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CONTROLLING STIFFNESS OF A MECHANICAL METAMATERIAL BY PNEUMATIC ACTUATION

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Mechanical metamaterials feature an artificially designed microstructure resulting in specific macrostructural mechanical behaviour [1]. Active metamaterials [2] can change their properties without change in geometry, for example by pneumatic actuation [3, 4]. Inspired by a beam exhibiting varying levels of resistance against compression when deformed into S-shapes of different wavelengths, we propose a two-dimensional square lattice metamaterial whose macroscopic stiffness under compression can be repeatedly tuned by pressure actuation. First, we test this idea on a material in which the different wavelengths are predetermined by the initial geometry. We perform computational tests on a finite element RVE model and find the expected effect on macroscopic stiffness in line with analytical predictions. We then propose a pneumatically actuated microstructure with switchable stiffness triggered by changing air pressure in the voids of the square lattice while still retaining the same initial geometry. Based on systematic computational testing we find the concept feasible. However, design drawbacks are identified, namely the necessity of transversal ligaments posing a problem to the full development of the desired pressurized shape of the material. We discuss several possible ways to overcome these obstacles.

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