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Hybrid Terahertz Imaging with Different Arrangements of 3D-Printed Beam-Shaping Components

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Optical imaging systems play a critical role across scientific and industrial fields, including non-destructive material inspection, security screening, and industrial quality control. While traditional imaging solutions usually depend on high-energy radiation like X-rays, which show clear drawbacks regarding operational safety, system cost, and potential sample degradation, terahertz (THz) imaging offers a safer alternative by utilizing non-ionizing radiation that can easily penetrate various dielectric materials [1].

This research investigates thin, 3D-printed diffractive optical elements engineered to shape different THz beam profiles, specifically Gaussian, Bessel, and Airy distributions [2]. These elements are incorporated into a hybrid THz imaging architecture capable of performing both amplitude-based and interferometric measurements. Fabricated using extrusion 3D printing, these diffractive components are utilized for beam focusing, and signal collection from the target. The imaging performance is evaluated by testing different combinations of these beam-shaping elements at various positions in the optical system. Different imaging targets such as low-absorbing and thick ones are investigated. The overall system capabilities are assessed by quantitatively comparing image quality between the direct amplitude and interferometric imaging modes. Finally, the impact of these various component configurations on spatial resolution and image contrast are evaluated to identify the optimal lens combinations for THz imaging applications.

The results show, that there is no single best optical component arrangement. The Bessel-Gaussian combination was shown to be the most verstile, while Gaussian-Bessel combination yields the highest numerical resolution. Upon thick object imaging evaluation, it was concluded that Bessel-Gaussian combination performs the best in direct imaging arangement while Airy-based combinations are superior for interferometric imaging applications.

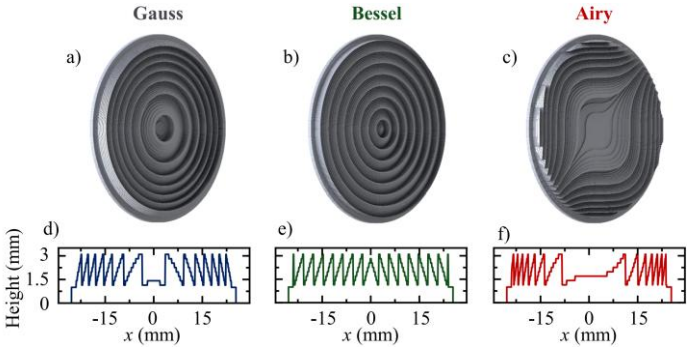

Fig. 1 (a) – (c) Models of THz optical components evaluated in the system, (d) – (f) height profiles along the x-axis

REFERENCES

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