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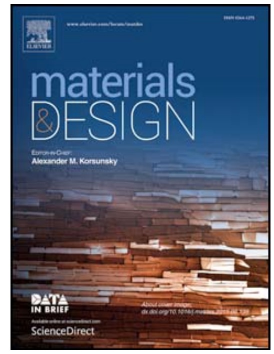

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Abstract
In this study, an energy absorption lattice, comprised of multiple tetra-beam-plate unit cells with negative stiffness, was designed, fabricated by selective laser sintering method, and analyzed both numerically and experimentally. Snap-through behavior of the unit cell developed due to negative stiffness caused by geometric nonlinearity from large deflection of the constituent elastic beams, resulting in energy absorption. A criterion for the unit cell to achieve the snap-through behavior was investigated numerically in terms of the beam slenderness ratio and the inclined angle. This approach was chosen to facilitate control of energy dissipation performance and further design space such as tuning force threshold. The unit cell with the selected geometric parameters was then created and used to construct the energy absorption lattice. Load-displacement relationships of the lattices obtained from cyclic loading tests disclosed an area enclosed by two distinct loading and unloading curves, which indicates energy dissipation. This was shown both numerically and experimentally. Drop tests were also performed to investigate energy loss of the lattices due to an impact. An energy absorption phenomenon was revealed by observing a reduced rebound height when the lattice exhibited the snap-through behavior.

Keywords: energy absorption, snap-through, negative stiffness, smart materials, bistability, lattice, wave dissipation, post-buckling, geometric nonlinearity, large deflection

1 Introduction

Bistable mechanisms are useful for a device that is to achieve stable states in two distinct positions without power input. Due to their notable behavior providing low power operation and prevention of external disturbances, such mechanisms have been applied to various engineering applications, including microelectromechanical systems (MEMS) [1] [2]. Examples are switches [3] [4] [5] [6], valves [7], shock sensors [8] [9], relays [10], binary modular reconfigurable robots [11] and devices for energy harvesting from vibrations [12].

Three main types of the bistable mechanism based on different design concepts have been reported in the literature. Latch-lock mechanisms were studied in [13] and [14], however complex actuation to lock and unlock was required for the mechanisms. Hinged multi-segment mechanisms were introduced in [15], [16], and [17]; these are based on zero friction, zero clearance and zero stiffness, which is difficult to accomplish with MEMS fabrication processes. Buckled beam or