FILM DECORATING APPLICATION FOR STRUCTURE PERFECTION EVALUATION OF HIGH PURITY MATERIALS FOR SILICON DETECTORS

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Lately a necessity has increased in having the charged particle detectors made by planar technology and intended for the work in the intensive beams and for a series of devices requiring a high crystal structure quality. With this connection the high sensitive research methods capable of evaluating and controlling the high resistive silicon wafers and the devices are of particular interest.

One should pay attention to the film decorating method, whose application has shown its efficiency for the analysis of silicon crystals used in photoelectrical device fabrication [1]. The method consists in forming both a macro and a micro pattern, obtained owing to color contrast made by the product of chemical reaction

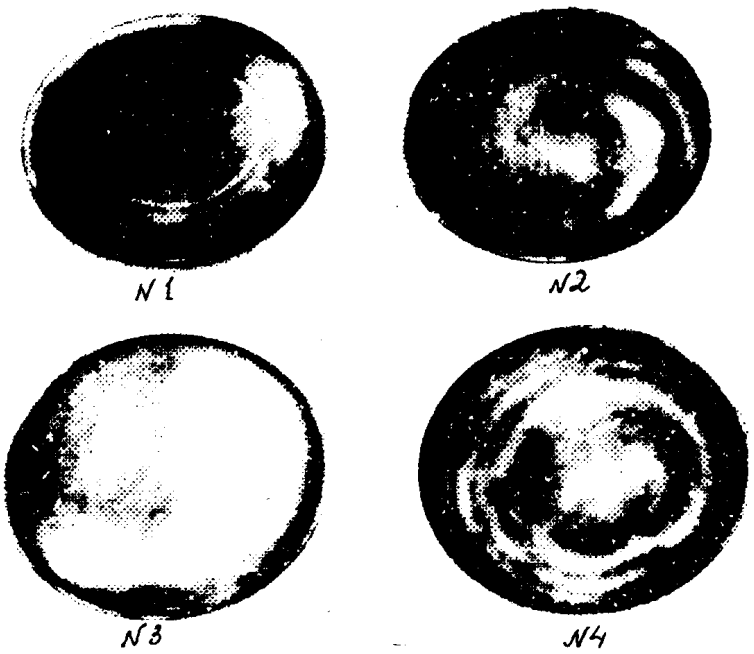

Fig.1. Appearance of original silicon wafers after film decorating

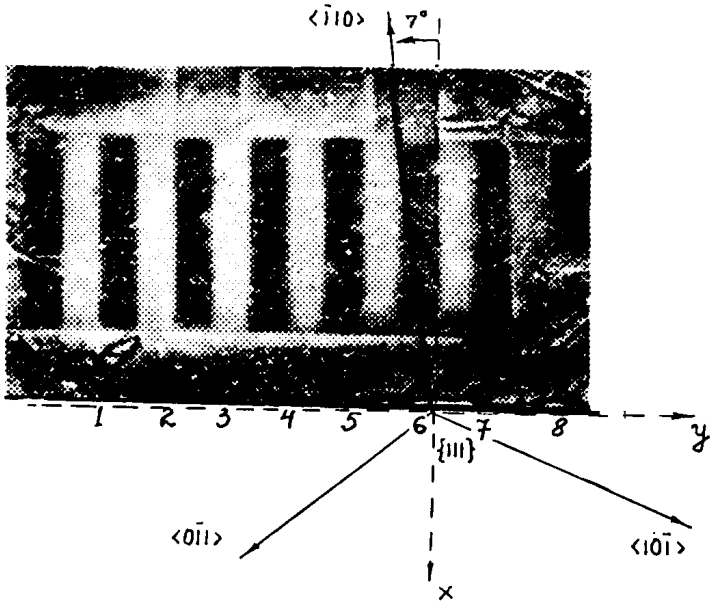

Fig.2. Film decorating result of 8-pad detector. Cutting crystal orientation is schematically shown relative to main crystallograghy directions

between Si and decorating solution. A rate of such a reaction is rather sensitive to structure homogeneity of silicon surface and has different values on "defect" and "undefect" places. Rate variety of the wafer parts with different inhomogeneities can be easily evaluated by color difference of the reaction product, which is due to interference of light reflected from the internal and external boundary of a silicon-film system.

The film substance is more chemically active than silicon due to Si—H bonds and can be easily removed from the surface without its destruction, if we don't take into account a silicon layer of 600—800 Å width, used on film formation.

The film decorating result of original Si wafers is shown in fig.1. There the polished <111> oriented wafers of n—Si with diameter of 60 mm and thickness of 300—500 μm having resistivity between 1000 and 5000 $\Omega \times cm$ fabricated in Zaporozhje (Ukraine) by floating-zone melting technique have been used. On high resistivity silicon wafers we have succeeded to reveal the mechanical surface defects such as scratches, marks and microcracks during the same operations as with low resistivity silicon. At the same time we are not able to reveal in detail impurity inhomogeneities in all the cases of high resistivity silicon due to a lower (by several orders) impurity content in comparison with low resistivity wafers. The obtained figures of impurity inhomogeneities (fig.1) indicate the difference in distribution of doping impurities, which is in agreement with SHF-profiling measurements of resistivity (ρ) and minority carrier life time (τ). Thus, for homogeneous wafer (#3) ρ variation is 16%, τ variation being 8%. As for the wafer with swirl inhomogeneities (#4) variation of ρ and τ is consequently equal to 69% and 40%.

Fig.2 shows a Si—H film, grown on a back side of 8-pads detector, used in the Fermilab experiment E-761 on E^+ hyperon spin rotation effect in a bent crystal. The greatest number of slip lines is revealed in the place of 7th and 8th pads, which is in a good agreement with crystallography orientation of crystal cutting (fig.2) and the results of particle dechannelling, observed in this part of crystal during the above mentioned experiment. One should pay attention to the dark rectangles in fig.2 with dimensions equal to the size of diodes placed of the opposite side of the detectors exactly under these areas. Electrical measurement has indicated that in this case Si—H film decorates variation of the ionized centers concentration between $3 \cdot 10^{12}\, cm^{-3}$ (light strips) and $6 \cdot 10^{12}\, cm^{-3}$ (dark strips).

The method involved has advantages over a selective etching due to its high sensibility and low destructiveness. The wafers controlled in such a way, can be later on applied for device production. The Si—H film method has been used during the development of technology and production of microstrip detectors [2]. At present we continue the work to reveal other possibilities of this method.

References

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