Measurement and significance of roughness inhomogeneity on as-cut and isotextured wafers

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Purpose

- The study was carried out to measure, to explain and to analyse the significance of roughness inhomogeneities on as-cut and isotextured wafers.
- Roughness homogeneity on isotextured wafers apparently influences cell appearance (homogeneity of SiNx thickness / colour) and electrical performance (Jsc) via reflection.
- In order to allow for roughness measurements in production processes a new fast measurement method, the Decima device, was tested for utilizability.

Approach

- isotexture of neighbouring multi-crystalline wafers by a single recipe in an inline machine using different roller speeds, i.e. etching depths.
- Two of the wafers were isotextured with the same etching depth but with saw marks either parallel or vertical to the driving direction of the inline tool.
- Surface topographies of as-cut and isotextured wafers were analysed using laser scanning microscopy (LSM).
- Roughness Sq was calculated according to [1, 2] from 100 LSM pictures per wafer (10 x 10 grid).
- At the same coordinates single wavelength reflection measurements were carried out using the Decima device, delivered by Aurora Control Technologies.
- Some of the textured wafers were processed to cells, which were analysed by reflection spectroscopy and LBIC.

Results

- Roughness depends on etching depth and on position on the wafer. A characteristic pattern is found, which is clearly not resulting from the inline isotexturing process (ﬁg. 2).
- The roughness pattern is determined by roughness inhomogeneity on as-cut wafers (ﬁg. 2).
- Decima device signals are correlated to roughness Sq on isotextured wafers as well as on as-cut wafers. The Decima device signals are depending on etching depth and orientation of the wafer during measurements (ﬁg. 2).
- Roughness differences on the wafer result in differences of SiNx layer thickness. With increasing roughness (decreasing SiNx thickness) the reflectance minimum shifts to lower wavelengths. At the same time the reflectance decreases at short wavelengths (ﬁg. 2, 4).
- Decrease of reflectance at short wavelengths results in current increase (ﬁg. 2, 5).

Conclusions

Roughness inhomogeneity on isotextured wafers is clearly related to inhomogeneity of as-cut-wafers, which in turn can be attributed to the wire sawing process: Roughness decreases from the wire inlet to the wire outlet. The difference increases with wire speed [3]. Roughness homogeneity of as-cut wafers should be monitored in wafer sawing processes. This could be done by the Decima device, which is far faster than LSM and thus suitable for inline monitoring. The Decima device may be used, moreover, for inline control of etching depth in the isotexturizing process.

References


Figure 1: Roughness Sq [µm] for as-cut wafer (A) and wafers processed in inline isotexture with saw marks either parallel to driving direction (B) or vertical to driving direction (C).

Figure 2: Roughness Sq of isotextured versus Sq of as-cut wafers as a function of etching depth (A: 2.80 µm, B: 3.16 µm, C: 3.86 µm, D: 4.37 µm, E: 4.87 µm) and y-coordinate (average for all x(y)).

Figure 3: Decima signals versus roughness Sq of as-cut wafers (left) and isotextured wafers (center) and Decima signals of isotextured wafers versus Decima signals of as-cut wafers (right) as a function of etching depth and wafer orientation with respect to the Decima device.

Figure 4: Reflectance from spectrometer measurements at three spots on a completely processed isotextured mc Si sample compared to LBIC reflectance. Low reflecting areas (red in LBIC) at 405nm turn into high reflecting areas (blue in LBIC) at 878 nm and vice versa.

Figure 5: LBIC current [µA] at 405 nm (left) and 878 nm (right) vs surface roughness Sq [µm]. y-coordinate in (mm) (compare Fig. 1).