**Title:** Investigation of spectral properties and lateral confinement of THz waves on a metal-rod-array-based waveguide and its sensing applications

**Abstract**

A high-aspect-ratio metallic rod array (MRA) is experimentally and theoretically demonstrated to deliver highly confined terahertz surface waves under end-fire excitation of THz waves with transverse-magnetic, TM, and transverse-electric, TE, polarizations. The transverse modal power distributions and polarization-dependent spectral properties for the MRA-bound THz waves are characterized based on various geometric parameters and superstrate integrations of MRA. For TM waves, the MRA works as a photonic crystal waveguide to longitudinally resonate for good confinement on the metal rod tips and with a low propagation loss about 0.003 cm-1. The experiment results show that THz photonic crystal features in the transmission spectrum, spectral power ratio, and the lateral field confinement can be manipulated by the geometry parameters, including the rod diameter, the interspace between adjacent rods, and the propagation length based on interactive MRA-layer number. For TE waves, the miniaturized MRA-based waveguide can be performed as a band pass filter to transport the TE waves originated from the resonance among rod slits. The resonance guidance makes the optical path length (OPL) of the MRA-guiding wave longer than the physical waveguide length and is benefit for sensing applications. The extended OPL enables THz waves sufficiently overlapping the analytes embedded among or top-attached the rods, leading to strongly enhanced phase change by approximately one order of magnitude compared with that of the blank parallel-metal-plate waveguide. Based on the phase sensitive mechanism, the integrated MRA–based waveguide is successfully used to sense various thin films deposited on the polypropylene superstrate as well as incorporated into microfluidics for fluidic sensing. The investigation expresses that THz wave sensing based on a MRA structure exhibits different phase detection sensitivities due to various confined fields in the MRA air gaps. Deep-subwavelength thicknesses of SiO2 and ZnO nanofilms with an optical path difference of 252 nm, which is equivalent to λ/3968 at 0.300 THz, have been successfully identified using the integrated MRA waveguide. In addition, three kinds of colorless liquid analytes, namely, acetone, methanol, and ethanol, with different dipole moments are also successfully recognized using the MRA-based microfluidic sensor. The detection limit in molecular amounts of a liquid analyte is experimentally demonstrated to be less than 0.1 mmol, corresponding to 2.7 μmol/mm2. The MRA-based THz waveguide sensor can be integrated with various biochip platforms and has good adaptability in lab-chip technology for minute molecular detection, whose dimension is extremely smaller than the coherent length of THz wave.

**Biography**

**Ja-Yu Lu** received the B.S., M.S. degrees in physics from National Cheng Kung University (NCKU), Tainan, Taiwan, in 1998, 2000, and Ph.D. degree in the Graduate Institute of Photonics and Optoelectronics (GIPO) from National Taiwan University (NTU), Taipei, Taiwan in 2007, respectively. In 2008, she joined the department of photonics (DOP), NCKU, and is currently an Associate Professor, directing Terahertz Optics Laboratory. Her research interests include the electromagnetic wave sensing using terahertz (THz) fibers, waveguides, and any integrated THz structure to manipulate THz photon for near-field detection.