CHAPTER FIVE : CONCLUSIONS AND SUGGESTIONS

The effective minority carrier recombination lifetime of metal contaminated and oxidized wafers was investigated using LM-PCD technique. A simple two species model which employs a combination of surface defects inter-conversion and energy band-bending was suggested to explain the change of effective minority carrier recombination lifetime in both cases. The model shows a general trend of effective minority carrier recombination lifetimes for appropriate interconversion rate constants, k_1 or k_2 and total number of localized energy states, n_t. The trends of change of effective minority carrier recombination lifetime obtained from the model compares well with the experimental data for metal contaminated and oxidized wafers.

In the metal contamination case, the model shows that the threshold time decreases when the total number of localized energy state, n_t are reduced. Hence, this suggests that n_t may be reduced after the wafers have been contaminated by the metal. The metals may form complexes[81-88](species 1 and 2) with the dangling bonds or defects on the silicon wafer surface. During UV irradiation, the bond breaking of the complexes by UV may cause the complexes (species 1) to be converted to other form of complexes (species 2) which have a different energy states in the energy gap. However, the model is not consistent with the case of copper under UV irradiation. Inconsistency between the model and the experimental results may be due to the change of bulk minority carrier recombination lifetime which is a constant parameter in the proposed model. An experiment to study the UV enhanced diffusion is

suggested to further improve the model proposed. Hence, this model only shows a general trend of effective minority carrier recombination lifetime for the metal contaminated wafers and it is only limited to the surface effect under UV irradiation. The types of the metal will not be able to be distinguished by this model.

For the thermal oxidation case, the model suggests that the conversion of species 1 to species 2 is slower in wafers oxidized at higher oxidation temperatures. A decrement of effective minority carrier recombination lifetime at initial stage of UV irradiation is shown in the thermally oxidized wafers. This decrement of effective minority carrier recombination lifetime is also predicted in the proposed two species model. Since effective minority carrier recombination lifetime is related to the surface potential, V_s (eqn. 2.1,2.11), it is conjectured that the change of effective minority carrier recombination lifetime could be due to the change of surface potential during UV irradiation. However, it took only a few minutes to complete the energy band bending process and the mechanism for this process is still unclear. For future work, the surface photovoltage (SPV) measurement technique could be used to study this mechanism of change of surface potential under UV irradiation. An expression for surface potential, V_S may depend on the charging time, the magnitude of the surface charge and the surface impedance[130-132]. In the case of metal contaminated wafers, the effective minority carrier recombination lifetime was not affected by the energy band bending process during the initial stage of UV irradiation.

From these experiments, it was found that the transient recovery after UV irradiation for metal contamination are faster than that for the oxidized wafers. The fast transient

recovery in contaminated wafers may recover the bended energy band during UV irradiation to its initial stage before UV irradiation in the order of seconds. In the oxidized wafer, the transient recovery time is much longer. It means that the oxidized wafers are able to maintain the charge on the oxide surface, however, the electrons will slowly leak back to the substrate in a few days. Therefore, the wafer surface passivation using low thermal oxidation temperature such as 700 °C within a few minutes and 10 min of UV irradiation, followed by LM-PCD lifetime measurement is possible to extract the value of bulk lifetime instead of high oxidation temperature and more than one hour of oxidation time.