produced by a spatially intimated coupling of pairs between dangling bonds and positively ionized impurities.

6-5. Summary

(1) The steady-state and transient HMC methods have been applied to determining densities and profiles of midgap states in undoped a-Si$_{1-x}$Ge$_x$:H, undoped a-Si:H and undoped a-Si$_{1-x}$C$_x$:H. The midgap states are correlated with D$^0$; the density in a-Si$_{1-x}$Ge$_x$:H ($E_0 \leq 1.63$ eV) represents the D$^0$ density of Ge, and in a-Si:H and a-Si$_{1-x}$C$_x$:H ($E_0 \leq 1.88$ eV) it represents the D$^0$ density of Si. The density of midgap states increases slowly with the Ge content in the film, while it increases rapidly with the C content. The peak of the midgap-state profile appears clearly in a-Si:H and a-Si$_{1-x}$Ge$_x$:H, but it does not appear clearly in a-Si$_{1-x}$C$_x$:H.

(2) Thermal annealing kinetics of metastable gap states in short-time light-soaked a-Si:H have been investigated. Monomolecular kinetics are suitable for explaining the experimental data. The thermal activation energy ($E_a$) for annealing decreases monotonously with an increase in ($E_C-E$). This is the first report which elucidates the relation between $E_a$ and ($E_C-E$).

(3) The midgap states having a small $\nu_n$ are created both optically and thermally, while the midgap states having a large $\nu_n$ are created only by light soaking. Both states are located around 0.85 eV below the conduction band edge.