STRUCTURED LIGHT MATTER INTERACTIONS IN NONLINEAR METASTRUCTURES

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Ultra-compact, low-loss, fast, and reconfigurable optical components, enabling manipulation of light by light, could open numerous opportunities for controlling light on the nanoscale. Nanostructured all-dielectric metastructures have been shown to enable extensive control of amplitude and phase of light in the linear optical regime. Among other functionalities, they offer unique opportunities for shaping the wave front of light to introduce the orbital angular momentum (OAM) to a beam. Structured light beams bring a new degree of freedom for applications ranging from spectroscopy and micromanipulation to classical and quantum optical communications.

To date, reconfigurability or tuning of the optical properties of all-dielectric metastructures have been achieved mechanically, thermally, electrically or optically, using phase-change optical materials. However, a majority of demonstrated tuning approaches are either slow or require high optical powers.

Arsenic trisulfide (As2S3) chalcogenide glass, offering ultra-fast and large $\chi^{(3)}$ nonlinearity as well as a low two-photon absorption coefficient in the near and mid-wave infrared spectral range, could provide a new platform for the realization of fast and relatively low intensity reconfigurable metastructures.

In this work, we design and experimentally demonstrate an As2S3 chalcogenide glass based metastructure that enables reshaping of a conventional Hermite-Gaussian beam with no OAM into an OAM beam at low intensity levels in the near infrared wavelength range, while preserves the original beam’s amplitude and phase characteristics at high intensity levels. Further, we extend these results to design an OAM beam converter that enables intensity-dependent switching between positive and negative OAM charges. Finally, we investigate silver/chalcogenide glass multilayers and develop the procedure for electron-beam and light-induced nanostructuring in order to realize metal-chalcogenide based nonlinear metastructures enabling optical analogue of electromagnetically induced transparency or broadband wavelength conversion. The results of these studies could find applications for a new generation of optical communication systems and optical signal processing.