LIGHT ABSORPTION ENHANCEMENT IN GAAS NANOWIRES EVIDENCED BY PHOTOLUMINESCENCE SPECTROSCOPY

Lutz Geelhaar[1], Francisca Marín[1], Ijaas Mohamed[1], Oliver Brandt[1]
[1] Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V.

Semiconductor nanowire arrays can be geometrically designed to absorb more light than planar layers, which is attractive for photovoltaic applications. The underlying reason is that nanowire dimensions are similar to the light wavelength, resulting in complex light-matter coupling. This benefit has been exploited for devices and extensively investigated by simulations, but experimentally it is challenging to study light absorption in single nanowires. Here, we introduce a new and simple method that is based on photoluminescence spectroscopy.

We measure photoluminescence spectra of GaAs nanowires at 10 K and different excitation densities. Due to the high phase-purity of our nanowires, the spectra exhibit only two lines that originate from the donor-acceptor pair transition related to carbon impurities and the free exciton transition. We find two effects that depend on nanowire diameter: First, the excitation density at which the impurity transition saturates and, second, the excitation density at which the transition from excitonic to electron-hole pair recombination occurs, as indicated by a blueshift. Both effects should occur at well-defined charge carrier densities resulting from excitation by light. Thus, our experiments evidence how the light absorption varies with nanowire diameter. We investigate nanowires with diameters in the range 60–160 nm and find a clear absorption enhancement with a maximum for a diameter of 80 nm (see figure). Qualitatively, this trend is consistent with numerical simulations of the absorption cross-section.

Our approach can be generalized and paves the way for further systematic studies of light absorption enhancement and its dependence on nanowire design parameters.