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Title: Energy Relaxation Behavior of Optically Generated Hot Carriers in GaN

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Energy relaxation behavior of hot carriers in nitride compound semiconductors has drawn much attention in view of understanding the role of electron-phonon interactions in solids as well as their device applications. Here, we present a study on the temporal energy relaxation behavior of optically generated hot carriers in GaN. We consider the case that the lattice temperature T_{ℓ} is kept at 4 K by means of an external heat bath, but the carriers are maintained at a higher temperature $T_{\rm c}$ through high power ultrafast lasers. The energy loss rates (ELRs) are evaluated as a function of $T_{\rm c}$ by means of the Fermi golden rule, treating the carrier-phonon interactions by perturbation theory, extended to degenerate electron--hole plasma. The energy losses of the carriers by various carrier--phonon interactions are taken into account by employing interaction-specific screened electron--phonon matrix elements. The screening of the electron--phonon interactions is included by assuming that the carriers respond as independent particles to the assuming that the carriers respond as independent particles to the total electrostatic potential. Energy relaxation curves are obtained from the ELRs, as a function of time, by equating the average rate of energy loss of an electron-hole pair to the ELR per electron-hole pair to the lattice. Our result shows an initial slow energy relaxation (of relaxation time on the order of $10^2 ~\rm fs$) followed by rapid successive relaxation processes over the temperature ranges $10^3 ~{\rm K} > T_{\rm c} > 10^2 ~{\rm K}$ and $10^2 ~{\rm K} > T_{\rm c} > 10 ~{\rm K}$. Rapid cooling in the higher temperature range is via both long-range polar and short-range non-polar optical phonon scatterings, while the lower temperature rapid cooling is dominated by the piezoacoustic coupling to the lattice. Supported in part by the Specialization Project Research Grant funded by the PNU(KSY).