Fiber-Optics Meta-tips for Light Manipulation and Sensing

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Metasurfaces nowadays constitute one of the most promising research thrusts in the field of artificial materials. By leveraging the concepts of radio-frequency "reflectarray" and "transmitarray" antennas, and expanding their applicability to terahertz and optical wavelengths, they enable precise control of an electromagnetic wavefront via the tailored design of metallic or dielectric resonating elements suitably arranged on a two-dimensional surface.

In an ongoing series of investigations, we have been concerned with the integration of metasurfaces on the tip of an optical fiber. In particular, we recently reported the first experimental realization of a "meta-tip" configuration featuring a Babinet-inverted plasmonic metasurface on the tip of an optical fiber (M. Principe et al., Light. Sci Appl., 6, e16226, 2017). This represents a significant milestone in the roadmap of the merging "lab-on-fiber" technologies (M. Consales et al., ACS Nano, 6, 3163, 2012), which may pave the way for the design of multifunctional devices completely integrated in a single optical fiber, with applications ranging from communications to optical imaging and sensing.

Here, we summarize the main results obtained, in terms of field manipulation (beam steering) and optical sensing (via the excitation of surface waves). Moreover, we also discuss some preliminary results from ongoing studies on the integration of dielectric metasurfaces, as well as the optimization of the surface sensitivity.