Performant composites with properties far exceeding their individual constituents can be obtained combining different materials with contrasting properties. Embedding stiff/brittle nanoscale elements into a soft/ductile matrix is a common approach to fabricate high fracture resistance structures. At the architectural level, i.e. a length scale intermediate between nanostructure and macroscopic component, the combination of positive and negative Poisson ratio (auxetic) materials can effectively extend the range of properties of both the traditional and the auxetic counterparts. In contrast to positive Poisson ratio, auxetic materials have the tendency to contract perpendicular to the compression direction; such contrast in the deformation behavior can give rise to a global stiffening effect. Different composites of auxetic and non-auxetic phases were designed and studied mainly through analytical and numerical approaches. The fabrication of architectured materials with local tuning of Poisson ratio is fairly challenging with traditional manufacturing routes.

Cellular materials offer the possibility to tailor the elastic properties (including Poisson ratio) by modifying the underlying architecture. Here we exploit cellular solids to design composites of auxetic inclusions embedded into a non-auxetic matrix. Firstly, we characterize the strain distribution around an auxetic inclusion obtained by transforming a single regular hexagonal cell into a re-entrant cell in an otherwise regular hexagonal isotropic two-dimensional honeycomb. Secondly, we investigate how the effect of Poisson ratio mismatch between the re-entrant (auxetic) and the regular hexagonal cells could be enhanced by tuning the local material properties around the inclusion. After designing lattices with a regular pattern of auxetic inclusions, we computed the corresponding mechanical properties through finite element simulations. Furthermore, we used multimaterial 3D printing to fabricate and experimentally tests the designed structured.