The impact of saw mark direction and diamond wire diameter on the fracture strength of thin (120 and 140 µm) Si wafers

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Improving efficiencies and reducing production cost per watt hour is ongoing process in silicon (Si) photovoltaics (PV) industry by implementing innovative concepts and techniques [1]. Sawing more number of wafers from a given silicon brick with less Si kerf is a main research in Si PV industry. This trend leads to thinner wire fixed with smaller abrasives than before. However, we found that in slicing thin wafers, this makes the wafer strength lower as reported below.

In the present study, using two types of fixed abrasive diamond (FAD) wires 80d-M6/12 and 100d-M6/12 (core-wire diameter of 80 and 100 µm and diamond particles of 6 - 12 µm in diameter range), we cut monocrystalline (100) Si bricks whose pseudo-square cross sections were 156 mm × 156 mm. By applying tension on the diamond wires at 19 N (100d-M6/12) and 13 N (80d-M6/12), the bricks are sawn into wafers with the thickness of 120 and 140 µm.

Using a three-line bending tester [2] as shown in Fig 1(a) and (b), we measured wafer fracture strength. To evaluate the dependency of wire saw marks on the fracture strength, loads are applied 1(a) parallel and 1(b) perpendicular (bi-directional) to the wire saw marks. The wafers are having higher fracture strength if bent perpendicular and lower (nearly half) strength if bent parallel to the saw marks shown as in Table 1. Also we found that the wafers sawn with a diamond wire 80d-M6/12 (140 µm) have lower fracture strength. This is probably because unsteady motion of the wire at lower tension (13 N) results in more damage on the wafer surface. We will discuss the mechanism at the upcoming meeting with further data obtained in ongoing experiments.

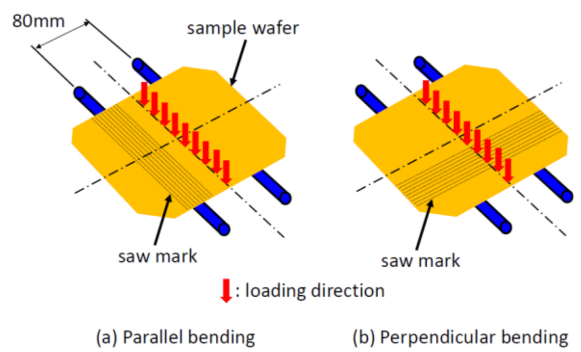

Fig. 1 Schematic drawing of three-line bending test. (a) Parallel and (b) Perpendicular bending.

Table 1. Fracture strength dependence on saw mark direction and wire diameter

Loading direction	Fracture strength (MPa)	
Parallel to saw marks	112±10	137±10
Perpendicular to saw marks	260±26	336±24
Wire specification	80d-M6/12	100d-M6/12
Wafer thickness (µm)	140	120

Reference:

1. H. Sekhar, et. al, Proc. of the 16th International Conference on Nanotechnology, 415–418 (2016).

2. T. Fukuda, et. al, ADV.1.30, EU-PVSEC 2017.