Measuring subsurface damage in diamond wire sawn mono-crystalline silicon wafers (120 μm) by Raman spectroscopy

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Crystalline silicon (c-Si) solar cells with the thicknesses of 180 - 200μm have dominated in the present market. To reduce the production cost per watt has resulted in thinning the wafer without sacrificing the surface quality, the mechanical strength and the efficiency of c-Si solar cell in the manufacturing. In slicing mono-crystalline silicon bricks into 120 μm thick wafers, diamond abrasives with a diameter of 6 to 12 μm fixed on core steel wire with a diameter of 100 μm are employed [1]. When the slicing with diamond abrasives fixed on a wire more seriously scratches front and backside surfaces of the wafer, damages the wafer subsurface and forms amorphous silicon. As-sliced wafers were labelled as a fresh wire side and worn-out wire side. After slicing, the sawn wafers undergo slight KOH etching (-1μm).
Nondestructive, noncontact measurement such as micro-Raman spectroscopy was employed to characterize the sawn wafers and to detect the presence subsurface amorphous silicon. Surface profile of an as-sawn wafer is shown in Fig. 1(a), which contains terraces and craters. Miro-Raman spectrum measured using 100X microscope excited with 532nm laser. The penetration depth is almost 800nm. The Raman signal measured at terrace contains broad signal from 400-600 cm^{-1} region, the characteristic peaks in this region are normally associated with mono-crystalline, multi-crystalline, and amorphous silicon (a-Si). The sharp peak at approximately 520 cm^{-1} can be attributed to the mono-crystalline silicon and broad peak at 470 cm^{-1} can be attributed to a-Si [2].
The Raman spectrum of as-sliced and KOH etch wafers shown in Fig. 1(b) and (c). In fresh-wire side wafers, Raman signal measured at terrace point shows broad a-Si peak. From this result we confirm that subsurface layer transforms into amorphous. After slight KOH etching, the Raman signal was shown in Fig. 1 (c). An interesting double-peak feature was observed on the terrace. The intensity of the amorphous phase reaches maximum in fresh wire side wafers before etching and the amorphous phase in worn-out side wafers completely vanished after etching. Raman signal measured at row of craters in all wafers shows sharp peak at 521 cm^{-1} indicating the absence of the amorphous phase. This work provides slight KOH etching completely remove a-Si from worn-out side wafers but cannot from fresh side wafers.

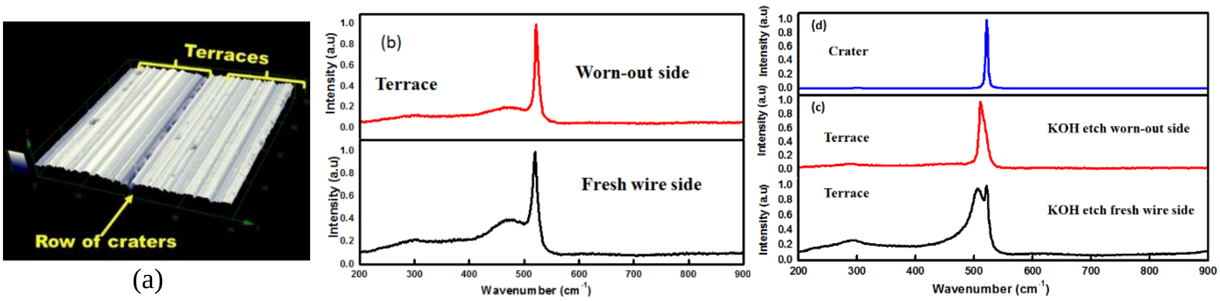

Figure1: (a) AFM image of an as-sliced wafer containing terraces and craters, (b) Raman signals on terrace of a worn-out wire side (upper) and fresh wire side (lower) wafers, (c) Raman signals on terrace of a worn-out wire side (upper) and fresh wire side (lower) wafers, both after KOH etching, and (d) Raman signal at the bottom of a crater.

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Reference:

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