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Overview

The papers in this volume were presented at the Advanced Workshop on Silicon Recombination Lifetime Characterization Methods held at Santa Clara, CA on 2–3 June, 1997. The workshop was sponsored by ASTM Committee F1 on Electronics and SEMI. In addition to the technical presentations and poster sessions, the workshop included two well-attended panel discussions, the impressions of which are provided in Appendix I.

The workshop addressed the state of the art in the following areas:

- Physics of recombination lifetime in single crystal silicon
- Effects of measurement system and sample characteristics
- Surface influences and interpretation
- Correlation between the various equipment types
- Application considerations
- Industry standard methods and practices

The proceedings section is divided as follows:

- Lifetime concepts
- Different measuring techniques, such as photoconductivity method, Elymat technique, surface photovoltaic technique, etc.
- Comparison among techniques
- Applications of lifetime measurement in silicon
- Standardization and round robins

Dieter Schroeder discusses the theory and concepts of lifetime as a parameter to characterize the purity of silicon. His discussion is augmented with experimental data. Weber, et al., of UC Berkeley, have experimentally determined that the diffusion of iron in silicon produces low diffusion lengths. The latter increases in the course of precipitation, reaches a certain maximum, and then, on the final stage of precipitation, slightly decreases again. The authors also provide understanding on the effects of other metal precipitates in silicon and devices fabricated therefrom. Zoth discusses the unique features of Fe in boron doped silicon. He observes that this impurity in the starting material used for most CMOS devices makes a ''perfect'' recombination center for lifetime measurements.

Three methods of measurement of lifetime are popular today. These are the photoconductivity by microwave reflectance, the Elymat technique, and the surface photovoltaic technique. More than 14 papers discuss details on these techniques. Not only are the details of the methods of measurement discussed, but various effects and interferences are also noted for each technique. The scientists are working on other techniques, as well, that are described in papers included in the ''Other Techniques'' section.

It is pointed out in many papers that the injection level, defined as the ratio of the excess minority carrier density to the equilibrium majority carrier density, is an important factor in the understanding of lifetime measurements and in the derivation of metal concentration from these measurements. According to Eichinger, this parameter may be used to identify the chemical nature of a dominant recombination center, such as iron and other dissolved metals, and oxygen precipitates in silicon.

Several authors describe various applications of lifetime as a measurement parameter in silicon. These applications include the determination of metal contamination introduced in silicon from many sources: during crystal growth; wafer processing; handling of the wafer during processing; and even in the cleaning processes. The defects generated during rapid thermal processing may be studied using these measurements, Karoui, et al. state.

Further, it is stated that because lifetime is affected by very low concentrations of metals in silicon this knowledge can be used to determine the purity of silicon. This is probably the only measurement today for the determination of very low levels of metals in silicon, of the order of ppt range or less.

This technique is currently going through the standardization process. There are standard test methods on many of the techniques already in the ASTM Book of Standards (Vol. 10.05). Few others are in the process of becoming standards.

Dinesh Gupta
Symposium chairman and co-editor
Mitsubishi Silicon America
Palo Alto, CA

Fred R. Bacher
Symposium co-chairman and co-editor
Wacker Siltronic Corp.
Portland, OR

William Hughes
Symposium co-chairman and co-editor
MEMC Electronics Materials Inc.
St. Peters, MO