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- [54] PROCESS FOR INSPECTING MONOCRYSTALLINE MATERIAL FOR PRECIPITATION OF IMPURITIES
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- [58] Field of Search 378/73, 74

References Cited

U.S. PATENT DOCUMENTS

- 4,217,493 8/1980 Li et al. 378/73
- 4,788,702 11/1988 Howe et al. 378/73

OTHER PUBLICATIONS

- Iida, S., Sugiyama H., Sugita Y., and Kawata H. (Jun. 1988). Measurement and Analysis of the Static Debye-Waller Factor of Cz-Silicon with Small Oxygen Precipitates. *Japanese Journal of Applied Physics*, 27(8), 1081-1087.
- James, R. W. (1965). *X-ray Crystallography*. New York: Wiley, pp. 56-70.
- Bragg, W. L. (1975). *The Development of X-ray Analysis*. New York: Hafner, pp. 79-87.

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[57] ABSTRACT

In the manufacture and processing of monocrystalline material, it is important to be able to detect and measure deviations from the ideal crystal structure. Data are required on the density and average extent of impurity precipitations. The irradiation of discrete crystal areas with wave or particle beams, the determination of the intensity distribution of the beams scattered under Bragg conditions, and the determination of static Debye-Waller factors are to be performed automatically and universally, on different specimen thicknesses, with high resolution and flexibility regarding changes in wavelength. For this purpose, a variation of the angle of incidence of the beams on the diffracting lattice planes is performed, and the reflection factor is measured by means of a photon or particle detector, and the integral reflection factor R_{int} is determined. Pivoting the specimen around an axis which is perpendicular to the diffracting lattice planes leads to a variation of the specimen thickness. R_{int} is measured as a function of the specimen thickness. From the measured dependence, fitted to a theoretical function, the static Debye-Waller factor is determined, and when several diffraction orders are measured, the density or number and the average extent of the precipitations can also be determined. Important applications include the in situ determination of impurity precipitations in inspections of Si wafers, which can be mapped with high-sensitivity resolutions as a function of density and size of SiO₂ precipitations, etc.

12 Claims, 4 Drawing Sheets

