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Partially coated ceramic layer under thermal stress

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Thin films and coatings technology has known a large development in the last decades due to the large number of devices involving thin films employed in high-tech industries, mainly in microelectronics, electrochemistry, semiconductors and optical electronics. Indeed, realization of MEMS and NEMS used into biomedical components, chemical reactors, integrated circuit, solar cells, flat panels displays, sensors, insulator and protection systems, transducers, high-precision measuring instruments, etc. are examples of important applications having significant commercial implication. Recently, many theoretical and experimental studies have been focused on the feasibility of a crystalline undulator (CU), that is a special kind of MEMS realized by covering a ceramic substrate. This micro-device can be used to produce a coherent beam of X-ray at high energy levels by exploiting the channelling phenomenon [1]. The substrate generally consists of a Silicon or Germanium crystalline plate covered by a thin film deposed on both surfaces by a proper chemical process (e.g. LPCVD) at high temperature. Through a suitable photolitho-graphic process, the film is properly patterned in order to impart a periodic deformation to the crystalline substrate, suitable to produce coherent interaction with a beam particles. The system adopts a periodic curvature as a result of the misfit strain due to the different thermal expansivities of the layer and the film

The present work provides an extension of the paper [2] by taking into account the anisotropy of the substrate and coatings. The substrate is modelled as a 2D orthotropic elastic layer under plane strain conditions, whereas the film is assumed to behave like a membrane, thus neglecting its flexural stiffness. The problem is formulated by imposing perfect adhesion between the film and the substrate, thus leading to a singular integral equation. The problem can be reduced to a linear algebraic system by using a series expansion of Chebyshev polynomials for the interfacial shear stress and Fourier series expansion for the displacement field. The effects of anisotropy of the materials are then examined and discussed.

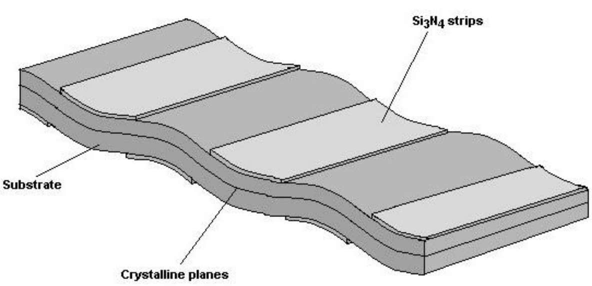

Figure 1: Crystalline undulator

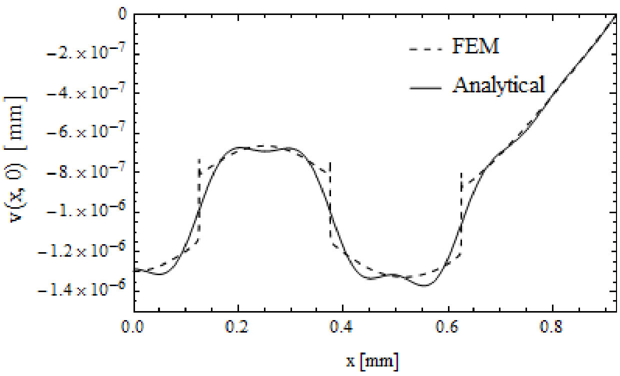

Figure 2: Transversal displacement in crystalline undulator

References:
[1] Guidi V., Lanzoni L., Martinelli G., Mazzolari A., Tralli A. 2007. Design of a crystalline undulator based on patterning by tensile Si_3N_4 strips on a Si crystal. Appl. Phys. Lett. 90, 114107.
[2] Lanzoni L., Radi E. 2009. Thermally induced deformations in a partially coated elastic layer. Int. J. Solids Struct. 46, 1402-1412.