4 THz beam filter based on a back to back Si-lens system

Gan, Y.; Mirzaei, B.; Van Der Poel, S.; Silva, J. R.; Finkel, M.; Ridder, M.; Hu, Q.; Van Der Tak, F. F.S.; Gao, J. R.; More Authors

Publication date
2020

Document Version
Accepted author manuscript

Published in
Proceedings of the 31st Symposium on Space Terahertz Technology, ISSTT 2020

4 THz beam filter based on a back to back Si-lens system

Y. Gan[1,2], B. Mirzaei[1,3], S. van der Poel[3], J. R. Silva[1,2], M. Finkel[1], M. Eggens[1], M. Ridder[1], A. Khalatpour[4], Q. Hu[4], F.F.S. van der Tak[1,2], and J. R. Gao[1,3]

We report a novel, spatial beam filter using two elliptical silicon (Si) lenses, mounted back to back, between which there is an opening aperture, to produce a Gaussian beam at 4 THz. The two Si lenses with a diameter of 10 mm have an antireflection coating layer, while the opening aperture is a circular hole on a thin Au layer defined on a double-side polished Si wafer. A mechanical lens holder is introduced to allow for aligning the 1st lens, the Si chip (with the aperture), and the 2nd lens as an integrated beam filter with an accuracy of 1 μm along their optical axis.

We demonstrate experimentally that such a back-to-back Si lens beam filter works using a 3.8 THz quantum cascade laser (QCL) as the source. We have shown that :

a) When the back-to-back Si lens has no aperture, namely only a bare Si wafer sitting between the two lenses, we obtained the transmission of a Gaussian beam through the system to be 72.5%±1%, which agrees to the simulation (77%) by COMSOL Multiphysics.
b) With an input beam of non-Gaussian profile (see Fig.1), and with an aperture, the back-to-back lens system shows an output beam with a Gaussicity of >98% and a transmission of 35-50 % from the input beam. The results are illustrated in Figure 1.

We are currently adjusting the aperture sizes and also input beams to optimize the performance of the beam filter. The ultimate goal of this research is to realize an ideal LO source for heterodyne arrays at supra-THz frequencies by combining a spatial beam filter with a QCL. An LO with an ideal Gaussian beam is crucial for optical system designs and for reducing stray light in practice.

A back-to-back Si lens beam filter is an alternative to the back-to-back (corrugated) metallic feedhorn approaches [1], which are known to be extremely difficult to be fabricated at the THz frequencies and also expensive. Furthermore, the latter has also a narrow bandwidth.

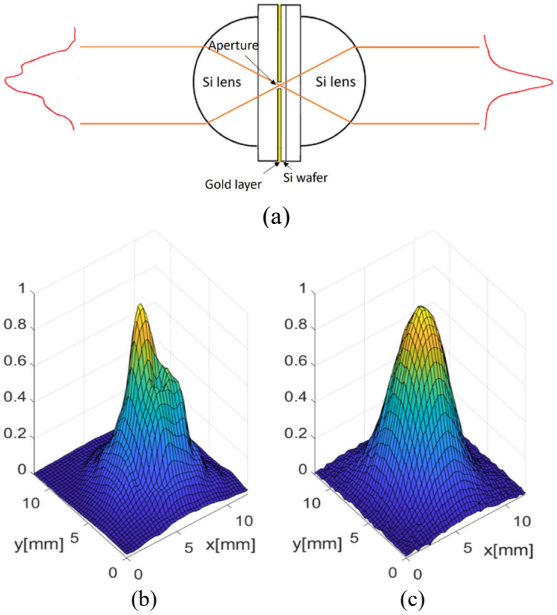

Fig. 1. (a) The schematic of the back to back lens system. Two Si lenses are used to focus and collimate the incoming beam, and an opening aperture defined by the gold layer on the Si wafer is used to filter non-Gaussian components; (b) The 3D profile of the input beam, generated by a 3.8 THz QCL and collimated by a Polyethylene lens; (c) The 3D profile of the output beam from the back-to-back lens and aperture system. Compared to the input beam, the output beam has a nearly perfect Gaussian profile, with 99.8 % Gaussicity.

REFERENCES

[1] As an example, see Hong Pu, et al., "A Broadband Back-to-Back Corrugated Horn Structure for Gaussian Mode Filtering in Terahertz Band," 2018 International Conference on Microwave and Millimeter Wave Technology (ICMMT), 18321784.

[1] SRON Netherlands Institute for Space Research, the Netherlands.
[2] Kapteyn Astronomical Institute, University of Groningen, 9747 AD, Groningen, The Netherlands.
[3] Faculty of Applied Science, Delft University of Technology, the Netherlands.
[4] Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, USA.

NOTES: