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Composition du Jury

Civilité	Nom	Prénom	Grade / Qualité	Rôle
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Résumé

Crystalline silicon has attracted substantial attention for decades because of its large applications in solar cells and microelectromechanical systems. The high brittleness of silicon raises wide concerns since the failure of this semiconductor material increases the cost of fabrication and decreases the efficiency of the utilization of Si-based devices. Crack propagation of crystalline silicon is the main cause of catastrophic failure of silicon components. It has been intensively studied but is not fully understood yet due to intricate dynamic fracture behavior linked to small-scale phenomena. Therefore, the development of feasible methods to study the dynamic fracture and further understanding of fracture mechanism of crystalline silicon are of paramount importance to improve the reliability and durability of Si-based systems for both industrial and scientific practitioners. In this work, dynamic fracture behavior of solar-grade single crystalline silicon wafers under mechanical loads was studied. The fracture experiments were carried out on the (001) silicon wafer using three-line or four-line bending apparatus under quasi-static loading. The entire fracture process was captured using a high-speed camera and analyzed by the high-speed imaging technique. The post-mortem fracture surface was studied using a digital microscope, a laser scanning profilometer, as well as an atomic force microscope. The failure source of the silicon wafer was identified using fractographic analysis. Coupling the crack velocity measurement and fractographic analysis, the source of (110)-(111) cleavage plane deflection phenomena during high-speeding crack propagation was revealed. Besides, jointly with the finite element simulations, how dynamics of the crack front is governed by the crystallographic direction-dependent dynamic fracture toughness was demonstrated. Finally, in comparison with linear elastic waves that lead to the Wallner lines on the fracture surface, the nucleation and strong nonlinear characteristics of out-of-plane corrugation waves was highlighted, leaving specific traces that alter the surface roughness of asperity-free material.