolution spectroscopy in atmospheric research or astronomy and imaging in the fields of security, non-destructive testing, and biomedicine.

QCLs have several advantages over other sources. In particular, they are frequency tunable, small, and require low electrical input power. However, liquid-helium cooling or cooling with bulky cryocoolers requiring large electrical power are impractical for air- and spaceborne or commercial applications. We report on the development of a compact, easy-to-use, continuous wave THz source, which is based on a QCL and a compact, low-input-power Stirling cooler.

Discussion

The QCL, which is based on a two-miniband design, has been developed for high output and low electrical pump power. Efficient carrier injection is achieved by resonant longitudinal-optical phonon scattering [1]. The amount of generated heat complies with the cooling capacity of the Stirling cooler. The whole system weighs less than 15 kg including cooler, power supplies etc. The output power is well above 1 mW at 3.1 THz. With an appropriate optical beam shaping, the emission profile of the laser becomes a fundamental Gaussian one (Fig. 1). Sub-MHz frequency accuracy has been achieved by locking the emission of the QCL to a molecular resonance [2]. We will present the performance of the QCL-based source along with some application examples in high-resolution molecular spectroscopy.

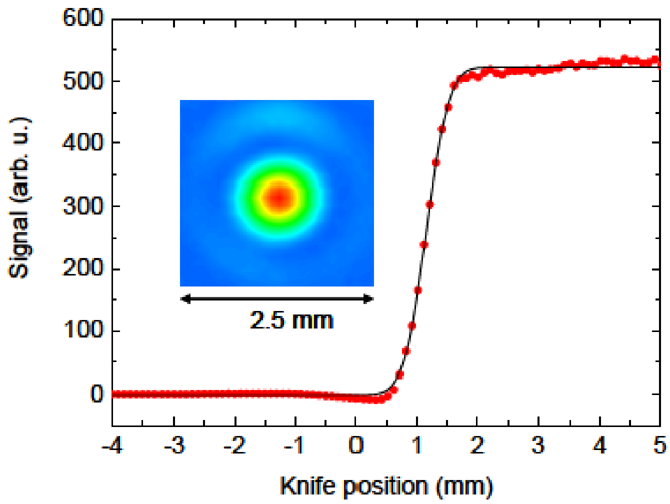

Fig. 1: Beam profile at the position of the minimum waist by scanning a sharp metal blade. The output power is well above 1mW at 3.1 THz.

The QCL's broad frequency coverage of almost 10% of the emission frequency makes it attractive for implementation into an external cavity. This will allow for tuning of the emission frequency across a broad range as required for a spectrometer. Along with the sub-megahertz frequency stabilization to a molecular absorption line this source is an attractive option for a THz local oscillator in a heterodyne spectrometer. The results indicate that future developments of this source may result in many scientific or even commercial applications.

References

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