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Yuhao He, Yunxin Li, Zishun Liu, K.M. Liew

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Buckling analysis and buckling control of thin films on shape memory polymer substrate

Yuhao He[a,b], Yunxin Li[a], Zishun Liu[a*] and K.M. Liew[b]

[a] *Inter. Center for Applied Mechanics; State Key Laboratory for Strength and Vibration of Mechanical Structures, Xi'an Jiaotong University, Xi'an, 710049, China*
[b] *Department of Civil and Architectural Engineering, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong*

Abstract
This paper presents a theoretical study and finite element simulation for the buckling of a thin film on the compliant substrate. First, we develop a continuum mechanics approach for large deformation buckling analysis based on minimizing the total energy of the film/substrate structures, and considering the precise curvature of the buckled film and the Poisson's ratio of the substrate. The predicting results using this proposed theory agree quite well with previous experimental results. Then, we make a modification for the model to simplify the expressions for the wavelength and amplitude of the buckled geometry. Furthermore, considering a thin Si film on shape memory polymer (SMP) substrate, we investigate the buckling behavior of the thin film through theoretical analysis and finite element method. Through the investigation, it is found that the evolution rate of the buckling geometry of thin film depends on the temperature of the SMP substrate, and the buckling geometry changes faster at a higher temperature. Finally, a programmed method to control the buckling of thin Si film on the SMP substrate is proposed and is realized with finite element simulation in ABAQUS.

Keywords: buckling; film/substrate; theory and simulation; shape memory polymer

1. Introduction

During the past decades, the thin film/substrate structures have attracted many researchers because of their potential applications in many fields, such as stretchable electronics (Khang and Rogers, 2006, Sun et al., 2006), tunable phase optics (Harrison et al., 2004, Yang and He, 2014), high precision micro- and nano-metrology methods (Stafford et al., 2004, Stafford et al., 2006, Wilder et al., 2006, Zhou and Huang, 2014), and pattern formation for micro-/nano-fabrication (Bowden et al., 1998, Bowden et al., 1999, Yoo et al., 2002, Chiche et al., 2008, Chen and

* Corresponding author: Inter. Center for Applied Mechanics; State Key Laboratory for Strength and Vibration of Mechanical Structures, Xi'an Jiaotong University, Xi'an, 710049, China
E-mail address: zishunliu@mail.xjtu.edu.cn (Z. S. Liu).