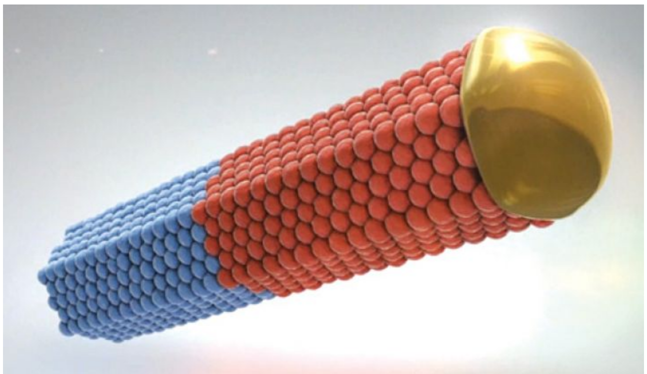
Austin Irish

Nanoengineering Solar Technology

Solar energy is a well-known pathway for reducing pollution and mitigating the climate crisis. Worldwide, millions of people have already seen the benefits of installing solar panels and generating energy locally. Despite its successes, solar energy technology is still quite new and must be developed further before it can completely surpass fossil fuels. One of the most promising ideas currently being researched combines intricate, nanosized structures with advanced, highly efficient materials. Previously, high-efficiency (but expensive) semiconductor materials like gallium arsenide could only be used in unique settings like outer space. Material rarity and production complexity made large scale implementation impractical. That era may very well be over.

Cutting-edge research seems to be unlocking their potential. Over the past few decades we've greatly increased our ability to design structures at the atomic level. As these structures have improved, so has our understanding of them. Just a few years ago a fascinating phenomenon was discovered. Subwavelength nanowires, almost invisibly small, were shown to absorb huge amounts of light. Nearly ten times more light than their size should have allowed them to. This discovery electrified the scientific community and has stimulated enormous research. The concept has been proven; now it must be perfected.

To further improve solar cell efficiency and understand this nano-sized world better, a comprehensive study of Lund University nanowires has been performed. A strategic and diverse set of surface modifications were characterized with a technique called time-resolved photoluminescence. With the help of ultra-short pulses of light, the electrical charges inside thousands of nanowires were simultaneously measured, giving detailed information about material efficiency and device performance.



Several unexpected and exciting results were observed. First, a cheap and novel polymer-based surface treatment showed mixed results prompting further study. Second, an established method using a rocket fuel, hydrazine, was not found to be effective, contradicting published literature. Third, a never-before-used (and safer) nitrogen plasma alternative demonstrated preliminary success. Though the most dramatic improvements were observed at sub-freezing temperatures, significant improvements were also observed at relevant, operating temperatures and the method shows promise for future research. To the best of the author's knowledge, the corresponding research represents the first publicly available data demonstrating the ability of nitrogen plasma to improve gallium arsenide nanowire surfaces for photovoltaics.

Supervisors: **Dr. Magnus Borgström and Dr. Stephanie Essig**
Master's project in physics 60 hp 2019
Division of Solid State Physics, Department of Physics, Lund University

*Subject of the work: see syllabus