Structure design and analysis of the multilayer stack consisting of both hard and soft layers for flexible electronics

Shuang Li[1], Rui Li[2] and Yewang Su[3]

[1] State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing 100190, China; lishuang@lnm.imech.ac.cn

[2] State Key Laboratory of Structural Analysis for Industrial Equipment, Department of Engineering Mechanics, Dalian University of Technology, Dalian 116024, China; ruili@dlut.edu.cn

[3] State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing 100190, China; yewangsu@imech.ac.cn

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ABSTRACT

Flexible electronics has attracted much attention in recent years due to the favorable applications to many emerging devices. Composite structures, such as stacks consisting both hard and soft layers are widely adopted in the design of flexible electronics. Here, a series of related work are presented. 1) Flexible piezoelectric mechanical energy harvesters (MEHs), which are able to supply the pacemaker, are of recent interest as an important emerging variant of traditional piezoelectric devices. We propose the design of stacking multilayer MEHs with adhesive in between as an effective way to enhance the magnitude of power generation. An analytic model is established to study the mechanical behavior of the multilayer MEHs subjected to Euler buckling. Being different from the hypothesis of the plane section for the entire structure, it is found that each polyimide (PI) layer holds plane section of its own, while soft adhesives serve as shear lags. The deformation is almost the same for each PI layer, as well as PZT arrays, which is very beneficial to avoid the premature failure of devices. 2) We also present a rational analytic model to study the bending of a laminated structure on a cylinder, which is often regarded as an important approach to mechanical reliability testing of flexible electronics and photonics. 3) For this kind of laminated structure, we only take into account the shear deformation of the soft adhesive layers but some researchers only incorporate the normal strain-induced deformation of the same layers. By establishing an accurate enough analytic model, a significant finding is revealed that shear deformation dominates in the soft adhesive layers of the laminated structure of flexible electronics while the normal strain-induced deformation is negligible. The model is well validated by the finite element method (FEM). The effects of the membrane energy and bending energy of the soft layer are also investigated by incorporating or neglecting the shear energy. The model accurately captures the key quantities such as the strain distribution in each layer and the locations of the neutral mechanical planes of the top

and bottom layers. These works are expected to provide the design guidelines for the laminated structure-based flexible electronics.