11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

FOLDING OF NEO-HOOKEAN BILAYER SYSTEMS UNDER BIAXIAL COMPRESSION

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Key words: *Wrinkles, Creases, Folds, Elastomers, Bilayer systems, Stretchable electronics.*

In stretchable electronics, it is a great challenge to achieve conductive electrodes that can reversibly sustain mechanical loading and ensure reliable electrical conduction between the electrical devices. One of the strategies to achieve a stretchable conductor is to use elastic instabilities of hard films on soft substrates: wrinkles and folds. These structures emerge spontaneously from homogeneous state during global deformation induced by growth/swelling, drying or confinement. Small compression of the system creates sinusoidal wrinkles with a broad spatial distribution of energy while large compression creates sharp folds with localized energy [1, 2]. The wrinkle-to-fold transition has been mostly focused on two-dimensional plane-strain models under uniaxial compression. In experiments, however, the biaxial compression often lead to complex three-dimensional spatial structure due to the interplay between elasticity and geometry. The nucleation and growth of folds in biaxial compression remain elusive. Here, using the combined finite-discrete element method [3], we study folding dynamics of neo-Hookean bilayer systems under biaxial compression in the systematic way. We explore the nucleation and growth process of folds by modifying the ratio of parameters involved layers such as the shear moduli and the thicknesses. We also demonstrate that in the highly compressed state of the hard film the stress focusing at the localized folds can evolve to yield cracks. The ideas introduced here could offer opportunities for the rational design of stretchable electrodes with folded structures.

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