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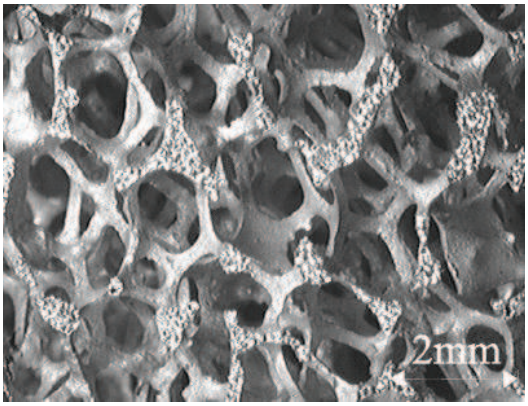
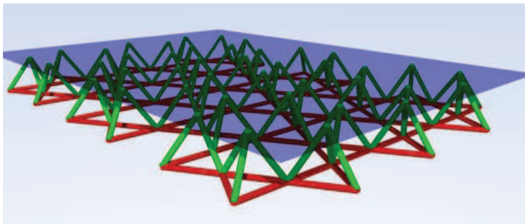
A quest for shape morphing lattice materials

Master of Science project

Introduction Cellular materials comprise of interconnected network of struts or plates where the size of the constituent cells being much smaller than the global length scale . The most important quantity that characterises the cellular solid is the its relative density $\bar{\rho} = \rho^*/\rho_s$ where ρ^* is the density of the cellular material and ρ_s is the density of the solid material from which the cell walls are made. Cellular materials with random cellular structure are known as foams (see fig. 1a), whereas cellular materials comprise of a periodic micro-architecture are termed lattice materials see (fig. 1b). Properties of lattice materials can be tuned with either varying the relative density or upon changing the micro-architecture. Upon optimizing the micro-architecture for a certain physical property, lattice materials can be significantly superior to their foam counterparts with the same relative density.



(a)



(b)

Figure 1: (a) metallic foam (b) cellular kagome lattice materials

Recent studies have shown that some lattice materials (e.g. 2D Kagome structure and its 3D equivalent) have a great potential to be used in multi-functional applications: if one of the lattice elements (beams or rods) is replaced with an actuator, the material can undergo large shape changes when the actuator is deployed, while it provides stiffness against external loads when the actuator is not triggered. Determination of 2D or 3D lattice structures that can offer a combination of properties, such as high stiffness and toughness at low density, remains a challenging issue. Moreover elastic energy storage and release upon shape morphing can be appealing for applications such as sportswear.

Tasks After surveying the recent developments in the literature, a number of potential micro-architectures will be preselected as suitable for shape morphing capability by way of identifying the states of self-stress and mechanisms using matrix method and block wave analysis. subsequently, you will be using and improving discrete finite element models developed in an earlier project, to characterise elastic and plastic properties preselected lattice materials with various micro-architectures as a function of relative density. Single strut actuation and shape morphing abilities of various micro-architectures will be tested with the finite element models in order to discover and design new lattice materials to be used in shape morphing applications. Elastic energy storage and release in the context of actuation will be also explored.

Student If you are interested in this challenging but equally interesting work and have basic knowledge of to finite element modelling. If you are eager to write conference/journal papers to make a an original contribution to the scientific literature you are who we are looking for.