NANOTECHNOLOGY FOR SOLAR ENERGY CONVERSION

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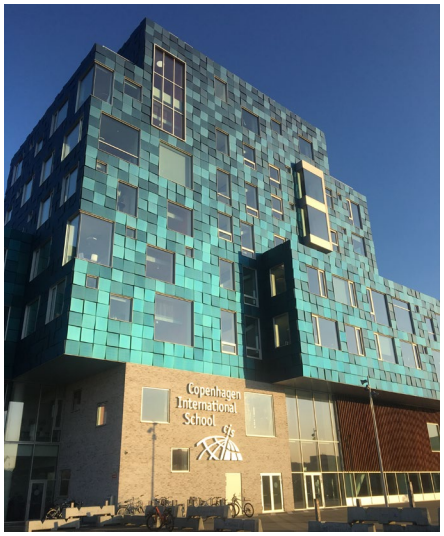

Copenhagen International School with solar cladding based on technology patented by LESO-PB

Due to their fascinating optical and electronical properties, nano-metric scaled structures play an important role in solar energy conversion. The research group "Nanotechnology for Solar Energy Conversion" develops and characterizes novel nanostructured materials for solar energy applications. The nanocomposite coatings consist typically of dielectrics, semiconductors or metal nano-crystals embedded in a dielectric matrix.

We focus especially on smart materials, such as thermochromic selective solar absorber coatings, and electrochromic coatings for switchable windows. Further applications include novel microstructured glazing with strong seasonal dependence of the solar heat gains, photoluminescent quantum dot solar concentrators for photovoltaic energy conversion, antireflection coatings on solar collector glazing, colored coatings with high solar transmittance for novel glazing of photovoltaic facades, selective solar absorber coatings for thermal solar collectors and thermoelectric power generation, as well as novel insulating glazing with high transmittance for the microwaves of mobile communication.

The group carries out fundamental research on novel nano-composite materials and thin film materials and promotes the introduction of novel solar technologies through upscaling of the corresponding innovative manufacturing processes. It has submitted and been granted several patents.

Published work relates to

- Electrochromic and thermochromic films for smart solar energy applications
- Optical microstructures for advanced architectural glazing
- Structured transparent low emissivity coatings with high microwave transmission
- Quantum dot solar concentrators for building integrated photovoltaics
- Coloured thermal collectors and PV modules for solar facades and solar roofing
- Durable selective absorber coatings for solar thermal collectors and electricity generation by concentrated solar power (CSP)
- Nanostructured low refractive index materials on solar collector glazing

Recent Activities

Highlights of this year include:

- Two prestigious awards – Watt d'Or and Railtech 2019 – for research on the development of insulation windows made permeable to mobile communication.
- Olivia Bouvard's PhD thesis on coatings with tailored electronic and optical properties for advanced glazing as well as Jing Gong's PhD thesis on glazing with novel embedded optical microstructures for seasonal thermal dynamics, daylighting, glare protection and clear view, in various locations and climates.
- Collaboration with Sage Glass on photoelectron spectroscopy of electrochromic coatings.
- NEST module SolAce, showcasing several innovative developments of our group: coloured photovoltaics, coloured solar thermal collectors, insulating glazing with high transmission for mobile communication and microstructured glazing for daylight management.
- Advances in the development of thermochromic coatings for overheating protection of solar thermal collectors, and interesting applications in microelectronics.

Current Projects

Reduzierung des Heizenergiebedarfs von Bahnfahrzeugen durch verbesserte Wärmedämmung der Fahrzeughülle
Funding: Swiss Federal Office of Energy (SFOE)
Duration: 2017-2019
To reduce electricity consumption in rail transport, a large project with multiple partners investigates all relevant aspects of vehicle envelopes. Based on Phase I of this project, which included the development of insulation glazing transparent to microwaves used in mobile networks (Windowave), a prototype train wagon is installed, monitored and compared to a reference train.

SCCER FEEB&D Phase II, Task 1.1.2 Glazing with dynamic solar heat gains
Funding: Swiss Innovation Agency (Innosuisse)
Duration: 2017-2020
Novel glazing with dynamic solar heat gains is developed applying two approaches: the development of light-redirecting microstructures that allow a clear view while providing seasonal thermal control and visual comfort and the development of nanostructured electrochromic materials with enhanced switching speed and durability.

Photoelectron spectroscopy of electrochromic coatings
Funding: Sage Glass
Duration: 2019
Photoelectron spectroscopy is a powerful tool for the characterization of the electronic properties of thin films, surfaces and interfaces. By X-ray photoelectron spectroscopy (XPS), we gain relevant information on the chemical composition of the electrochromic thin films, as well as on the oxidation state of the involved metal ions. By ultraviolet photoelectron spectroscopy (UPS) we characterize the properties of the valence bands at the multiple interfaces within the multi-layered electrochromic devices. The obtained insights are useful for further improvement of today's electrochromic windows.

Selected publications

- Krammer A., Schüler A., Predicting the thermal performance of thermochromic flat plate solar collectors, CISBAT 2019, Switzerland, Sept. 4-6, 2019 http://dx.doi.org/10.1088/1742-6596/1343/1/012201
- Ni W., Krammer A., Hsu C.-S., Chen H. M., Schueler A., Hu X., Ni3N as an Active Hydrogen Oxidation Reaction Catalyst in Alkaline Medium, in Angewandte Chemie-International Edition, vol. 58, num. 22, p.7445-7449 , 2019-05-27 http://dx.doi.org/10.1002/anie.201902751
- Kostro A., Couty P., Moroder D. G., Pohl W., Schüler A., Hafner A., From university to industry - challenges in upscaling optical microstructures for daylight redirection in buildings, CISBAT 2019 | Lausanne, Switzerland, Sept. 4-6, 2019 http://dx.doi.org/10.1088/1742-6596/1343/1/012194
- Daviran S., Krammer A., Schüler A., In-situ and post annealing effect on the microstructure and the optical properties of black Cu-Co-Mn oxide spinel coating for Parabolic Trough Collector (PTC) applications, CISBAT 2019, Switzerland, Sept.4-6, 2019 http://dx.doi.org/10.1088/1742-6596/1343/1/012200
- Fleury J., Burnier L., Lanini M., Di Domenico M., Zimmermann E., Genoud C., Salvadé A., Schueler A., Novel microwave transparent low emissivity coating for energy-efficient glazing: towards 5G frequencies, CISBAT 2019, Switzerland, Sept.4-6, 2019 http://dx.doi.org/10.1088/1742-6596/1343/1/012199
- Bouvard O., Schüler A., Color neutral nanocomposite nickel-tantalum oxide for electrochromic windows, CISBAT 2019, Switzerland, Sept. 4-6, 2019 http://dx.doi.org/10.1088/1742-6596/1343/1/012192

PhD Theses

- Gong J., Advisors: Scartezzini J.-L., Schueler A., Novel daylighting system based on advanced embedded optical microstructures for various facade orientation and climates, EPFL thesis n°9390, 2019
- Bouvard O., Advisors: Scartezzini J.-L., Schueler A., Coatings with tailored electronic and optical properties for advanced glazing, EPFL thesis n° 9199, 2019

Patents

- WO2017134589 A1: Coating for optical and electronic applications
- EP2882921: Glazing with embedded microstructures for daylighting and seasonal thermal control
- WO 2014045141 A2: Laminated glazing with coloured reflection and high solar transmittance suitable for solar energy systems
- WO 2014045144 A1: Interference filter with angular independent orange colour of reflection and high solar transmittance, suitable for roof-integration of solar energy systems