Nanoengineered spintronic-metasurface terahertz emitters enable beam steering and full polarization control

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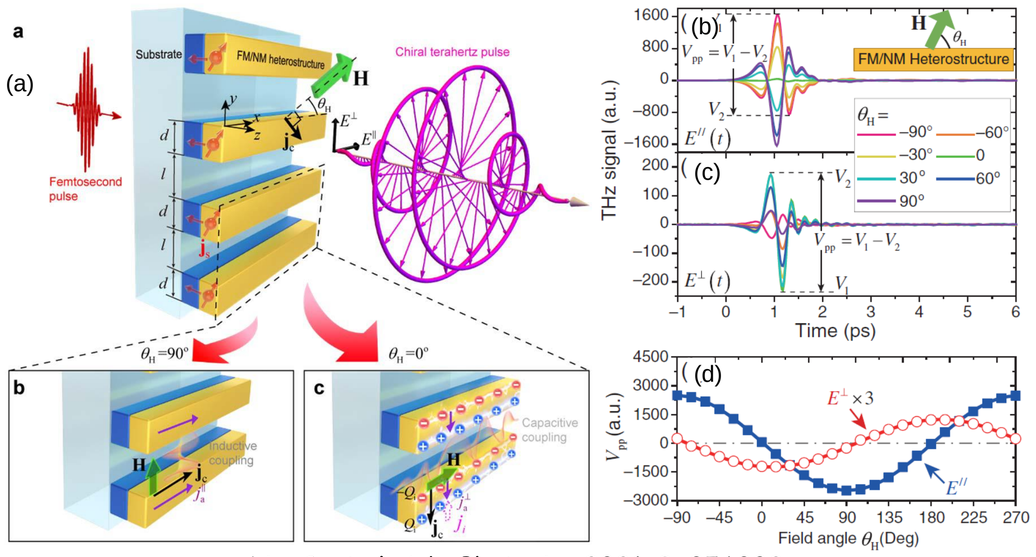
Ⅰ Introduction

Active spintronic-metasurface terahertz emitters(SMTE)

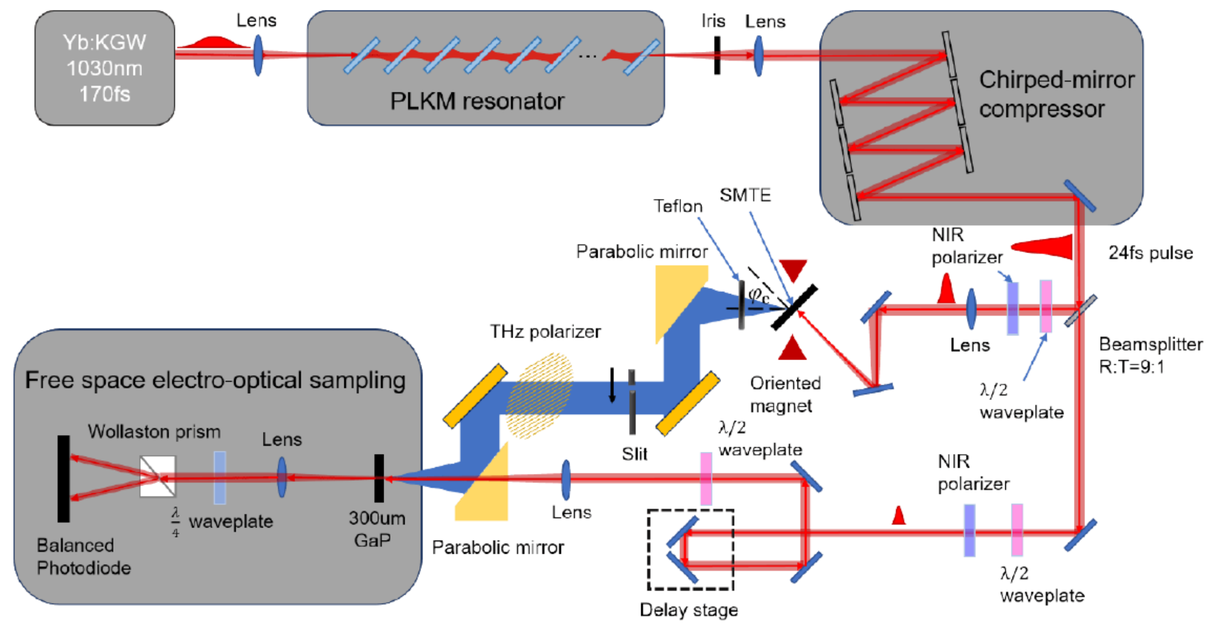


- Liu, C, et al. Adv. Photonics 2021, 3, 056002.

- The metasurface can influence the device functionality by inducing strong amplitude and phase modulations onto the emitted terahertz waveforms.

Ⅱ experiment

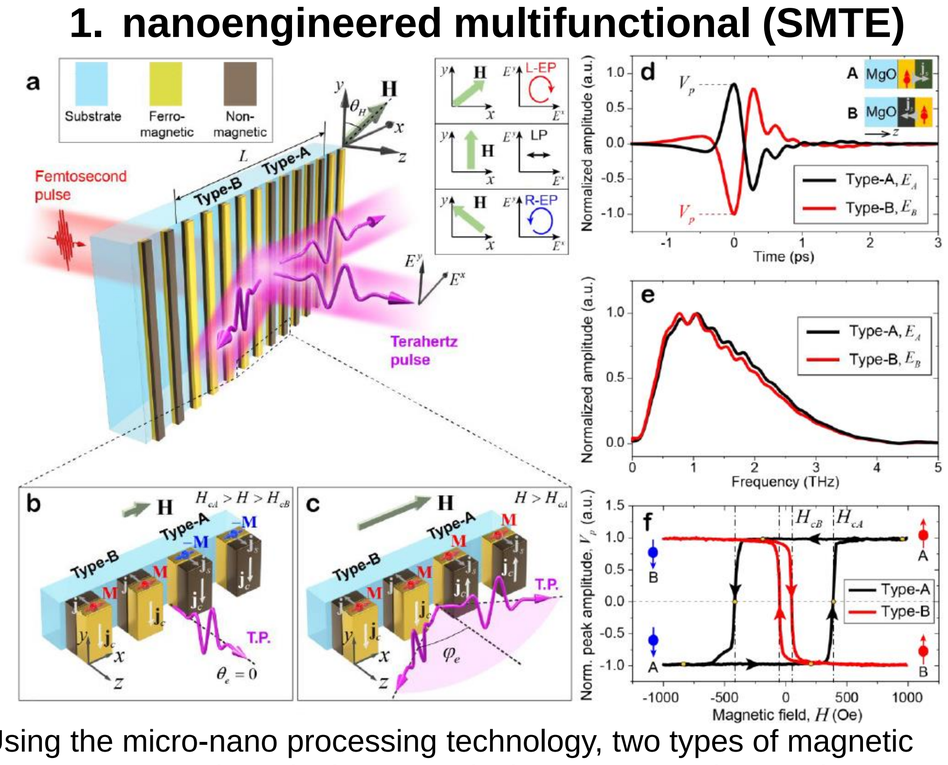
Schematic of experiment setup



- The ultrashort laser pulses (**duration ~24 fs**, center wavelength 1030 nm and repetition rate 100 kHz) generated by the a compressed Yb:KGW laser amplifier are used to excite SMTE device.
- The emitted terahertz field and its polarization state are detected by the **polarization- and time-resolved terahertz spectroscopy** setup based on electro-optic sampling.
- The slit is installed on a motorized stage which allows us to scan the terahertz radiation in the transverse direction with **high spatial resolution**.

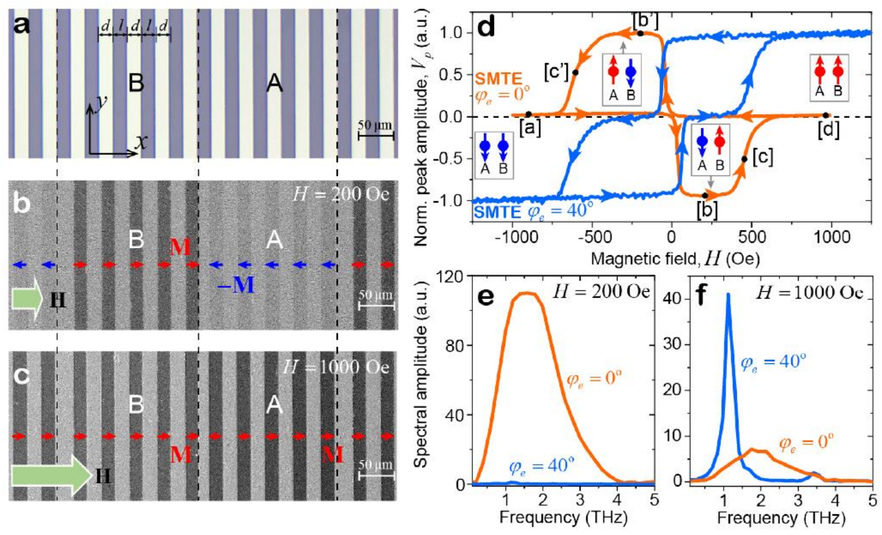
Ⅲ Main Results

1. nanoengineered multifunctional (SMTE)



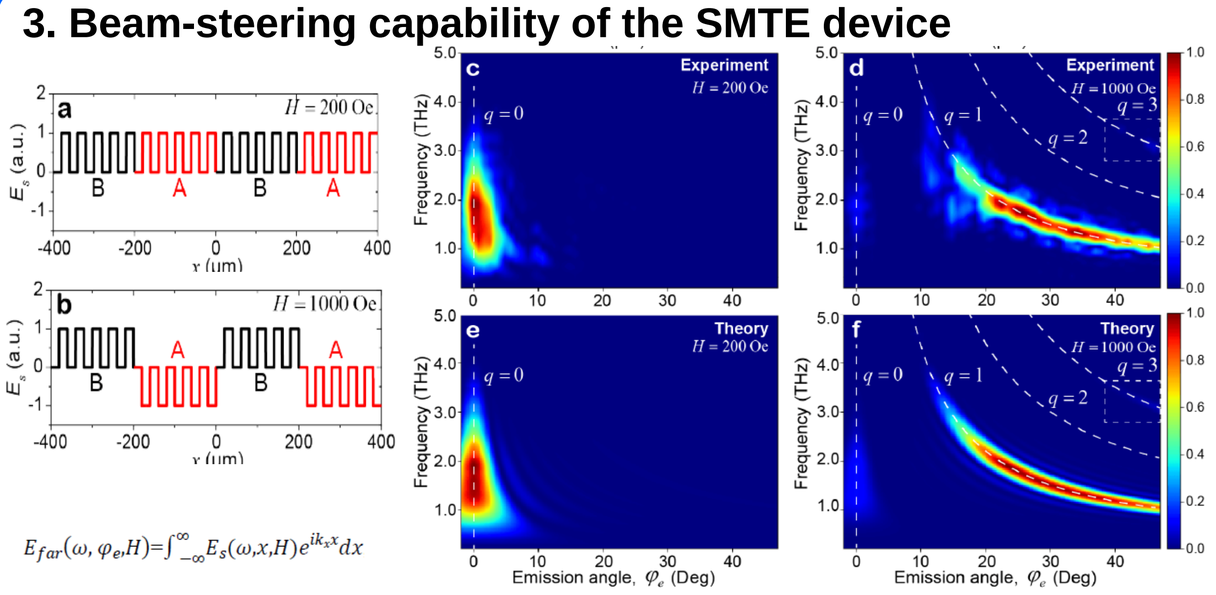
- Using the micro-nano processing technology, two types of magnetic heterostructures in a single STME device: type-A FM/NM and type-B NM/FM have been fabricated to control the generated terahertz waves.

2. Hysteresis behaviors of the SMTE device



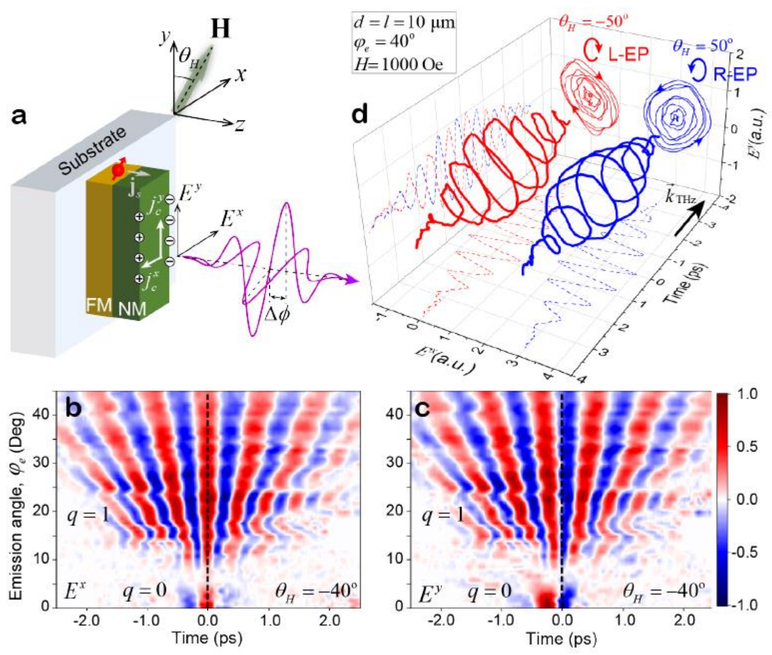
- Because the two types of stripes can well preserve the **difference in coercivity**, the THz emission amplitude in different emission angle(φ_e) can be controlled by **the strength of external magnetic field**.

3. Beam-steering capability of the SMTE device



- The stripe-patterned SMTE here works as a metagrating, with the lattice constant Λ controllable by the external magnetic field.
- H=200 Oe, THz emission is normal to the SMTE surface (q=0 order).
- H=1000 Oe, metagrating diffraction leads to the spatial chirp of the terahertz waves at different φ_e.

4. Polarization-control capability of the SMTE device.



- The full control the **polarization states** of the generated terahertz beams can be enabled by changing the **field angle θ_H** and utilizing the transverse geometric confinement of the laser-induced charge currents (j_c) applied by the individual stripes.

Ⅵ Conclusion

- In conclusion, we show the realization of the nanoengineered multifunctional SMTE device, which enables the generation of broadband terahertz waves, and meanwhile possesses **the beam-steering and polarization-control capabilities** which are mutually independent of each other.
- By further introducing different magnetic materials, spintronic effects, as well as the laser-assisted magnetic-printing technology, it has great potential to develop **advanced multifunctional metasurface emitters** for arbitrarily realizing various complex terahertz waveforms, including terahertz vortex beams and toroidal pulses.