Tailoring the Optical Response of III-V Nanowire Arrays

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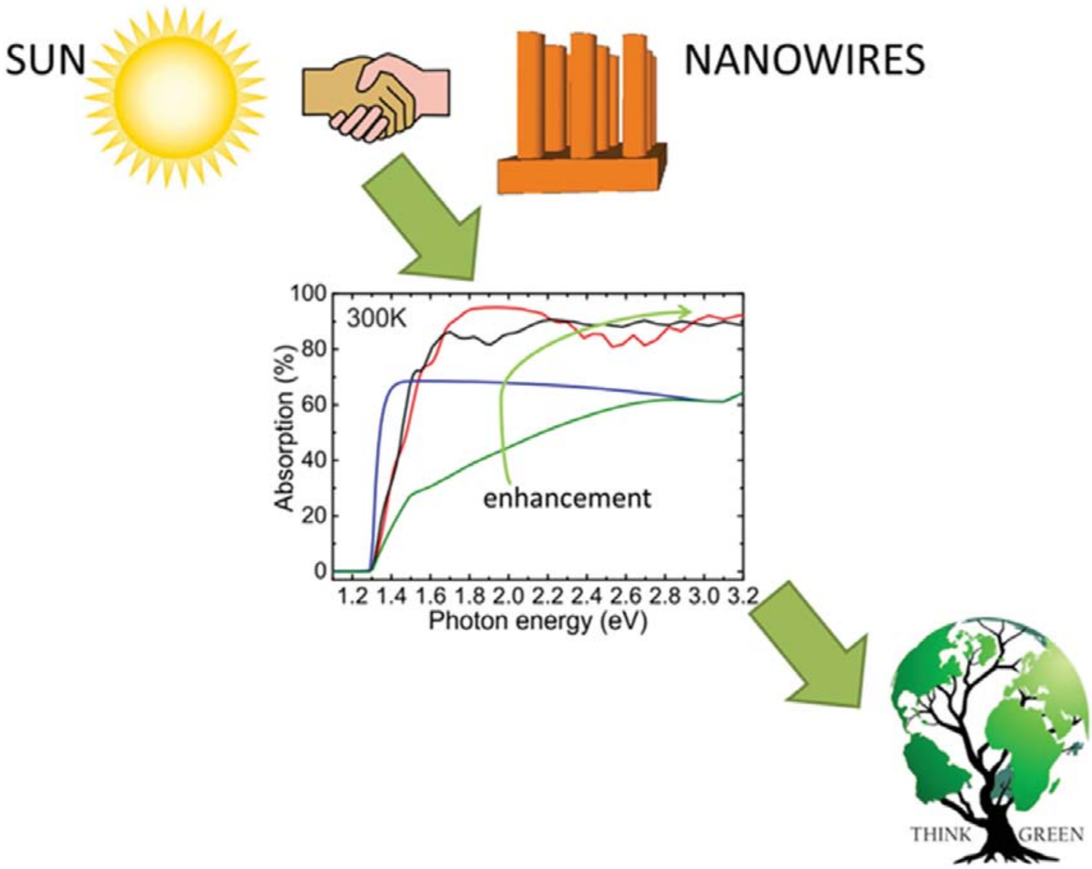
Popular scientific summary

You are driving in Sahara and you get lost. The car has almost run out of fuel, and you have no idea of your geographic location. How far are you from the next fuel station? You start to get nervous. The intense heat from the sun shocks you like lightning. You suddenly remember that your hybrid car is equipped with the latest solar cell technology for efficient charging of the battery. You take a deep breath of relief and truly appreciate the sun as an energy source available almost everywhere. The sun has never been more enjoyable and for the first time you realize the great potential in solar energy and you just can't let go of the growing feeling that you want to contribute to the development of future photovoltaics….

The primary challenge occupying my mind for the last four years has been how to use sunlight more efficiently. For example, how can we harvest more solar energy with less absorbing material exposed to the sun? To answer this question, I have investigated how to arrange so called nanowires, tiny needles of matter more than 1000 times thinner than a sheet of paper, in the best way to act as efficient antennas for absorbing solar energy, instead of partially reflecting it off the surface or simply ignoring (transmitting) it.

In my PhD work, I have studied different ways to improve light absorption in nanowires in order to enhance the efficiency of solar cells. With my colleagues, I have investigated theoretically how the absorption can be tailored, by tilting the nanowires relative to the incoming light, by replacing the nanowires with more complex nanotrees with branches, and by studying how light can be trapped inside the nanowires by embedding tiny mirrors, forcing the light to bounce back and forth. We have focused on nanowires because they are made of materials that can be modified for enhanced absorption. Like conventional wires, nanowires can be made from a variety of conducting and semiconducting materials. In my work, I have focused on the semiconductor indium phosphide since it is able absorb a large portion of the sunlight. The more sunlight that is absorbed by the nanowires, the more precious green energy will be generated. At the moment the efficiency of nanowire-based solar cells is limited to about 18%, so there is still plenty of room for improvement to reach ultimate high-efficiency solar cells! By increasing this efficiency further, we can guarantee a cleaner future for the world where the ever-increasing need for energy is supplied by green solar energy.



The diagram suggests how improved absorption of sunlight through nanowires is a promising route to generate more green energy. The absorption spectra have been adapted from Paper V. The green, blue, red and black traces, demonstrate the absorption of different photon energies (colors of sun light) by an indium phosphide (InP) thin film of 167 nm thickness, an InP thin film of 2 µm thickness, an InP nanowire array at normal incidence, and an InP nanowire array at 45˚ incidence respectively.