Tunable terahertz vortex source based on difference frequency generation

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1. Introduction

An optical vortex [1] carries an annular intensity profile and an orbital angular momentum, characterized by a topological charge ℓ, owing to its helical wavefront, and it provides us a variety of potential research opportunities, including chiral fabrications [2-4], high-speed communications and scanning microscopes with a spatial resolution beyond the diffraction limit. The above-mentioned applications require strongly frequency versatility of the vortex light sources, thus, a THz vortex source will offer entirely new fundamental sciences and advanced technologies for THz photonics.

To date, we have successfully developed THz vortex sources by employing a Tsurupica vortex phase plate (VPP) [5-6]. However, the VPP is typically designed for a specific frequency, and it inherently constrains the frequency versatility of THz vortex sources.

In this presentation, we propose a novel THz vortex source based on a difference frequency generator (DFG) formed of a 4'-dimethylamino- N-methyl- 4-stilbazolium tosylate (DAST) crystal. This system exhibited an extremely wide tunability in a frequency range of 2-6 THz.

2. Experiments and results

The experimental setup of the system is shown in Fig. 1. The output from PPSLT-OPA1 was converted into an optical vortex ($\ell = 1$) by using a VPP (Fig. 1(b)), and its wavelength, λ_1, was then fixed to be 1.56 μm. The PPSLT-OPA2 output with a Gaussian spatial form (Fig. 1(c)) was tuned within a wavelength range of 1.50-1.64 μm. Subsequently, the OPA1 and OPA2 outputs were then delivered to a DAST crystal, thereby generating a THz vortex output as a different frequency output.

The 4 THz output exhibited a vortex mode with a topological charge of $\ell = \pm 1$ (Fig. 2 (a-b)), as evidenced by an annular spatial form and a twin-lobed far-field rising to the right and left by an inclined focusing method (Fig. 2 (a'-b')). Also, it is noteworthy that the undesired higher-order radial modes were suppressed owing to soft-aperture effects in the DFG. The THz vortex output with a topological charge of $\ell = \pm 1$ was continuously tuned within a frequency range of 2-6 THz.

3. Conclusions

We have demonstrated a widely tunable THz vortex source formed of a picosecond DAST difference frequency generator. The THz vortex outputs with a topological charge of $\ell_{THz} = \pm 1$ are obtained at a frequency range of from 2 to 6 THz. Such THz vortex source will provide new advanced technologies, such as the 2-dimesional identification of structures (crystalline, polymorphism, chirality etc.) of crystals with a high spatial resolution beyond the diffraction limit.

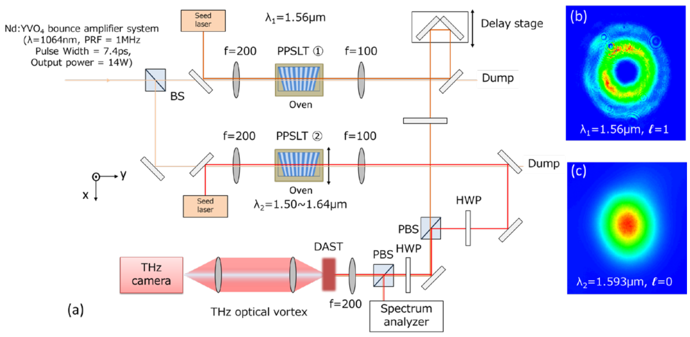

Fig.1 Experimental setup of a tunable THz vortex generator based on a 1.5 μm vortex pumped DAST-DFG

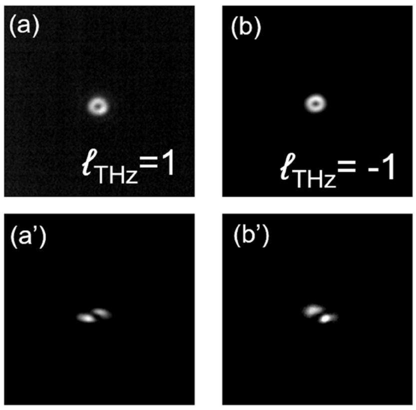

Fig. 2. (a),(b) Spatial profiles of the THz vortex output. (a'),(b') Astigmatically focused THz vortex outputs.

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