UNIVERSITÀ DEGLI STUDI DI BERGAMO | Scuola di Ingegneria

An analytical study of electromechanical buckling of micro spherical thin film bonded to a spherical compliant substrate

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ABSTRACT

This work investigates the electromechanical buckling and post-buckling response of a micro spherical shell that is bonded to a spherical compliant substrate. The system consists of thin elastic spherical electrode that is bonded to a spherical compliant substrate. The compliant substrate is bonded to a rigid electrically grounded electrode. The applied voltage difference between the elastic and the rigid electrodes induces mechanical compression stresses in the elastic spherical shell. The governing nonlinear Föpple-Von Karman equilibrium equations of the critical electromechanical buckling and post-buckling of the elastic thin spherical shell are analytically solved.

The electromechanical buckling modes are periodic patterns and are characterized by the upper-bound elastic strain energy. Each of the postulated buckling patterns is characterized by the extent of strain-energy reduction relative to the unbuckled perfect spherical shell state. Based on experimental results in literature, the postulated periodic buckling patterns are one-dimensional, square checkerboard, hexagonal, and herringbone pattern. The preferred pattern is identified as the pattern that is characterized with maximum elastic strain energy reduction relative to the unbuckled state.

The analytical solutions of the buckling and postbuckling states of each pattern revealed that the hexagonal one is the preferred pattern for small values of the spherical shell radius (i.e. larger curvature). Hoverer, increasing the voltage leads to a second instability at which the hexagonal pattern becomes unstable and it bifurcates to the herringbone one. It has been found that for small values of the thin shell curvature the herringbone pattern is energetically preferred among other patterns.

The electromechanical buckling phenomena of the thin spherical shell electrode can be implemented in different MEMS and NEMS devices, such as On/Off switching of micro mirrors.

Keywords: Föpple -von-Karman equations, electromechanical buckling, micro spherical shell.

Dr. Samy Abu-Salih received the B.Sc., M.Sc., and Ph.D. degrees from the Technion—Israel Institute of Technology, Haifa, in 1995, 2002, and 2006, respectively, all in Mechanical Engineering. From 2007 through 2008, he was a postdoctoral research staff member at the MEMS Lab, Department of Mechanical Engineering, University of Alberta, Canada. He has been staff academic member at the Department of Mechanical Engineering at the ORT Braude Engineering College since 2012. His current research interests are MEMS, solid mechanics, Chemo-Electro-Mechanical response of micro Hydrogel structures and plasticity. His activity in MEMS includes modeling and simulation of electrostatic, piezoelectric actuation methods.

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