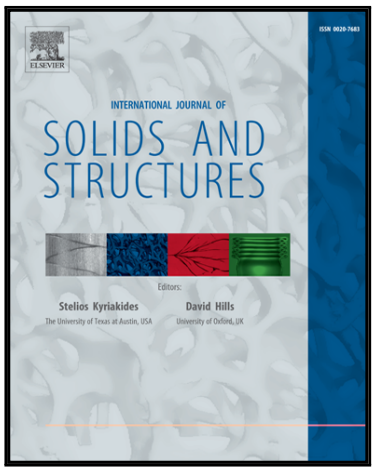

Contact involving a functionally graded elastic thin film and considering surface effects

Xin Zhang , Q. Jane Wang , Yuxing Wang , Zhanjiang Wang , Huoming Shen , Juan Liu

PII: S0020-7683(18)30248-8
DOI: 10.1016/j.ijsolstr.2018.06.016
Reference: SAS 10026

To appear in: *International Journal of Solids and Structures*

Received date: 29 March 2018
Revised date: 29 May 2018
Accepted date: 14 June 2018

Please cite this article as: Xin Zhang , Q. Jane Wang , Yuxing Wang , Zhanjiang Wang , Huoming Shen , Juan Liu , Contact involving a functionally graded elastic thin film and considering surface effects, *International Journal of Solids and Structures* (2018), doi: 10.1016/j.ijsolstr.2018.06.016

Contact involving a functionally graded elastic thin film and considering surface effects

Xin Zhang [a, b], Q. Jane Wang [b, c, *], Yuxing Wang [a], Zhanjiang Wang [c], Huoming Shen [a] and Juan Liu [a]

[a] School of Mechanics and Engineering, Southwest Jiaotong University, Chengdu 610031, China
[b] Department of Mechanical Engineering, Northwestern University, Evanston, IL 60208, USA
[c] Tribology Research Institute, Traction Power State Key Laboratory, Southwest Jiaotong University, Chengdu 610031, China

*Corresponding author: Q. Jane Wang, E-mail: qwang@northwestern.edu

Abstract

This paper reported a size-dependent semi-analytical model (SAM) on the contact involving a functionally graded elastic film indented by a rigid frictionless cylinder, where Chen-Yao's surface elastic theory is employed to account for the effects of surface energy and surface strain. The model assumes that the film is perfectly bonded to a rigid substrate, and that the shear modulus of the film varies along the thickness direction following a simple exponential form. The core fundamental solutions of the elastic displacements and stresses for such an elastic thin film with respect to the unit applied force are derived firstly, incorporating the surface effects by means of Chen-Yao's surface elastic theory. Then the frequency response functions (FRFs) and their conversion into the corresponding influence coefficients (ICs), are analytical obtained. Efficient numerical techniques, supported by the conjugate gradient method (CGM) and the fast Fourier transform (FFT), are applied to obtain the unknown pressure and stress distributions. The combined effects of shear modulus ratio, film thickness, and surface energy on the contact behavior of the thin film are explored, and a schematic map is constructed to reveal the influences of film thickness and material characteristic length, which correlates the geometric configuration (i.e. a film or a half-space) and surface behaviors (i.e. with or without considering the surface effects).

Key words: Thin film; functionally graded materials; surface effects; semi-analytical modeling.