2:30pm T59 Investigation on Hydrodynamic Impact Ionization (II) in n-MOSFETs

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We have analyzed the II in an Enhanced Drift Diffusion (EDD) model and in a fully self-consistent hydrodynamic (HD) model. In both models the influence of a surface reduction of the generation rate is considered. In the EDD model the electron temperature is calculated from a previous HD or Monte Carlo simulation. In both models the carrier temperature is used to calculate the generation rate using an exponential law. This rate is proportional to the particle flux density.

The influence of a surface impact ionization model is analyzed when looking at a vertical section of the current density in the maximum generation point. The simulation results show that in the EDD simulation there is a sharp local maximum of the current density. In the HD model the current density is much smoother. At low gate biases the maximum current density is in the LDD-doping region rather than beneath the surface. Using high gate biases, the maximum current density moves towards the surface. Comparing EDD and HD simulations it can be seen that the shift of the relative current density is much higher in the EDD model than in the HD model. Therefore, when the generation rate is calculated, the influence of the surface reduction in the HD model is much smaller compared to the conventional EDD model.

To study the current distribution after the pinch off point, the partial driving forces in the EDD and HD models are analyzed. For that purpose the prefactors to the concentration gradient in the EDD and HD model are compared. This is done by introducing a new modified HD model in which the prefactor to the concentration gradient depends on the lattice temperature in contrast to the electron temperature. The advantage of the modified HD model is that it allows a direct comparison of the partial driving forces in the EDD and HD model. When the modified HD model is calculated with the carrier temperatures of the HD model and when the results are compared with the conventional EDD model, the influence of the grad n term in the HD model can be seen.

The results show that the high diffusion of the electrons after the pinch off point is caused by the prefactor to the concentration gradient and not by the partial driving force of the grad T_n term. This high diffusion is responsible for the smoothness of the current density in the HD simulation which finally leads to a smaller influence of the surface II model.