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Control of microstructures and reduction of stress in multicrystalline Si ingot grown by floating cast method using designed double crucibles

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We report on our attempt to control microstructures and reduce stress during crystal growth in multicrystalline Si (mc-Si) ingot by the floating cast method combined with specially designed double crucibles. The concept of the floating cast method is to control the crystal growth and microstructures by utilizing dendrite crystals from the top of Si melt in a crucible with minimizing the contact of the ingot with the inner wall until the melt is entirely solidified (Fig. 1a and 1b). We propose to use specially designed double crucibles to avoid the strong contact of the ingot with the bottom of the crucible at the final stage of the solidification, which would generate dislocations. This effort leads to spontaneous removal of the residual melt from the inner crucible to outer one (Fig. 1c), leading to the reduction in the densities of crystal defects and incorporation of impurities.

As a result, an appropriate cooling lead to the appearance of faceted dendrite crystals on the upper surface and the crystallization was directionally done from the top to the bottom, as seen in Fig. 2a. Figure 2b shows the horizontally sliced wafer from around top of the ingot. It is seen that the ingot contains large crystal grains originating from the dendrite crystals. Specially designed double crucibles were utilized to reduce introduction of the stress to the ingot at the final stage of the solidification so that generation of dislocations can be suppressed. The floating cast method combined with double crucibles was successfully implemented to grow high-quality mc-Si ingot for practical size (156 mm × 156mm) wafers.

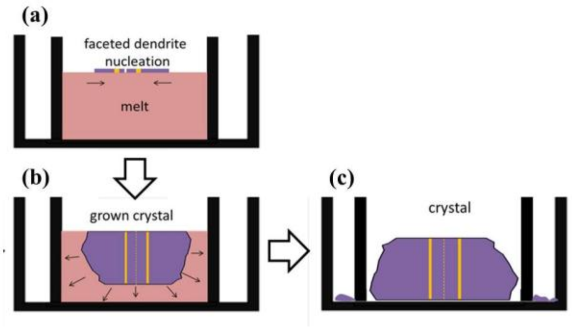

Fig. 1 Schematic illustration of the concept of the floating cast method using specially designed double crucibles.

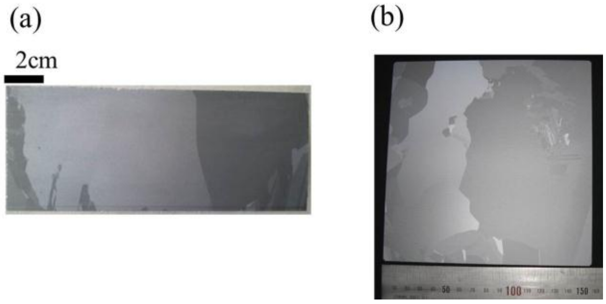

Fig. 2 Pictures of (a) vertically sliced wafer and (b) horizontally sliced wafer from the mc-Si ingot.

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2) N. Usami *et al.*, J. Appl. Phys. **109**, 083527 (2011).