

Elektrotechnik-Elektronik-Informationstechnik

EEI KOLLOQUIUM

A theoretical study of ordered III-V nanowire arrays for light emission and detection

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In this presentation, the physical principles of semiconductor nanowire arrays are discussed, with a focus on applications for photovoltaics and solid state lighting. As analysis tools, specific physics-based numerical models for nanophotonics and nanoelectronics have been developed, which will be discussed. In particular, the three-dimensional nature of a wire array, including the substrate and the free space on top is included in the study. For the optical extraction efficiency of an LED, absorption of electromagnetic energy in the contacts and the active layers themselves, as well as re-emission (photon-recycling) are investigated. The latter is an effect that couples the electronic and the optical system. In addition, the optical density of states is analyzed and its impact on the extraction efficiency is shown. Finally, the total electro-optical efficiency of a nanowire array LED emitting at 400nm is presented and compared to state of the art thin-film LEDs. For the nanowire array solar cell, a detailed electromagnetic and electronic analysis is presented, from which fundamental rules in terms of materials choice and wire geometry will be derived. It shows that low density regular III-V nanowire arrays can reach absorptivities identical to bulk cells, with the advantage of substrate flexibility, low material consumption, and improved strain engineering for multi-junction cells.