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Nanoindentation Behaviour and Microstructural Evolution of Annealed Single-Crystal Silicon

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Abstract : The nanoindentation behaviour and phase transformation of annealed single-crystal silicon wafers are examined. The silicon specimens are annealed at temperatures of 250, 350 and 450ºC, respectively, for 15 minutes and are then indented to maximum loads of 30, 50 and 70 mN. The phase changes induced in the indented specimens are observed using transmission electron microscopy (TEM) and micro-Raman scattering spectroscopy (RSS). For all annealing temperatures, an elbow feature is observed in the unloading curve following indentation to a maximum load of 30 mN. Under higher loads of 50 mN and 70 mN, respectively, the elbow feature is replaced by a pop-out event. The elbow feature reveals a complete amorphous phase transformation within the indented zone, whereas the pop-out event indicates the formation of Si XII and Si III phases. The experimental results show that the formation of these crystalline silicon phases increases with an increasing annealing temperature and indentation load. The hardness and Young's modulus both decrease as the annealing temperature and indentation load are increased.

Keywords : nanoindentation, silicon, phase transformation, amorphous, annealing
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