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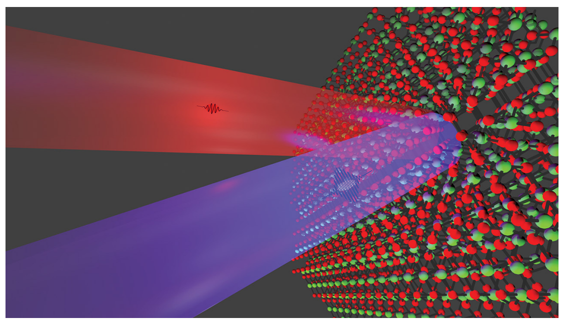
A recombination center model suggests role of crystal defects for photoexcited carriers in monoclinic symmetry gallium oxide.



A material's breakdown voltage depends exponentially on its bandgap, so wide bandgap semiconductors are sought for applications requiring or benefiting from high voltage operation. For example, power electronics operate more efficiently at higher voltages since losses are proportional to the current. One such material with a relatively high bandgap (~5 eV) is gallium oxide with monoclinic symmetry, which, due to its availability as an inexpensive substrate for device fabrication, allows for realization of small, high-speed, power electronic devices. However, there is relatively limited knowledge about its crystal defects and their effect on its electronic properties, such as electron-hole recombination.

Koksal et al. used a two-color pump-probe spectroscopy technique that excites valence band electrons with the pump light, while the subsequent probe light provides subpicosecond dynamics information for the photoexcited electrons and holes. The authors were able to fit the experimental results to a model that combines principles of photoexcitation in semiconductors and the recombination of excited charge carriers aided by defect states.

The authors showed that the behavior of the electrons and holes captured by the crystal defects in the gallium oxide phase were fundamentally different. The hole capture rate was dependent on the temperature, while that for the electrons was not. This suggests that the physical capture phenomenon of the holes was based more on significant lattice relaxations while the electron capture was dominated by electron-electron scattering processes.

Fitting the model to the experimental results provided high-fidelity approximations for the capture rates and the defect density. The specific experimental results using the polarization- and fluence-dependencies of the two-color setup allowed for precise characterization of low defect densities and the polarization dependence of the defect capture, which conventional spectroscopic systems cannot measure.

Source: "Measurement of ultrafast dynamics of photoexcited carriers in β-Ga_2O_3 by two-color optical pump-probe spectroscopy," by Okan Koksal, Nicholas Tanen, Debdeep Jena, Huili (Grace) Xing, and Farhan Rana, *Applied Physics Letters* (2018). The article can be accessed at https://doi.org/10.1063/1.5058164.