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Disturbance and recovery in high speed (110) cleavage in single crystalline silicon

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Abstract

Stress perturbations and material defects can significantly affect the fracture initiation and propagation behaviors in brittle materials. In this work, we show that (110) [110] cleavage in silicon deflects onto (111) plane in the presence of contact stresses. The deflection is however not permanent as the crack returns to the (110) plane after a certain length of propagation, even in the case where the crack velocity is up to 78% of the Rayleigh wave speed. The recovery behavior indicates that the (110) [110] cleavage is invariably prevailing when perpendicular to the maximum stress. Following this indication, it can be concluded that the observed (110) [110]–(111) deflection in previous literature is most likely driven by the external disturbance rather than the crack velocity induced toughness evolution. We also highlight that the extra energy for the (110) recovery is minimized at the expense of a large propagation distance upon the plane switch.

Keywords: Fracture, silicon single crystal, crack deflection, high speed propagation

1. Introduction

Crystalline silicon occupies a dominant place in the current photovoltaic (PV) applications. However, due to the brittle characteristic, catastrophic failure of the solar cells eventually leads to large power loss and severely impacts reliability and durability of the Si-based PV technology [1, 2]. A full understanding on the fracture mechanism in silicon is necessary for the design and the use of PV devices. Albeit continuous investigations have been performed, the fracture behaviors, particularly those manifest during the dynamic propagation, still involve an open discussion [3, 4, 5].

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