Domino plasmons for subwavelength terahertz circuitry

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Electromagnetic radiation in the terahertz (THz) regime is a central resource for many scientific fields such as spectroscopy, sensing, imaging, and communications. Within this context, the building of compact THz circuits would stand out as an important accomplishment. This requires the design of THz waveguides carrying tightly confined electromagnetic modes, preferably with the following properties. First, structures should be easily manufactured, planar, and monolithic. Second, subwavelength transverse size is also needed. Finally, absorption and bend losses should be small, and the waveguides sufficiently versatile for the design of key functional devices. Particularly important are in/out-couplers since they work as the interface to external waves. In this context, compact tapers able to laterally compress the modes down to the subwavelength level seem essential.

With the aim of addressing the above mentioned issues, in this paper a new approach for the spatial and temporal modulation of electromagnetic fields at terahertz frequencies is presented. The waveguiding elements are based on plasmonic and metamaterial notions and consist of an easy-to-manufacture periodic chain of metallic parallelepipeds protruding out of a metallic surface (Fig. 1, left). The electromagnetic modes supported by such structures are termed *domino plasmons*.

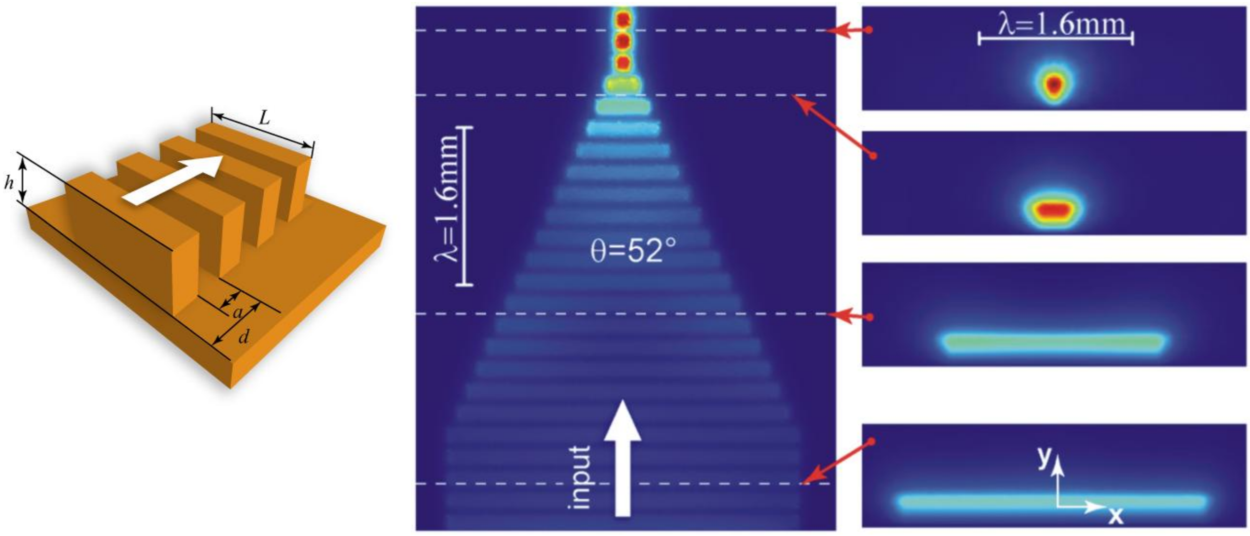

Fig. 1 Left: A domino plasmon structure consists of a periodic array of matallic box-shaped elements protruding out of a metallic substrate. Right: Top view and cross sections of a tapered domino structure, displaying the subwavelength field confinement and enhancement with negligible loss and reflection

The properties of domino plasmons are controlled by the structure geometry, the most important parameters being the periodicity, *d*, and the height, *h*, of the parallelepipeds. In the talk it will be shown that, when the operation frequency lies in the far infrared or the THz regime, the dispersion relation of domino plasmons is rather insensitive to the waveguide width, *L*. This susprising behavior can be understood as a consequence of the existence of a metallic substrate and the fact that the gaps between consecutive parallelepipeds are open not only at the top but also at both lateral sides. In contrast with other conventional structures, the insensitivity to the waveguide lateral size of domino plasmons is achieved preserving at the same time a tight confinement even when the waveguide transverse dimension, *L*, is well in the subwavelength regime. This property enables the simple implementation of key devices, such as tapers (Fig. 1, right). Such elements allow the subwavelength confinement and enhancement of THz electromagnetic fields.

The ohmic absorption losses and the radiative losses in bent waveguides are characterized, finding reasonably low values. These properties, when considered together with the previously mentioned insensitivity to lateral width, suggest that domino plasmons could find application to build subwavelength THz devices and circuits. This is confirmed by the implementation of essential circuit elements such as power dividers, directional couplers, waveguide bends, and ring resonators. These elements are characterized by means of rigorous Finite Elements simulations, demonstrating the flexibility of the proposed concept and the prospects for terahertz applications requiring high integration density.

References

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