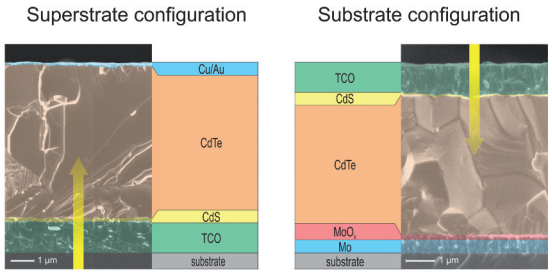
CdTe THIN FILM SOLAR CELLS

15.6% – Superstrate and
13.6% – Substrate Configuration CdTe solar cells on glass

Lowest solar module production costs on the global PV market have been achieved with CdTe based technology. Our lab is pioneering the development of low-temperature processes (< 450 °C) for both superstrate and substrate configuration enabling fabrication on various substrate materials. This allows to further reduce the production costs of CdTe solar cells in the future.

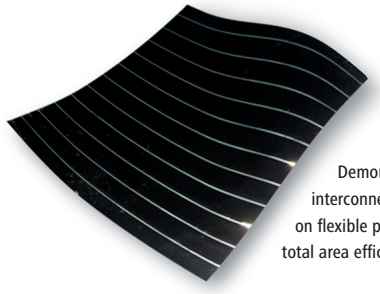


CdTe PV technology is safe and enviromentally benign!

FLEXIBLE CdTe THIN FILM SOLAR CELLS

13.8% – World record for flexible CdTe solar cells

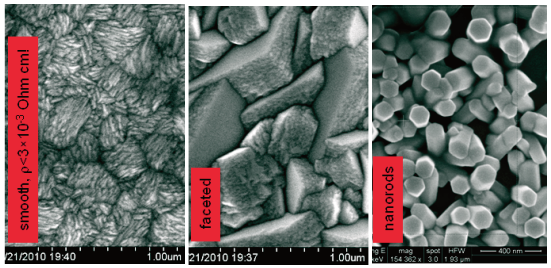
We are involved in the development of flexible CdTe solar cells on polymer films and metal foils. We have demonstrated CdTe solar cells with efficiencies of 13.8% on flexible polyimide film and 10.9% on flexible steel foil. Our low-temperature processes are suitable for high throughput roll-to-roll manufacturing.



Demonstration of a monolithically interconnected CdTe mini-module (32 cm^2) on flexible polyimide substrate with 8.0% total area efficiency (9.4% active area).

MULTIFUNCTIONAL OPTICAL AND ELECTRICAL COATINGS

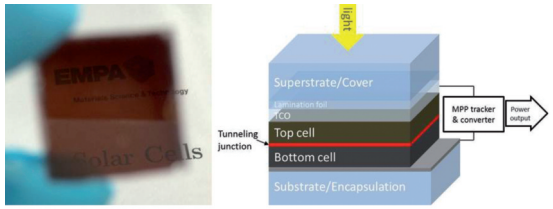
The demanded properties of advanced coatings extend well beyond the characteristics of transparency and/or conductivity and aim at multi-functionality: element diffusion barriers, moisture and corrosion resistant barriers, controll of electronic transport at interfaces, texturing for efficient light trapping. Investigated materials include metals, oxides (SiO_2, TiO_2, ZnO, In_2O_3 or SnO_2-based) and nitrides (SiN, Ti_3N_4) deposited by PVD and non-vacuum methods.



By controlling solution chemistry, the morphology of Al-doped ZnO transparent conductive layers can be tuned from flat to faceted and nanorod.

SOLAR DEVICES WITH EFFICIENCIES TOWARDS 30%

A promising approach to reach efficiencies of 30% and above are the multijunction solar cell concepts. The main challenge in that case is the development of highly efficient wide band gap solar cells with both electrical contacts transparent. We are developing tandem solar cells with the novel technology based on trihalide organo-metal perovskite absorber combined with our highly efficient CIGS technology.



Left: trihalide organo-metal perovskite absorber layer
Right: Example of 2-terminal tandem device architcture

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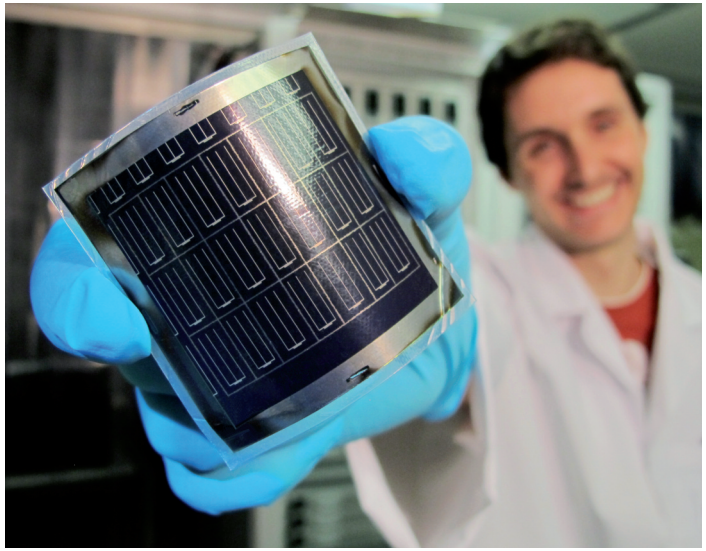
Materials Science & Technology

Laboratory for Thin Films and Photovoltaics



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RESEARCH PORTFOLIO AND EXPERTISE

- Development of deposition processes for thin films based on vacuum (sputtering, thermal evaporation, e-beam) and non-vacuum (printing, spray, solution) techniques
- R&D on transparent **conductive**, **semiconducting** and **insulating** thin films
- Development of **multifunctional optical and electrical coatings** including diffusion barrier layers
- **Materials characterization** of surfaces, layers, and interfaces in multi-layer structures
- R&D on inorganic **thin film solar cells** based on $Cu(In,Ga)Se_2$, CdTe, CZT(S,Se) and Perovskite absorber materials
- R&D on functional materials for innovative **thin film batteries**
- **Full diagnostics** of lab scale solar cells
- World leader in R&D of flexible and lightweight inorganic solar cells on polymer and metal foils
- Novel materials for better functional windows, energy conversion and storage applications.

OUR OFFER

- **Collaboration in R&D projects**: If you are looking for a partner to realize scientific and development projects in the field of energy conversion (PV), energy storage (battery) or multifunctional coatings, we are interested to team up.

- **Services**: We offer characterization services for thin films and small PV devices and assist in interpretation of the results and correlation to material properties.

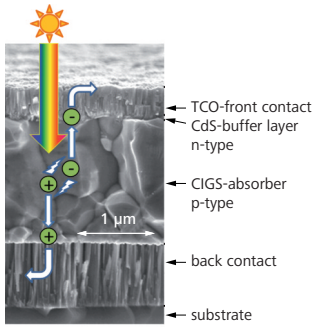
- **Consulting**: Experts will assist and advise you in solving your specific problems on PV devices, diagnostics, and thin film coatings including up-scaling of deposition processes.

- **Technology transfer**: Some of our technologies are ready for industrialization.

FLEXIBLE AND LIGHTWEIGHT CIGS THIN FILM SOLAR CELLS AND MODULES

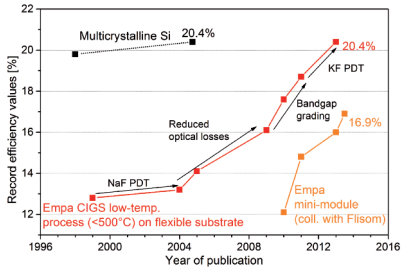
20.4% – World record flexible solar cell

Solar cells based on $Cu(In,Ga)Se_2$ absorbers show the highest efficiencies and performance stabilities among all thin-film technologies. Empa has developed a deposition process for CIGS thin-film solar cells which is suitable for high-speed and in-line production on low-cost glass substrates. Main research topics include: band gap and interface engineering of the CIGS absorber in order to find the optimum tradeoff between highest device efficiency and cost-effective mass production; development of processes for other constituent layers; multijunction (tandem) solar cells.



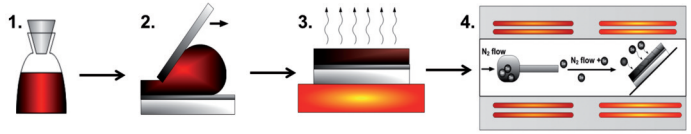
16.9% – World record for flexible CIGS solar modules on plastic film

Substituting flexible and lightweight foils for rigid glass substrates opens the possibility for cost-effective roll-to-roll production as well as novel attractive product applications. Empa has developed a low-temperature deposition process that is suitable for polymer films (e.g. polyimide) as well as for metal foils (e.g. steel). By combining roll-to-roll deposition with laser scribing technology for monolithical interconnection, highspeed production of large area flexible CIGS solar modules is feasible. We have high level of experience in up-scaling of vacuum deposition techniques on moving substrates.



Solar cell performance of flexible CIGS devices on polyimide film.

NON-VACUUM CIGS AND CZT(S,Se) THIN FILM SOLAR CELLS



Non-vacuum deposition includes: 1) paste formulation from solutions or nanoparticle dispersions; 2) paste deposition by doctor-blading, printing or spraying; 3) drying, and 4) selenization.

Non-vacuum based deposition methods from non-toxic and non-explosive solvents enable a very high potential for low-cost production due to the simplicity and rapidness of the deposition process. This technology is targeting a high throughput roll-to-roll processing at high materials utilization. New material systems e.g. kesterites based only on earth abundant elements Cu, Zn, Sn, Se and S – $Cu_2ZnSn(Se,S)_4$ – are under investigation.

Non-vac CIGS: 8.7%

Non-vac CZT(S,Se): 8.3%

Empa, Swiss Federal Laboratories for Materials Science and Technology

Empa is an interdisciplinary research and services institution for material sciences and technology development within the ETH Domain. Empa's research and development activities are oriented to meeting the requirements of industry and the needs of our society, and link together applications-oriented research and the practical implementation of new ideas, science and industry, and science and society.