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Spatial Distribution of Crystal Defects and Their Impact on Electrical Properties in Multicrystalline Si

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Photoluminescence (PL) imaging and lifetime spectroscopy were used to study the spatial distributions of crystal defects affecting the electrical properties in multicrystalline Si (mc-Si) grown by floating cast method. [1, 2] Figures 1a and 1b show band-to-band PL images of unpassivated as-cut silicon wafers from various ingot heights. Wafer number 1 denotes the top of the ingot, to 143 at the bottom. Surprisingly, grain boundaries (GBs) regions are predominantly bright, while inside random grains are mostly dark only for the wafers around the top of the ingot (Fig. 1a). We speculate that an anomalous contrast observed is possibly caused by the gettering of impurities in GBs where high energy GBs can act as the sink for impurities, leaving a cleaner area around them. To confirm above speculation, phosphorus (P) diffusion gettering was introduced to remove impurities in GBs, and it was found that a significant better cleaning of the GB is clearly seen after P diffusion. As for the central part of the ingot, the anomalous contrast was not observed anymore, it is reasonable to say that the wafers in the central part are clean with relatively low levels of impurity (Fig. 1b). This idea was further supported by the spatial distribution of the minority carrier lifetime measured by microwave photoconductive decay (μ-PCD). A line scans of lifetimes across the wafers is shown in Fig. 1c. The average lifetimes on mc-Si wafers increase with ingot height, however start to decline again for the very bottom of ingot. By comparing wafer 13 and 74, it is obvious that the lifetime around GBs becomes shorter than that inside the crystal grain with increasing average lifetime of the wafer. It can be said that spatial distribution of minority carrier lifetimes has a direct correlation with the crystal defects and impurity distributions.

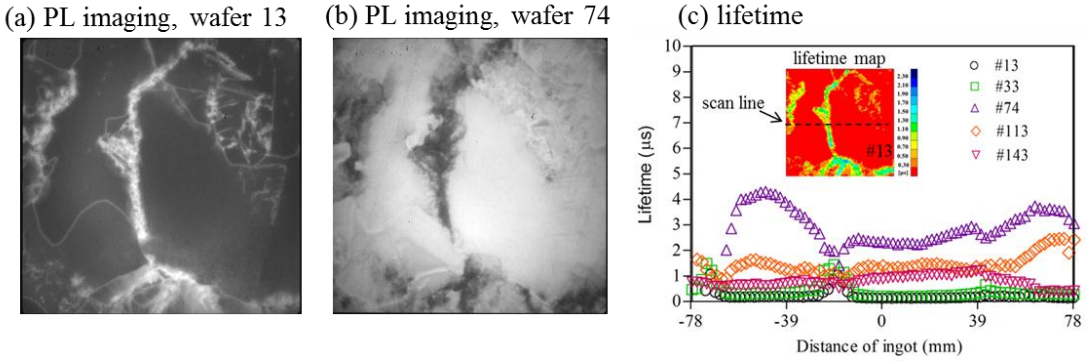

Fig. 1. (a) PL imaging of wafer 13, (b) PL imaging of wafer 74, (c) a line scans of lifetimes across the wafers. Broken line in the inserted lifetime map indicates the position of cross section.

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Ref. 1) Y. Nose *et al*., J. Cryst. Growth **311**, 228 (2009), 2) N. Usami *et al.*, J. Appl. Phys. **109**, 083527 (2011).

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