MICRONOVA
CENTRE FOR MICRO- AND NANOTECHNOLOGY
TKK – HELSINKI UNIVERSITY OF TECHNOLOGY

DYNAMICS OF MICROSCOPIC DEFECTS IN SILICON

ELECTRON PHYSICS LABORATORY

Continuous improvement in silicon crystal growing and wafer technology has enabled the manufacture of ever-smaller and complicated IC and MEMS components. To ensure the efficiency of these components, requirements for material purity and structural perfection have become very stringent. Even extremely small concentrations of foreign atoms or crystal defects in silicon wafers can be detrimental for device performance and can dramatically degrade long-term stability of electronic circuits resulting in yield losses. Crystal defects are not, however, solely harmful. Oxide precipitates and related crystal defects, which are located deep in the bulk of the wafer, can have a beneficial effect in driving impurities and defects away from the active device region, this is called gettering. However, so far a full understanding of the oxygen precipitation and gettering mechanism has not been achieved. Within this project we aim to have more accurate control and predictability of oxygen related defects. This requires a deep understanding of the interaction of point-like defects, oxygen and high temperature processes, which will be achieved through detailed modeling and a variety of experiments.

RECENT RESULTS

Based on the classical nucleation theory and diffusion kinetics, we have created a simulation model that calculates the dissolved oxygen and the size distribution of oxide precipitates as a function of depth when process parameters are given as input. The model is applicable both to the silicon crystal growing and wafer processing. In addition, we have modelled vacancy and interstitial behavior during crystal growth with varying pull-rates of the crystal by taking into account convection and the Frenkel pairing. We have also created a new model for the growth and dissolution of iron precipitates at oxygen-related defects, i.e. internal gettering, for details see Publ.1. We have also developed a new technique to measure copper contamination that is based on the recombination lifetime (Fig. 1, Publ. 2 and 5).

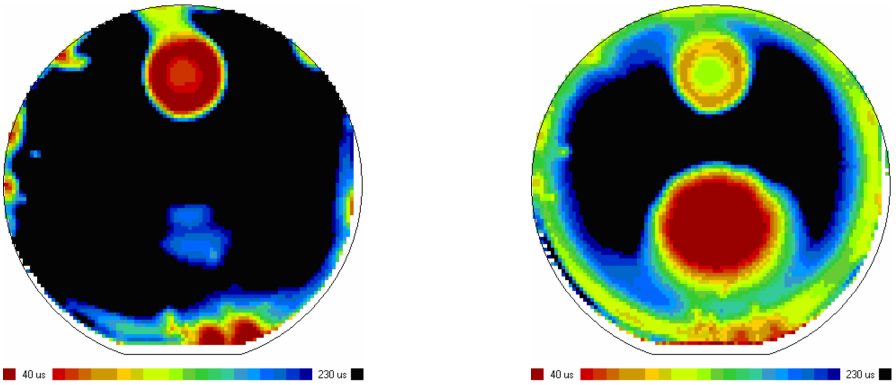

Figure 1: a) A conventionally measured recombination lifetime map with spot-like iron and copper contaminations. The iron contamination is clearly visible in the upper part of the wafer (lifetime is about 25 μs) while the lifetime in the copper contaminated area is above 200 μs.

b) A recombination lifetime map of the same wafer after 10 minutes of light illumination (0.2 W/cm^2). The lifetime has increased in the Fe contamination area to about 100 μs while the lifetime has decreased in the copper contamination area to about 20 μs.

Funding

Funding for this work has been provided by Tekes, Academy of Finland (graduate school positions) and our industrial partners.

Industrial Partners

Okmetic Oyj, Micro Analog Systems Oy, VTI Technologies Oy, Semilab Inc

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Recent Publications

1. A. Haarahiltunen, H. Väinölä, O. Anttila, E. Saarnilehto, M. Yli-Koski, J. Storgårds, and J. Sinkkonen, Modeling of heterogeneous precipitation of iron in silicon, Applied Physics Letters, 87, 151908 (2005).

2. H. Väinölä, E. Saarnilehto, M. Yli-Koski, A. Haarahiltunen, J. Sinkkonen, G. Berenyi and T. Pavelka, Quantitative copper measurement in oxidized p-type silicon wafers using microwave photoconductivity decay, Applied Physics Letters, 87, 032109 (2005).

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4. H. Savin, Controlling iron and copper precipitation in silicon wafers, Doctoral Dissertation, Helsinki University of Technology, Espoo 2005.

5. M. Yli-Koski, H. Savin, E. Saarnilehto, A. Haarahiltunen, J. Sinkkonen, G. Berenyi, T. Pavelka, Measurement of copper in p-type silicon using carrier lifetime methods, Solid State Phenomena Vols. 108-109, pp.643-648 (2005).