Plasmonics-Enhanced Inorganic Solar Cells

In order to fulfill the growing demand for energy, human beings have exceedingly explored and used the conventional sources of non-renewable energies such as oil, natural gases, and coals. These resources are limited in storage and can lead to environmental pollution and a global climate change. These challenges can be overcome by using solar photovoltaic energy, since the solar power that strikes the earth is more than earth's requirements. The main challenges in photovoltaics are either the cost or the insufficient efficiency of the photovoltaic modules. If a thin absorbing layer is employed in solar cells, the cost of the solar cell modules decreases as less material is employed for the development of the solar cells. On the other hand, as the thickness of the semiconductor layer decreases, the absorption in the active layer decreases, which leads to a decrease in the efficiency solar cells. In order to increase the absorption in the thin semiconductor layer, several light trapping techniques have been introduced. The introduction of plasmonic and photonic nanostructures into the solar cells allows for the possibility of reducing the absorbing layer thicknesses, without compromising with the absorption of light. This can enable the development of low cost and high-efficiency solar cells.

The initial part of the thesis describes a numerical study using FDTD simulations of the indium-rich InGaN thin-film solar cells. The performances of these thin solar cells are enhanced by incorporating a periodic array of 1-dimensional and 2-dimensional plasmonic and photonic nanostructures on the back side and/or on the front side of the solar cells. We show significantly improved performances of these solar cells by employing a dual nanostructure (i.e. a combination of plasmonic and photonic nanostructures) as compared to the solar cells without nanostructures or having only photonic nanostructures or only plasmonic nanostructures. Moreover, we examine the effect of the single and dual nanostructures on the InGaN solar cells for various indium compositions in the active layer. Furthermore, we study the performance of the indium-rich InGaN solar cells containing various plasmonic and photonic nanostructures under oblique light incidence. The later part of the thesis describes the improved performance of the microcrystalline silicon thin-film solar cells by employing a periodic array of plasmonic nanostructures on the back side of the solar cell.