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Search for New Multi-functional Materials with Ruga Mechanics

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Abstract

In recent years nano science and technology has enabled us to explore new functional properties of hierarchical ruga structured materials through folding or wrapping thin surface layer structures with nanometer scale features. The Latin word *ruga means a state of a “large-amplitude”* wrinkle, crease, fold or ridge to form various 1-D or 2-D patterns. As multi-scale surface morphologies of rugae determine effective properties such as wetting, adhesion, friction and optoelectronic properties, ruga state control is considered as a viable method for real-time regulation of effective surface properties. It is found that graded or layered elastic properties of the substrate can provide diverse bifurcation paths of surface deformation under lateral compression, producing various surface ruga states. Here we introduce mathematical analysis of sequential bifurcation processes in surface deformation of a neo-Hookean substrate with its elastic modulus exponentially decaying along the depth from its free surface. In turn, iso-periodic-compression Ruga Phase Diagram of neo-Hookean solids with their moduli exponentially decaying with depth has been constructed, and its implications on engineering multi-scale ruga structures are presented.