Nanophotonic Metasurfaces: VO2 Phase Control and qBIC-Enhanced Non-Reciprocity

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In this presentation I will address engineered metasurfaces involving external tuning via vanadium dioxide (VO2) and non-reciprocal enhancement via quasi-bound states in the continuum (qBICs).

VO2 exhibits a notable insulator-to-metal transition at 68°C with a dramatic change in electrical resistivity, enabling applications in photodetection and bolometry. Two VO2-based systems are examined: arrays of gold (Au) nanodisks embedded in VO2 thin films to reduce the laser power needed for phase transition by 30% through localized plasmonic field enhancement[1]; and perforated Au films with sub-micron slits on VO2 to enable temperature-controlled reflectance modulation from 90% to 10%, acting as optical valves[2].

In parallel, qBIC phenomena in tilted silicon (Si) nanodisks and n-doped indium antimonide (InSb) micropillar metasurfaces are investigated. Overlapping dipolar resonances produce dark and asymmetric qBICs at modified Brewster angles, resulting in cloaked excitation with strong near-field enhancement and minimal reflection[3]. In magneto-optical InSb metasurfaces under external magnetic fields, qBICs enhance non-reciprocal cross-polarization coupling, tunable via structural tilting. These effects facilitate low-power, tunable optical switching and amplified magneto-optical responses[4].

Together, these studies demonstrate how structural design, resonance hybridization, and external stimuli such as temperature and magnetic fields enable novel, tunable nanophotonic devices with enhanced light–matter interactions.

References

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