SUBCRITICAL CRACK GROWTH IN FREESTANDING SILICON NITRIDE AND SILICON DIOXIDE THIN FILMS USING RESIDUAL STRESS-INDUCED CRACK ON-CHIP TESTING TECHNIQUE

Sahar Jaddi, Institute of Mechanics, Materials and Civil Engineering, Université catholique de Louvain, Belgium
Sahar.jaddi@uclouvain.be
Michael Coulombier, Institute of Mechanics, Materials and Civil Engineering, Université catholique de Louvain, Belgium
Jean-Pierre Raskin, Institute of Information and Communication Technologies, Electronics and Applied Mathematics, Université catholique de Louvain, Belgium
Thomas Pardoen, Institute of Mechanics, Materials and Civil Engineering, Université catholique de Louvain, Belgium

Key Words: Residual stress; Thin films; On-chip mechanical testing; Subcritical crack growth; Fracture resistance.

Thin film materials are ubiquitous in a large number of applications like flexible electronics, microelectromechanical / nanoelectromechanical systems (MEMS/NEMS) and functional coatings. In the present work, a new mechanical testing method on a chip is developed to characterize the fracture behavior of freestanding thin films. This on-chip technique is based on the residual stress inside what is called here actuator material. Two beams are fabricated with the actuator film and attached to a specimen, incorporating a notch induced by lithography. The residual stress upon release by chemical etching leads to the actuator contraction, hence pulling on the central notched specimen. A crack is initiated at the notch tip, propagates and finally stops when the energy release rate has decreased down to its critical value. This crack arrest measurement avoids the problem of introducing a sufficiently sharp precrack. Besides, using a freestanding film leads to extract the real intrinsic fracture resistance of the film without any substrate effect. By tracking the crack length growth over different time intervals as well as environments using this crack on-chip testing method, the subcritical crack growth mechanisms can be investigated without monopolizing any test equipment. Thin film materials that are showing time-dependent failure are used in numerous devices that its reliability is determined by the understanding of the mechanisms causing the subcritical crack growth. Low-pressure chemical vapor deposition (LPCVD) silicon nitride (SiN) and silicon dioxide (SiO_2) films deposited by electron beam-evaporation technique are studied with a variety of thicknesses. The specimens are tested in laboratory air and dry nitrogen environments under various temperature conditions. The stress intensity factor (K) and the crack velocity (v); K-v curve in different environments is determined based on both experimental data and finite element simulation results (FE), following classical exponential law.