Characterisation of Bulk and Surface Properties in Semiconductors Using Non-Contacting Techniques.

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Non-contacting techniques for the characterrization of semiconducting materials and devices are widely used nowadays, as these are very useful for in-line process characterization. Furthermore, the possibility to detect organic surface contamination is of fundamental importance for microelectronic applications as ions or organic molecules released from plastic packages on the starting wafer since they have a detrimental impact on device performance.

Two, widely known [1,2], non-contacting techniques such as SPV (Surface Photovoltage) and SKP (Scanning Kelvin Probe) have been implemented on the same wafer stage to monitor surface and bulk properties of mono and multi-crystalline Si. In particular the minority carrier diffusion length and the near-surface doping distribution [3] is measured by the SPV method, while the semiconductor work function WF is measured by the SKP technique. WF has been correlated with organic contaminant surface distribution [4], thus by SKP analyses the surface contaminant distribution can be detected. Mapping is also possible since the two probes are allowed to move in the xy plane.

The results concerning the application of these methods to the characterization of different Si wafers will be reported in the present contribution. One example of diffusion length evaluation by SPV on multicrystalline Si wafers is reported in Fig.1. Here the diffusion length distribution of as-grown wafers is compared with diffusion length distribution of wafers that have been P (emitter) diffused.

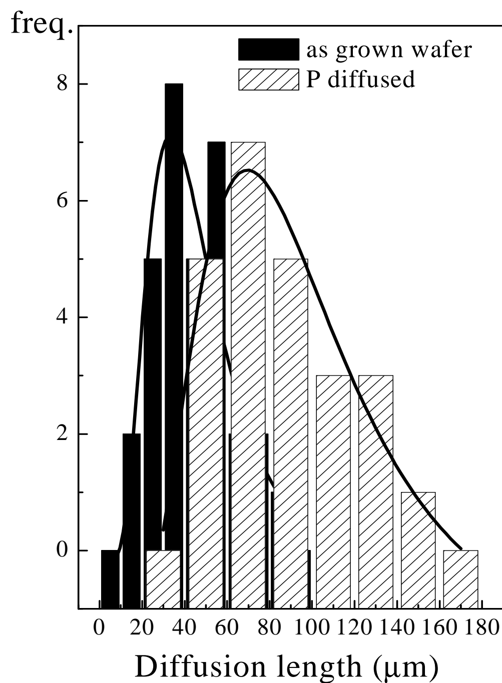

Figure 1. Evolution of minority carrier diffusion length distribution with device processing.

This result shows that diffusion lengths can be measured at different process steps and that their values significantly increase due to the P diffusion gettering mechanism [5].

An example of SKP analyses is reported in fig.2, where the work function map of a monocrystalline Si wafer is shown. The dark spots in the map are correlated to the presence of organic surface contamination. This method does not allow for the identification of the chemical species involved in the contamination and further complementary spectroscopical techniques are required for this [6], but it allows for the detection of contamination in fast, non-contact way.

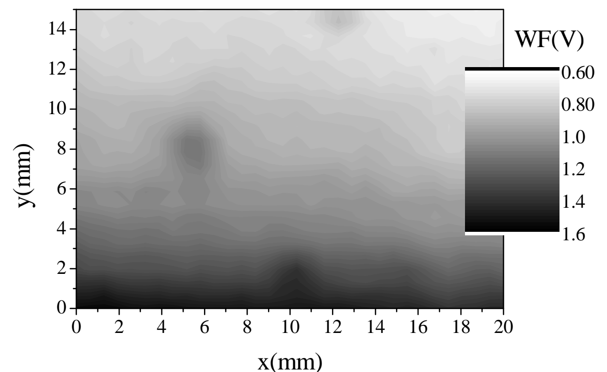

Figure 2. Work function map of Cz grown Si as measured by SKP: the dark spots represents region where organic contamination has been found.

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References

1. J. Lagowski, P. Edelman, M. Dexter and W. Henley *Semicond. Sci. Technol.* **7**, A185 (1992).
2. D. Baikie and P. J. Estrup *Rev. Sci. Instrum.* **69**, 11 (1998).
3. E. Kamieniecki *J. Vac. Sci. and Techn.* **20**, 3 (1992).
4. E. Spiecker, M. Seibt and W. Schroeter, *Phys Rev B* **55,** 15 9577 (1997).
5. A.Castaldini, D.Cavalcoli, A.Cavallini and M.Rossi. *Mat Sci and Eng B*, **91-92** 234 (2002).
6. D. Cavalcoli, A.Cavallini, M.Rossi, S.Binetti, F.Izzia and S.Pizzini submitted to Journal of Electrochemical Society.