Fall 10-5-2015

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Recommended Citation

Rafel Soler, Sriam Venkatesan, Roman Roth, Johannes Zechner, Michael Nelhiebel, Josef Fugger, Christoph Kirchlechner, and Gerhard Dehm, "Interface fracture resistance of thin films at elevated temperatures" in "Nanomechanical Testing in Materials Research and Development V", Dr. Marc Legros, CEMES-CNRS, France Eds, ECI Symposium Series, (2015). http://dc.engconfintl.org/nanomechtest_v/9

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INTERFACE FRACTURE RESISTANCE OF THIN FILMS AT ELEVATED TEMPERATURES

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Reliability of modern microelectronic devices is strongly influenced by the delamination resistance of the many bimaterial interfaces present on the device. In particular, metal-ceramic systems are of increasing interest in microelectronic applications because the metallization layer also act as a diffusion barrier. However, these systems can suffer from weak interfaces, leading to catastrophic delamination failures during device operation. Interface failure in such complex multi-layered structures is usually driven by thermal expansion mismatch stresses, both produced during the thin film growth process (and subsequent cooling from processing temperatures) and from thermal cycling during device operation. It is well known that structural integrity of the constituent interfaces can be tailored by choosing certain compositions and processing conditions. However, the influence of multiple loading conditions (e.g. temporal and spatial temperature gradients) is less well understood.

In this study we report on the interface fracture resistance of multi-layered structures under elevated temperature and controlled atmospheric conditions, to mimic loading conditions during device operation. The study focuses on various metal-dielectric interfaces, i.e. Cu, Ti, or WTi, on SiOx. The mechanical experiments are conducted by means of 4-point bending technique. The technique is based on a well-established interface fracture mechanical sample geometry containing the interface of interest sandwiched between two significantly larger elastic substrates. This particular design has the advantage that the macroscopic or effective work of fracture --measured in terms of the Critical Strain Energy Release Rate, Gc-- is independent of the crack length, which greatly simplifies calculations. The mechanical experiments are thereby accompanied by thorough microstructural and chemical analysis, i.e. SEM, EDX, TEM. The temperature dependence of the interface strength will be discussed with respect to the chemical composition and the underlying film microstructure.