# Fabrication and characterization of THz meta-lens by ultraviolet femtosecond laser ablation

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In recent years, various applications of terahertz (THz) waves have been proposed, including high-speed communication and imaging [1]. THz optical elements are essential to realize these applications.

Metasurfaces are optical elements which achieve a designed functionality by tailoring the optical response of wavelength-scale structures. Metasurfaces have made it possible to design optical elements which are not limited by bulk material properties. In particular, meta-lenses, or metasurfaces tailored for light-focusing performance, have attracted much attention for their potential to realize ultimately thin lenses [2]. Recently, it has gained attention that highly efficient meta-lenses can be designed by using Mie resonance in subwavelength dielectric structures [3]. In particular, a THz membrane meta-lens realized by forming through-holes several hundred micrometers in diameter in a Si thin film was proposed, demonstrating impressive focusing performance and efficiency [4]. Typically, the fabrication of such meta-lenses necessitates the utilization of lithography technology. This involves the operation of various specialized devices and chemicals in a cleanroom environment. Consequently, the processing procedure becomes costly and complicated; to improve the practicality of meta-lens technology, a simplified fabrication method is desired.

Femtosecond laser processing is capable of micrometer-order, high-precision processing and has been shown to be applicable to the fabrication of THz optics [5]. Using such technology, we reported on the fabrication of a free-standing membrane meta-lens with a 20 mm diameter and 30 mm focal distance for a design frequency of 0.8 THz [6]. An optical microscope image of the laser fabricated meta-lens is shown in Fig.1(a). The focusing performance of this meta-lens was found to be comparable to that of commercial polymer-type THz lenses, and was able to focus THz light to a spot diameter of approximately 1 mm in diameter, as measured by a THz camera (Fig.1 (b)). In this work, we compare the performance of this lens with that of a 3D simulation model. By considering both the spectral width of the evaluating THz wave and the camera spectral sensitivity, we find good agreement in the focus profile between both simulation and experimental results, showing that the lens has high potential designability (Fig.1 (c)). This result demonstrates that laser processing is available option for THz meta-lens fabrication and establishes a simple meta-lens fabrication technique.

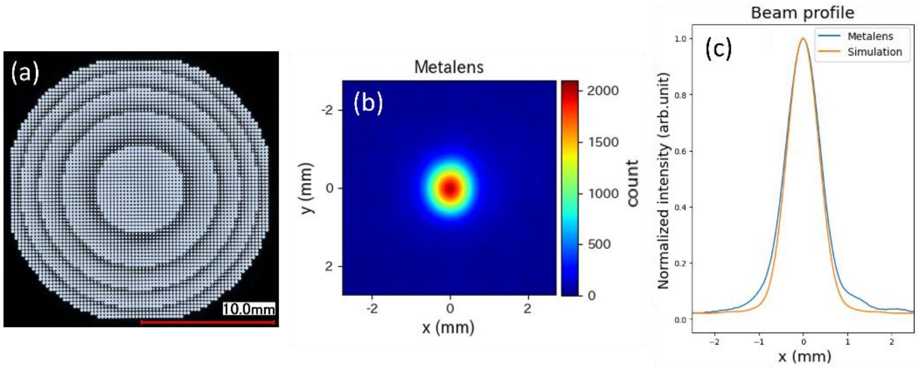


Fig.1 (a) Microscopic images of the fabricated THz metalens. (b) The profile at the focal point achieved by the membrane meta-lens, observed by a THz camera. (c) Full width at half maximum of meta-lens and simulation results at the focal point

## References

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