Terahertz Surface-plasmon Polariton Scattering from Semiconductor Groove Arrays: Gap Formation and Switching

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We present experimental and theoretical results of terahertz surface plasmon polaritons (SPPs) propagating on gratings structured on semiconductor surfaces. Single-cycle pulses of terahertz radiation, focused on a gap formed by a razor blade closed to the interface, are used to excite SPPs in a broad frequency range. Time-domain measurements are performed by out-coupling the transmitted SPPs to radiated waves in a similar manner. A theoretical framework is presented that allows us to investigate the scattering of terahertz SPPs by arrays of sub-wavelength defects on semiconductors. The formulation is based on the reduced Rayleigh equation resulting upon imposing an impedance boundary condition. The efficient SPP scattering on the semiconductor periodic structure introduces significant dispersion and modifies the SPP propagation, leading to a rich phenomenology.

A stop gap, or a frequency range where SPPs are Bragg reflected, is observed on doped-Si surfaces. This gap depends strongly on the Si doping density and type. The resonant scattering at the edge of the gap reduces the group velocity by more than a factor of 2. The measurements show a good agreement with our numerical calculations [1].

Based on approximate estimations of the SPP gap broadening with temperature in the case of indium antimonide samples with rectangular grooves, numerical calculations are carried out to determine the spectral dependence of all the SPP scattering channels (reflection, transmission, and radiation) in the immediate vicinity of that gap. The thermally-induced SPP switching nearby the lower SPP band edge is investigated as a function of groove parameters (size and number), providing the most suitable configurations. Near-field intensity maps are presented that shed light onto the SPP scattering and switching physical mechanisms [2].

Our experimental results demonstrate indeed SPP switching for deep grooves. Since the above approximation is no longer valid for such groove depth, we make use instead of the formally exact Green's theorem surface integral equations to calculate the spectral dependence of the SPP transmission at different temperatures. Comparisons with experimental results yield good agreement [3].

REFERENCES

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