4.5.15. NONDESTRUCTIVE INSPECTION TECHNIQUE OF DIELECTRIC FILMS IN METAL-OXIDE-SEMICONDACTOR STRUCTURE

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The charge degradation and modification of MOS-structures consisting of interface state generation and charge generation in thermal SiO_2 occurs under many stressing situations such as high-field charge injection, exposure to ionizing radiation, plasma treatment etc. In the present work, a new nondestructive inspection technique of multilevel current stress is proposed. This technique allows to investigate the generation of positive and negative charges, accumulating in gate dielectric of MOS structures under stressing situations.

We propose the nondestructive inspection technique of the MOS-structure analysis based on applying a multilevel current stress to the MOS-structure, while current is flowing the variation of the voltage across the MOS-structure V_I is recorded. A change in the charge state of the MOS-structure is determined from the analysis of the V_I time dependence. The technique takes into account the process of the MOS capacitance charging by the constant current pulse. In comparison with the conventional techniques our technique enables to reduce the high-field stress time while measuring the injection current-voltage (I-V) characteristics of the MOS-structure. We consider this technique to provide higher accuracy and to decrease the probability of dielectric breakdown. The charge changing parameters obtained by the present technique are determined before and after high-field and ionizing radiation stressing. When using the high-field injection technique it must satisfy the following condition: the charge state variation of dielectric during high-field stress must be more less than the amount of injection charge (Q_{inj}).

Nowadays, the constant current stress technique [1, 2] is widely used for investigation of positive charge generation in MOS structures. In this technique, a constant current pulse is applied to a MOS structure, causing the charging of structure capacitance and initiating the mode of Fowler-Nordheim high-field tunnel electron injection. Measuring the MOS structure voltage shift one can estimate the charge state change of a sample [1].

However, under high densities of tunnel current, the positive charge generation rate increases. Hence, when an injection current begins to flow in a gate dielectric, it can generate a part of positive charge, not taking into account in this technique. As a result, the constant current technique at high densities of injection current can give underestimated values of positive charge. The usage of other techniques of positive charge value determining, for example C-V technique or charge pumping, requires the interruption of injection and the re-commutation sample. It can lead to relaxation of a part of the positive charge and significant errors in its determination.

To eliminate this shortcoming, a special algorithm to control the current stress applied to a sample was proposed. Two levels of current are applied to the structure: stress level I_S and measuring level I_m. Charge generation in the gate dielectric is caused by stress current value I_S. The current I_m must have a value of several orders less than I_S, to minimize the dielectric charge changing by this current. The MOS charge state change can be estimated by the voltage shift on MOS structure at current I_m. Voltage shift under current I_m takes into account charge generated in the gate dielectric right after the switching to the current I_s. Thus, the inherent errors of constant current technique are reduced when utilizing our technique.

References:

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