Optical metasurfaces implemented by highly-ordered Laser Induced Periodic Surface Structures

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Metasurfaces are ultrathin electromagnetic periodic structures with a response that can be engineered through the architecture of their subwavelength elementary units, the meta atoms; they have been used for a variety of applications, from shielding and wavefront shaping to solar cell harvesting, operating from microwave to THz and the optical frequencies. An acclaimed scheme for implementing optical metasurfaces is the Gap Surface Plasmon metasurfaces, where light is confined in the dielectric spacer of a metal-insulator-metal-type configuration. These extraordinary thin structures have been shown to provide exceptional electromagnetic properties and a variety of applications, including wavefront-shaping, wave-mixing, polarization control, high-harmonic generation, perfect absorption, color printing, energy harvesting and others. Traditional methods to fabricate such structures usually include photolithography, particle beam lithography, direct-write lithography, pattern transfer and hybrid patterning lithography. In their majority these conventional techniques are inherently multistep and involve the extensive use of chemicals. Here, we demonstrate a versatile and tunable approach for the fabrication of Gap Surface Plasmon metasurfaces which consists of direct material processing using pulsed laser light. The approach is based on the controllable and selective generation of highly-ordered Laser Induced Surface Periodic Structures (LIPSS) on nanometre-thick films [1], which are backed by a grounded dielectric layer. LIPSS imprinting is inherently a single-step and large scale approach and so far it has been used in a variety of application such as surface enhanced Raman scattering, enhanced thermal radiation emission efficiency, cell growth, wetting, etc. We focus on shaping resonant gap plasmonic states with polarization-dependent enhanced or perfect absorption. As theory predicts and experiments verify, the produced metasurfaces exhibit well-defined and tunable resonances which are sensitive to the impinging wave polarization, leading to perfect absorption of either the normal to LIPSS polarization, a narrowband operation, or the parallel polarization, a broadband operation, in the near-IR and mid-IR [2].

References

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