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Electronic properties of Single Impurities and Defects in PV Materials[1]

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Approaching the theoretical limits of solar cell efficiencies necessitates advances in the understanding of impurity and defects physics in photovoltaic material. Using optical spectroscopy with diffraction limited spatial resolution, it is possible to study the luminescence from single impurity centers in a semiconductor. By selectively studying individual impurity centers formed by two neighboring nitrogen atoms in GaAs1-xNx, I will show that one can identify their particular impurity configuration, map their spatial distribution, and demonstrate the presence of a diversity of local impurity-host environments. Circumventing the limitation imposed by ensemble averaging and the ability to discriminate individual electronic responses from discrete impurities provides an unprecedented perspective on the nanoscience of impurities in photovoltaic material. The ternary semiconductor alloy GaInP2 plays a very prominent role in High-Efficiency Multijunction Solar Cells as well as in Solid-State Lighting. The size-mismatch induced strain between the binary components of the alloy leads to spontaneous ordering, that results in dramatic changes to the electronic and optical properties. In addition to bandgap lowering, spontaneous ordering is accompanied by stacking fault defects which are poorly understood. I will discuss a novel photoluminescence (PL) snapshot technique that has been recently developed to probe the electronic properties originating from the microstructure of these defects.

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