Molecular identification based on terahertz surface field depletion of terahertz plasmonic metamaterials

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Metal thin films compositing two-dimensional (2D) hole arrays with subwavelength-scaled aperture widths and nano–micrometers of thicknesses facilitate the study of surface plasmon polaritons (SPPs) in the terahertz (THz) frequency range. Those THz waves supported by a metal-hole-array (MHA) structure are also called surface resonance waves (SRWs) because of the transmission-resonance effect of metal surface waves. Their spectroscopic feature entails a distinctly extraordinary transmission (EOT), as explained by the Fano model or indicated as the Fano interference effect. EOT of THz SRW has sharp peaks in transmission spectra with much higher transmittance than that of metal-hole guided THz waves, i.e., metal-hole waveguide modes. For EOT of THz SRW, high local-field intensity accumulates inside MHA structures, consequently performing one artificial material of THz plasmonics, i.e., THz plasmonic metamaterials.

In this presentation, the THz plasmonic metamaterial is considered from a metal-wire-woven hole array (MWW-HA), as shown in Fig. 1(a)–(c). MWW-HA is not a planar MHA that is perforated on one metal slab. MWW-HA does not have EOT of THz SRW, but the corresponding highest transmittance of metal-hole guidance approaches 0.94. However, the spectral peak splits due to middle-woven-metal wire of MWW-HA unit cell structure as decreasing THz frequency and shown at Fig. 1(d). The two spectral peaks are denoted by arrows and separated by one spectral dip. Power of the spectral-dip wave is confined by the middle-woven-metal wire of MWW-HA and strongly depletes without reflection. We apply this surface wave for molecular identification between polyimide (PI) and polyamic acid (PAA). PI and PAA have intrinsic difference of molecular polarity and water content, and thus surface field depletion of MWW-HA succeeds the molecular identification.

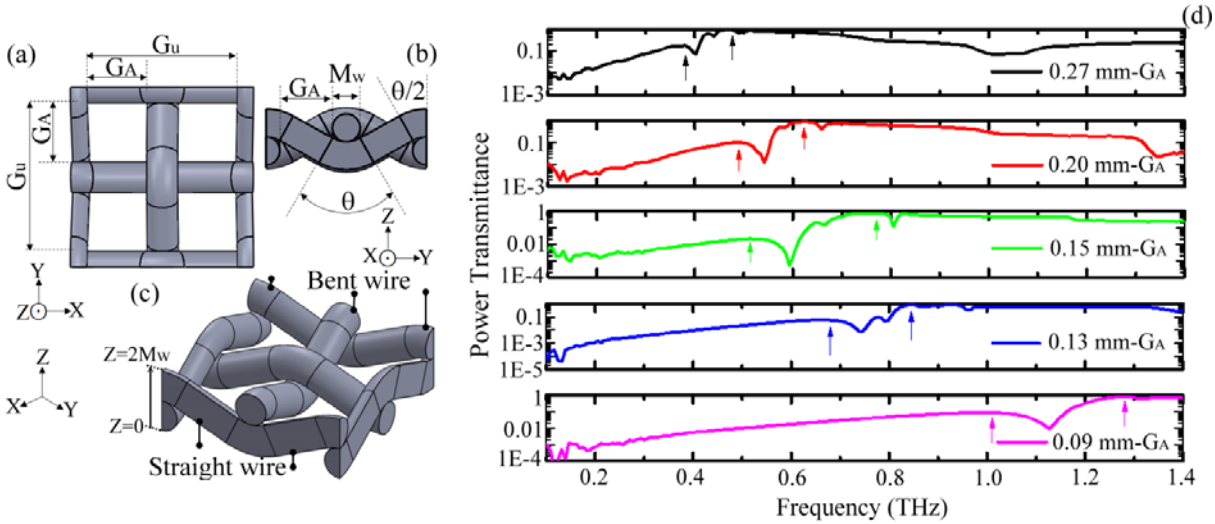

Fig. 1. (a) Top, (b) side, and (c) 3D views of MWW-HA structure. (d) Power transmittance spectra of MWW-HA structure.