Nanoscale Vectorial Photocurrents via Optoelectronic Metasurfaces

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Symmetry (and symmetry breaking) plays arguably the utmost important role besides chemical composition in determining material properties [1], ranging from electronic band structures and topological phases to optical transition rules and nonlinearities. While it is intrinsic in naturally occurring materials, artificial materials such as photonic crystals, metamaterials and metasurfaces [2] bear the advantage of designing their symmetries by tailoring the unit cell structures and lattice arrangements, leading to photonic band structure engineering and enhanced nonlinear responses as preeminent examples. Here we focus on the inversion symmetry breaking of optoelectronic metasurfaces for the generation and control of nanoscale directional ultrafast photocurrents, with tear-drop plasmonic nanoantennas on graphene as a model system [3]. We show recent results on photocurrent excitation, control, and reconfiguration through resonator design and spatial patterning along with the incident light polarization. As a direct application, these optoelectronic metasurfaces serve as efficient and versatile sources of ultrafast terahertz radiation, particularly for generating complex terahertz vector beams. The present principle of nanoscale directional photocurrents is quite general, not limited by graphene and specific mechanism [4,5], nor the excitation wavelength [6,7], thus providing broad implications for microelectronics and information processing in addition to the great interest in exploring fundamental science of light-matter interactions.

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