Incorporating superconductors in terahertz metamaterials potentially provide unprecedented opportunities to control resonance features which has huge implications in the real-world technologies. This thesis reports on new applications of superconducting terahertz metamaterials for ultra-low loss operation, ultrafast manipulation of electromagnetic radiation and novel quantum effects. We demonstrate ultrahigh-Q Fano resonances in superconducting asymmetric split ring resonator arrays at extremely low structural asymmetry regime which is inaccessible by identical high conductivity metallic structures. Furthermore, 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 discover that superconducting metamaterials of thickness 25 nm show well evolved Fano resonances while metallic samples of identical thickness do not show any resonance excitation. Ultrathin superconducting metamaterials provide solution for low threshold switching and inductance enhanced devices. Furthermore, a niche approach to realize Meissner effect at terahertz frequencies in quantum metamaterial system to achieve the quantum level switching between flux exclusion and flux penetration in a metal-superconductor hybrid quantum metamaterial system is developed. Most importantly, upon irradiation with the external optical pump, the quantum metamaterial undergoes ultrafast switching between the flux penetration and flux exclusion states at very low pump fluences and thereby lead to low-loss, ultrasensitive, frequency agile, switchable quantum photonics devices.