Optical Imaging of Diffusive Electrons with Different Kinetic Energies in a Semiconductor

Zhang, Sunny

When a solar cell is illuminated by light, free electrons are generated in the semiconductor. They need to diffuse to an electrode to be collected to form a current. A quantity called electron diffusion length is used to measure the material quality, or how far an electron can move. The larger the diffusion length, the better. One way to measure the electron diffusion length is to generate a high density of electrons in a small region of a thin semiconductor slab using a tightly focused laser beam less than one micron in beam size, then watch how the electrons diffuse from the generation site. This phenomenon is similar to pouring a bucket of water onto a surface and watching how far the water can flow. If the surface of the semiconductor is free of defects, the electron diffusion length will be long. Furthermore, at room temperature, the electrons will have different kinetic energies, due to thermalization. Do electrons of different kinetic energies have the same diffusion length? The answer to this question is important to the solar cell design for efficient electron collection. My hypothesis was that they would, because of rapid thermalization processes. My methodology consisted of the following. I applied a photoluminescence imaging technique with both spatial and spectral resolution to study the electron diffusion by imaging photoluminescence signals simultaneously from different spatial locations for different wavelengths that correspond to different electrons kinetic energies. Then I analyzed the spatial profiles of the obtained images to extract the corresponding diffusion lengths. My hypothesis was proven true.