Multifunctional chiral metamaterials: Multiplexing holograms and switching chirality

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Abstract: We use chirality to realize metamaterials with multiple independent functionalities, including independent holograms for circularly polarized waves of opposite handedness, switching directionally asymmetric transmission and chirality on/off, and normal mirror to chiral mirror transformation.

Chirality and phase transitions provide opportunities to realize a broad range of multifunctional metamaterials. For example, independent functionalities for left- and right-handed circularly polarized waves can be achieved by combining chiral resonators of opposite handedness. Furthermore, metamaterials can exhibit different symmetries at different temperatures (e.g. chiral/achiral) by engaging the insulator-to-metal phase transition of vanadium dioxide, allowing associated polarization effects to be controlled and even switched on/off.

Fig. 1(a) shows multiplexed holograms for circularly polarized THz waves. The metamaterial hologram is assembled from chiral resonators that only reflect either left-handed or right-handed THz waves, allowing the holographic images for circularly polarized waves of opposite handedness to be controlled independently, with negligible cross-talk. The concept is broadly applicable, e.g. for polarization-selective redirection, focusing, diffraction and detection of circularly polarized waves.

Fig. 1(b) illustrates chirality switching based on the insulator-to-metal phase transition of vanadium dioxide. The metamaterial is chiral at room temperature and consists of mutually twisted split rings in parallel planes. Upon heating to 87°C, the structure becomes achiral as vanadium dioxide short-circuits the split ring gaps with increasing temperature. This chiral-to-achiral transition results in dynamic control of asymmetric transmission of linearly polarized THz waves. The transmission asymmetry is 21% at room temperature and drops to 1% at 87°C.

We will give an overview over such metamaterials with multiplexed functionalities and switchable chirality. Examples will include holograms, switching of chiral polarization effects and switchable chiral mirrors.

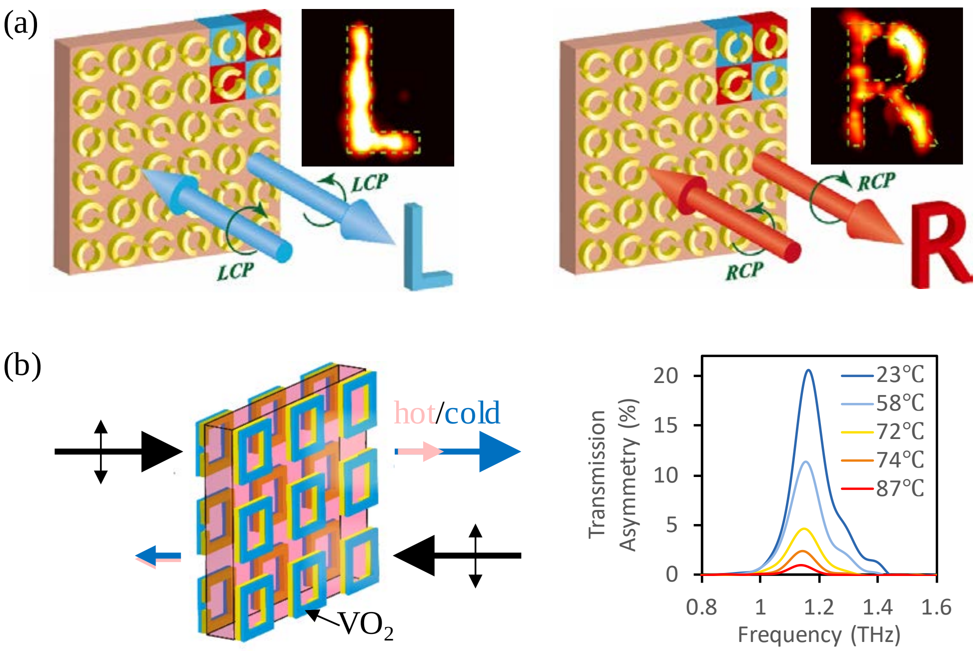

Fig. 1 Multifunctional chiral metamaterials. (a) Independent holograms for left-handed and right-handed THz waves (LCP/RCP) controlled by chiral resonators of opposite handedness (blue/red). Insets show detected holograms at 0.6 THz. (b) Switching a chiral polarization effect on/off. The insulator-to-metal transition of vanadium dioxide (blue) transforms the resonant structure from chiral at room temperature to achiral at 87°C. This causes the measured transmission asymmetry for linearly polarized THz waves to drop from 21% to 1%.