# Team demonstrates an ultra-broadband tunable terahertz absorber of graphene and hierarchical plasmonic metamaterials

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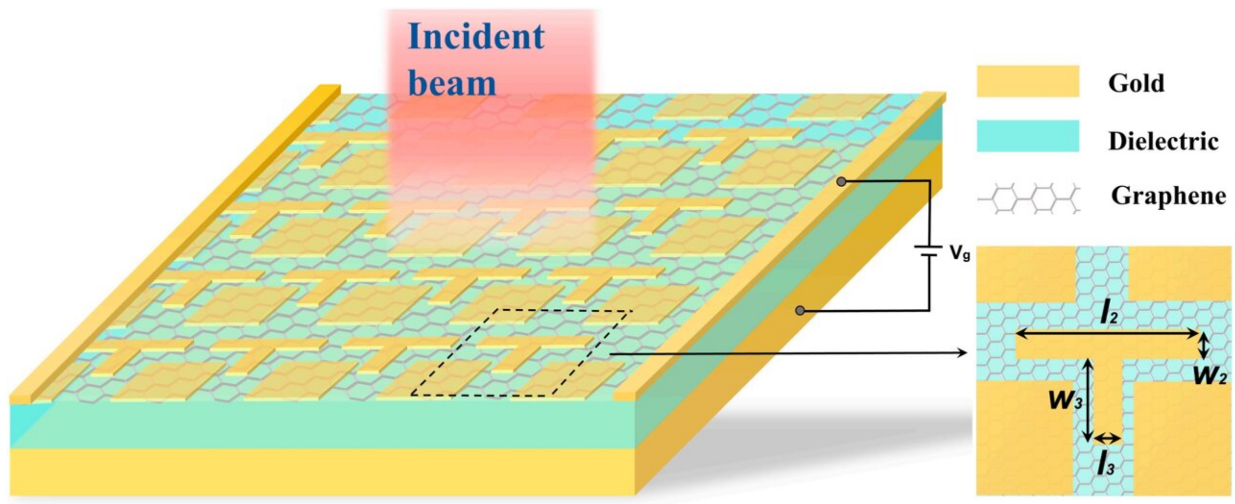


Broadband metamaterial-based perfect absorbers (MPAs) have significant potential in many applications. However, the design and fabrication of ultra-broadband terahertz MPAs pose considerable challenges. Credit: Advanced Devices & Instrumentation

Perfect absorption arises from the strong interaction of valence electrons with light in a conducting material. Optical metamaterial is an effective approach to exploit the superior photon capture capability. Thus, the perfect absorbers could be achieved by nanoscale resonant plasmonic and metamaterial structures.

A metamaterial perfect absorber (MPA) typically consists of periodical subwavelength metal (e.g., plasmonic superabsorber) or dielectric resonant units. Compared to static passive physical systems, tunable metamaterials can dynamically manipulate electromagnetic waves, improving multidimensional control of the optical response. There are two typical strategies to achieve tunable properties in metamaterials: mechanical reconstruction and changing the lattice structures of the metamaterials.

In contrast to these classical methods, the combination of functional materials and metamaterial structure offers a way to change the optical properties of materials through external stimuli and has a faster response rate. As a typical tunable functional material, graphene has excellent mechanical, electrical and optical characteristics. Incorporating graphene into metamaterial structures can significantly enhance light-matter interactions.

In this vein, Professor Weiping Wu's group has demonstrated a novel tunable ultra-broadband terahertz absorber utilizing the unique properties of graphene and hierarchically structured plasmonic metamaterials. The team's research paper is published in the journal *Advanced Devices & Instrumentation*.

The metamaterial structure comprises alternating T-shaped gold bars/squares, a dielectric layer, together with a graphene layer on a gold layer. The average absorption of the MPA achieved 90% over an ultra-broad frequency range spanning from 20.8 THz to 39.7 THz. The origin of the broadband characters is analyzed through electric field diagrams, and the modulation of the absorption window by graphene is investigated. Furthermore, the influences of different parameters on the results are studied, and the research discusses the potential application of this structure in the field of optoelectronics.

Finally, some recently reported broadband absorbers in the THz–far-infrared band are compared and analyzed with the results of the present work. The proposed metamaterial broadband absorber has a higher average absorption and a wider frequency range. The proposed structure has only one layer of patterned gold, which has great advantages compared to other literature in terms of fabrication.

In conclusion, a novel ultra-broadband tunable terahertz absorber of graphene and hierarchically structured plasmonic metamaterials is proposed and studied, and a near-perfect ultra-broadband absorption from 20.8 THz to 39.7 THz is numerically investigated. The proposed absorber is implemented by arranging two gold structures of different sizes alternately in each unit cell. The bandwidth exceeding 90% absorption of the broadband absorbers is about 18.9 THz.

By adjusting the Fermi energy level of the graphene, the position of the ultra-broadband can be tuned. Moreover, the effects of geometrical parameters on the absorption spectra of the absorber are analyzed quantitatively. These results imply that the metamaterial absorber proposed in this work can lead to further improvements in the field of tunable filtering, detectors, controlled thermal radiation and other photonic devices.

**More information:** Xiaoman Li et al, Ultra-Broadband Tunable Terahertz Absorber of Graphene and Hierarchical Plasmonic Metamaterials, *Advanced Devices & Instrumentation* (2023). DOI: 10.34133/adi.0014

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