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Superconductor Terahertz Photonics

Yogesh Kumar Srivastava(1,2), and Ranjan Singh* (1,2)
[1]Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, 21 Nanyang Link, Singapore 637371, Singapore.
[2]Center for Disruptive Photonic Technologies, The Photonics Institute, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798, Singapore, E-mail: ranjans@ntu.edu.sg

Superconductors are a fascinating family of materials, typically characterized by vanishing electrical resistance and perfect diamagnetism below a certain critical temperature (T_c). The unique and dramatic properties of the superconductors are attributed to the presence of Cooper pairs. Ultrafast response observed in the Cooper pair dynamics upon photoexcitation of the high- T_c cuprate superconductors is widely explored to understand the underlying physics and the mechanism which leads to Cooper pair formation. The ultrafast switching between macroscopic quantum superconducting phase and the resistive phase of photo-excited cuprate superconductors can be exploited for high performance quantum-photonic devices. In this work, we demonstrate all-optical dual-channel switching of sharp Fano resonances excited in superconducting asymmetric split ring resonators. Upon irradiation with optical pump, the ultrasensitive Cooper pairs in superconductor undergo dual dissociation-relaxation dynamics within a single superconductivity restoration cycle and lead to dual switching windows in picoseconds timescale. The extreme sensitivity of Cooper pairs to external perturbations enables access to such unique dual switching features, which can be readily engineered by varying the substrate properties.

Moreover, we introduce a thinnest superconducting terahertz metamaterial. We demonstrate that superconducting metamaterials of thickness 25 nm supports excitation of Fano resonances while metallic samples of identical thickness do not show any Fano resonance. Upon irradiation with optical pump, ultrathin superconducting metamaterials show extremely low threshold switching. Our results manifest new ways to realize extremely low threshold ultrafast dual channel switchable devices which could be highly advantageous for various application in time division multiplexing, superconducting photodetectors, THz high-speed wireless communication and superconducting radiation sensors.

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