Topological acoustic/elastic metamaterials and programmable photoacoustic manipulation

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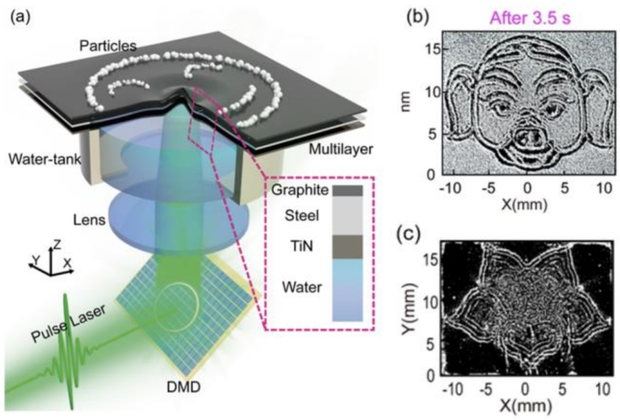
Abstract

Topological semimetals are materials whose band structure contains touching points that are topologically nontrivial and can host quasiparticle excitations that behave as Dirac or Weyl fermions. We experimentally realize Weyl points in a chiral phononic crystal system, and demonstrate surface states associated with the Weyl points that are topological in nature, and can host modes that propagate only in one direction. As with their photonic counterparts, chiral phononic crystals bring topological physics to the macroscopic scale.

Valley topological msaterials, in which electrons possess valley pseudospin, have attracted a growing interest recently. In this work, by using a micromanufacturing technology, valley topological materials are fabricated on silicon chips, which allows the observation of valley states and valley edge transport for elastic waves. The edge states protected by the valley topology are robust against the bending and weak randomness of the channel between distinct valley Hall phases. These results may enable the creation of on-chip high-performance micro ultrasonic materials and devices.

Optical and acoustic tweezers, despite operating on different physical principles, offer non-contact manipulation of microscopic and mesoscopic objects. The advantages and limitations of optical and acoustic manipulation complement each other, particularly in terms of trapping size, force intensity, and flexibility. We use photoacoustic effects to generate localized Lamb wave fields capable of mapping arbitrary laser pattern shapes. By using localized Lamb waves to vibrate the surface of the multilayer membrane, we can pattern tens of thousands of microscopic particles into the desired pattern simultaneously. Our approach merges the programmable adaptability of optical tweezers with the potent manipulation capabilities of acoustic waves, paving the way for wave-based manipulation techniques, such as microparticle assembly, biological synthesis, and microsystems.



Pic.1 Programmable photoacoustic patterning of microparticles in air

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