Transient response and electric field domain relocation in semiconductor superlattices

HUIDONG XU, STEPHEN TEITSWORTH, Duke University — Numerical simulation results are presented for a discrete drift-diffusion model that describes electronic transport in weakly-coupled semiconductor superlattices under voltage bias [1]. Sequential resonant tunneling between adjacent quantum wells is the primary conduction mechanism for this model which also incorporates an effective conductivity $\sigma$ associated with the injecting contact. We study time-averaged current-voltage characteristics and the transient current response associated with electric field domain relocation when the applied voltage is abruptly shifted by an amount $V_{\text{step}}$. For intermediate values of $\sigma$ and a range of $V_{\text{step}}$ values, two types of complex transient response are observed: 1) the \textit{tripole/dipole} mechanism in which a charge depletion and a charge accumulation layer move together from the contact, and 2) the \textit{injected monopole} mechanism, in which a small amplitude accumulation layer moves rapidly from the contact. Generally, the injected monopole relocation mechanism is much faster than the tripole/dipole mechanism. At moderately larger values of $\sigma$, the tripole/dipole mechanism is not observed for any value of $V_{\text{step}}$ because the higher levels of injected charge suppress formation of a moving depletion layer. Thus, a relatively small increase in $\sigma$ can result in significantly shorter domain relocation times. [1] L. L. Bonilla and H. T. Grahn, Rep. Prog. Phys. \textbf{68}, pp. 577 - 683, and references therein.