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A Study of Relationship of Wafer Breakage vs. Wafer Edge Analysis

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I. Introduction:

As semiconductor device feature size continues to increase, the wafer raw material cost was also increasing. It is well known that silicon was belonging to a hard and easy breakage (brittle) material. Due to its brittle nature, a lot of stresses induced in the in-line process, thus it is more applicable for silicon strength to be characterized at wafer level. When the trend in microelectronic process is going toward larger and larger in size, the study of silicon wafer strength has been recognized as an important parameter in IC process. The strength of silicon wafer is heavily dependent on how the wafer edge shape design is prepared prior to film stress induced on surface. Flaws such as small micro cracks or etch pits can occur during IC process causing the strength of the silicon to decrease and fracture.

In this paper, a study was investigating the effect of wafer strength to the design profile of wafer edge using a mechanical drop test [1] and in-line breakage ratio collection. The wafer strength was characterized using a mechanical drop test while the design profile of wafer edge was characterized using optical image analyzer.

II. Experimental:

Initially, a series (four kinds) of 200mm silicon wafers were prepare with differing grind wheel in profile. All wafers had the same nominal final thickness. Samples were P-type (boron doped, 8-12 Ωcm), CZ silicon (100) wafers the edge profile.

The experimental set-up for the mechanical strength was used drop test which was shown in Fig-1. A drop test was devised as a highly accelerated test to assess the strength of the wafers in encapsulated form. The recorded energy on drop test is a measure of its mechanical strength. The present drop test subjects encapsulated wafer on wafer guide finish to a mechanical impact or shock loading. A 200g weight is allowed to fall freely from some height once on to each wafer specimen.

III. Results:

Wafer fabrication finishing processes such as grinding, lapping, polishing and dry etching have a direct impact on the extent of edge surface. Fig. 2 shows two kinds causes for whole wafer breakage. The first type is starting breakage at wafer edge which was due to chip-like damage occurring and shown as Fig. 2 (a). This type breakage always happens at photolithography, wet bench cleaning, and furnace module. The other type is backside damage occurring at backside surface which are always with some micro in size shown as Fig. 2 (b). And this type breakage was often happened at CMP module [2-3]. A fracture in silicon wafer begins when the stress applied is concentrated at the tip of a micro crack. When the stress exceeds a critical value, atomic bonds begin to break where elastic energy is released. And a new surface is created as the crack propagates through the material.

In order to analyze the differences of the wafer strength correlated with various edge profiles. Four kinds wafer edge profiles were prepared as Fig. 3. In fig. 3 shows that the full round edge profile propose a higher resistance to break than other type ones.

It is interesting to study the breakage ratio of wafers with same material and processes but different edge profile (same as fig. 3). This is the first time to study wafer edge is also a factor of wafer strength and breakage ratio.

To study this effect, four kind types, type A to type D, were prepared over hundred thousand pieces and used in fab manufacturing line. The full round of edge profile wafers have about 1200ppm breakage ratio which is the lowest one as practical data as shown Fig. 4. In previous experience, all user always think that the wafer breakage was belong to the machine abnormal case. In this study, an improved edge profile was proposed to reduce the fab line wafer breakage ratio.

The start point of breakage was also examined by OM, which were shown in Fig. 5-6.

The wafer edge defects were checked by laser scanner detector (shown in Fig. 7). In general, the wafer edge's defects are containing not only pits and also bumps. These defects were calculated and correlated to the breakage rate, which was shown in Fig. 8.

Thus, a solid summary can be made that edge grinding does produce a week region for the wafer strength of it is 8-inch wafer.

We can demonstrate that the sharp edge profile will accumulate more defects or grinding mark on its edge surface.

Conclusions:

In this work, the characterization of failure strength of the whole wafer using a simple mechanical drop test has been investigated. The study shows that the wafer with full round of edge profile propose the largest breakage energy and lowest wafer breakage ratio than sharp type ones.

References:

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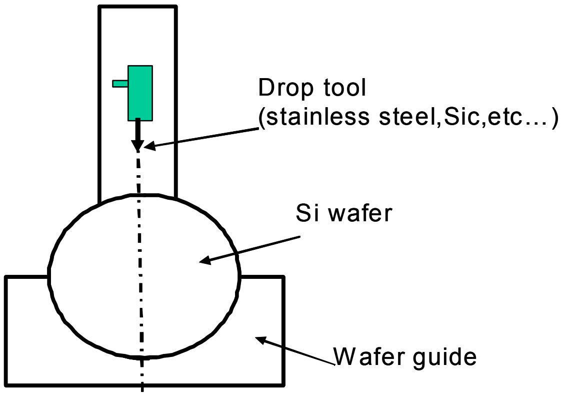

Fig. 1 The set-up of mechanical drop test is for wafer strength examination..

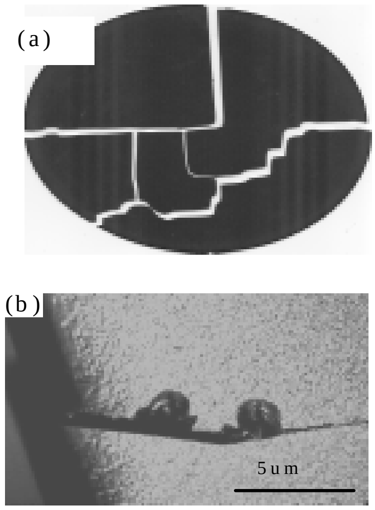

Fig.2 The OM (optical microscopy) analysis for wafer broken case .

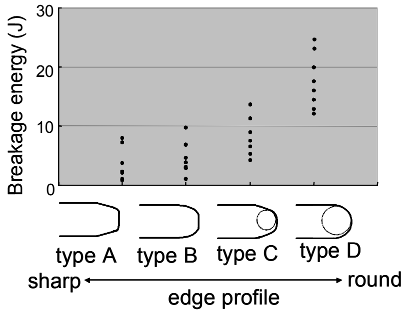

Fig. 3 The results of mechanical drop test.

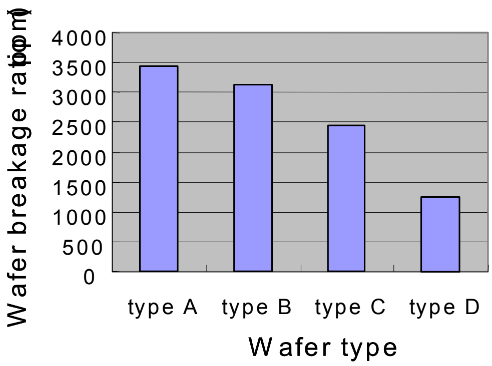

Fig. 4 The wafer breakage ratio of type A to type D.

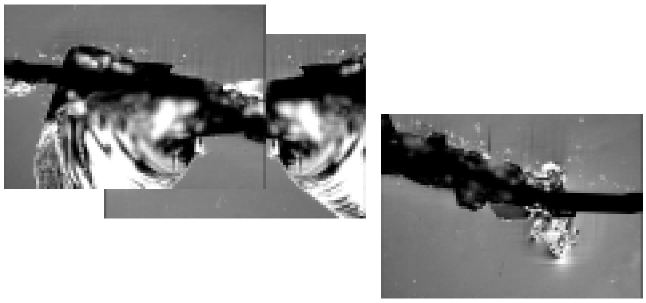

Fig. 5. The OM (optical microscopy) analysis

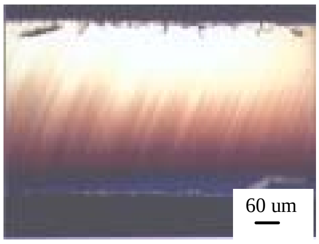

Fig. 6. The OM (optical microscopy) analysis

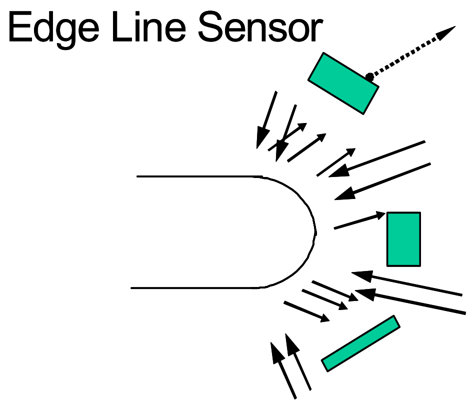

Fig. 7 The set-up of wafer edge analysis.

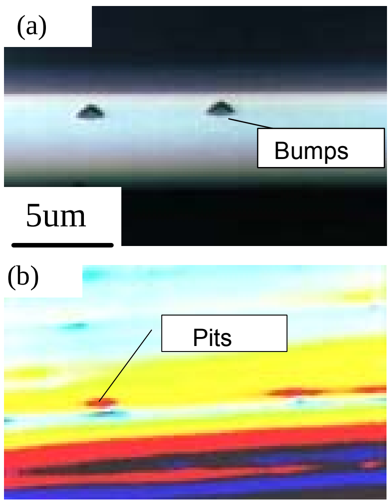

Fig. 8 The OM (optical microscopy) pictures of wafer edge analysis.