MULTISCALE FRACTURE MODELS FOR SILICON WAFER MANUFACTURING

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ABSTRACT

The process of manufacturing silicon on insulator (SOI) wafers involves a transfer of a thin layer of silicon (Si) from a bulk substrate onto a host substrate whose surface is previously chemically treated - caped with an insulator *e.g.* silica ($SiO2$). One technique used in the industry nowadays that enables an efficient film transfer and the incorporation of a heterogeneous material in SOI, is the "ion-cut". The process uses an ion-beam to implant gas atoms e.g. hydrogen, into the bulk Si, which is subsequently bonded to a host substrate. Upon thermal annealing the gas atoms diffusion into Si lattice defect sites caused by ion irradiation damage to form high pressure gas in turn driving the nucleation of micro cracks and their growth until complete exfoliation of the bulk Si is achieved.

The objectives of the project are to predict (i) micro crack nucleation points and direction, (ii) multiple crack paths until coalescence, (iii) time until complete fracture, and (iv) the final surface roughness of the SOI.

The model is based on linear elastic fracture mechanics (LEFM) considering plane-strain conditions and a homogeneous isotropic continuum. The gas pressure acting on the crack surfaces is set to be constant and crack growth is assumed to be quasi-static, obeying the criterion of maximum strain energy release rate. The eXtended finite element method (XFEM) [1, 2] is used for discretisation and representation of arbitrary cracks and their evolution with time [3]. In order to overcome blending problems associated with standard XFEM [5], a correction is made by using a weighted XFEM formulation [4].

Due to high computational effort involved in modeling a large number of cracks and crack length scales, a multiscale approach will be adopted, whereby the micro scale, considered as a homogeneous and isotropic medium, will be used to quantify the influence of micro cracks on the macro scale crack propagation via a damaged constitutive relationship in the macro scale.

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