B1-1 (INVITED) INDUCED DEFECTS IN CRYSTALS THROUGH MECHANICAL PROCESSINGS

Shin. Takasu and Y. Matsushita,
Toshiba R. and D. Center,
1-KomukaiToshibachyo, Saiwaiku, Kawasaki, 210.

The electronic industry has to solve many of the major production problems associated with high-volume and high-quality processings of single crystals. Their examples are semiconductor materials--Si, Ge, GaAs, GaP, InSb --, optoelectronic materials--Ruby, $Y_3Al_5O_{12}$, $YAlO_3$, $Ba_2NaNb_5O_{15}$, $LiNbO_3$, $LiTaO_3$--, surface wave device materials--$LiNbO_3$, quartz--, magnetic device materials--ferrospinels ($M^{2+}Fe_2O_4$),magnetic garnet ($Y_3Fe_5O_{12}$)-- and other single crystal materials.

These materials have high symmetry, cubic or hexagonal except $YAlO_3$ and $Ba_2NaNb_5O_{15}$ in above-mentioned crystals.

Generally, the processings of single crystal solid state devices starts from the mechanical step and ends in the mechanical step. Figure 1 shows the example of flow chart of single crystal solid state devices production.

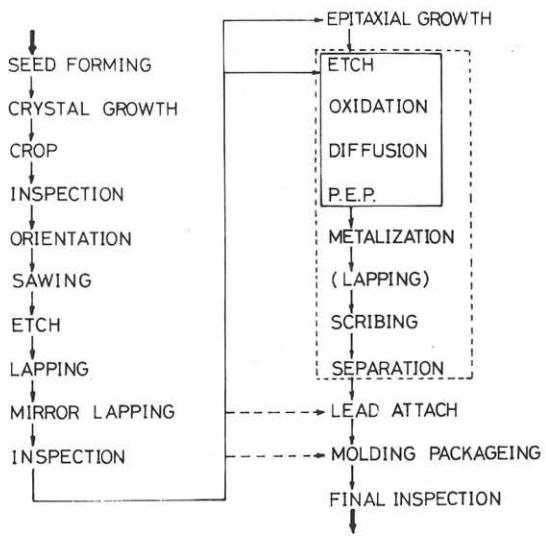


Fig. 1 Typical Flow Chart for Single Crystal Solid State Device.

The starting step is seed forming for Czochralski, floating zone, top seeded, hydrothermal and other seeded crystal growth methods. In special case, spontaneous nucleation methods in flux, aqous solution or gaseous phase is excluded. But slicing, grinding and lapping steps can not be excluded in these cases.

The final steps are scribing, wiring, packaging and molding. Yield of these steps is apt to be forgotten.

Hitherto, mechanical processings have had the demand of geometrical accuracy--orientation, thickness, diameter, flatness, positioning and others.

Recently, the mechanical accuracy has to add the crystal perfectness.

Usually, mechanical properties of single crystals are not isotropic. The cleavage and slip of crystal are typical one. And each crystal has its own definite orientations.

Figure 2 shows the differences of cleavage orientations for diamond type structure and zinc blend type structure crystals. Diamond type structure crystals show {111} cleavage--4 orientations--and zinc blend type structure crystals show {110} cleavage--6 orientations. (111) and (100) wafer for Si has not perpendicular cleavage but (110) wafer has perpendicular cleavage, but (111), (100) and (110) wafers of zinc blend type structure crystals have perpendicular cleavages.

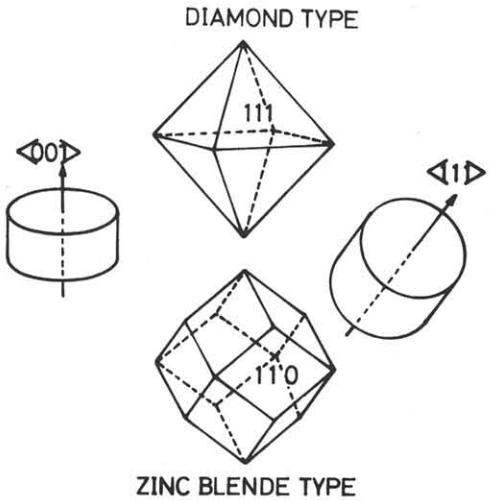
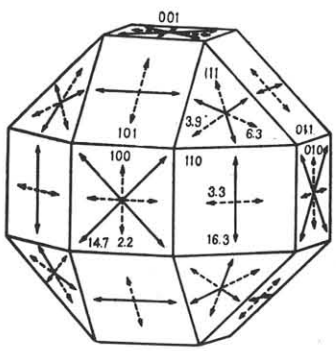


Fig. 2 Cleavage orientations for two cubic crystals.

These relations are very important in mechanical processing, scribing and cutting.

Figure 3 shows the hardness on several low index surfaces of diamond. This phenomena is applied to lapping of gem stone, but in solid state devices production processes it is disregarded[1,2].



---- Highest hardness in HKL surface

.... Lowest hardness in HKL surface

Fig. 3 Hardness anisotropies on low index surfaces of dimond.

Recently, we have found processing induced anisotropy on lapping surface of (111) Si wafer[3].

These orientation dependencies of mechanical properties must be taken into consideration in mechanical processings. At present, it is difficult to consider anisotropy of mechanical processing. Then, it is not desirable to simulate by isotropic materials.

In this state, it is very important that in-situ, in-process and non-destructive observation must be carried out through each processing for their own crystals.

In this paper, we talk about several methods in comparison of each special merit. We use following methods:

1) Optical observation (macro and microscopic)[4],
   - 1a) visible light,
   - 1b) infrared light,

2) X-ray methods,
   - 2a) X-ray topograph methods (Lang and Berg-Barret),
   - 2b) double or triple crystal diffractometer,

3) S.E.M. and C.E.M. observation,

4) Inter ferometry and multi-divided beam spherometer[5],

5) Other methods.

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