2nd Symposium on Innovation, cooperation in technology and international transfer of technology

APPLIED RESEARCH OF MULTILAYERS AND NANOPARTICLES

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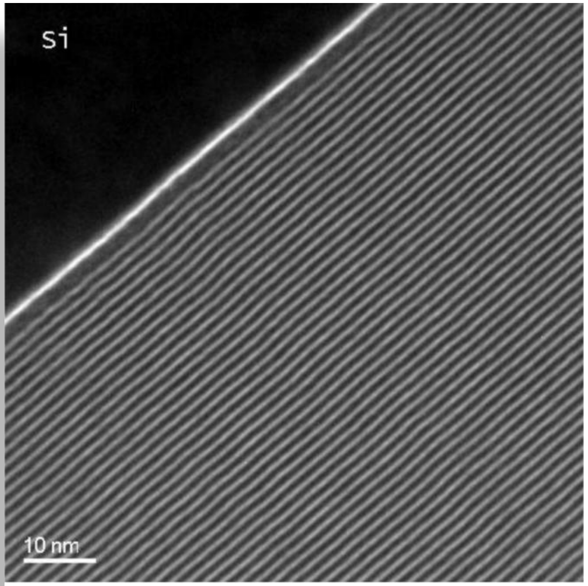
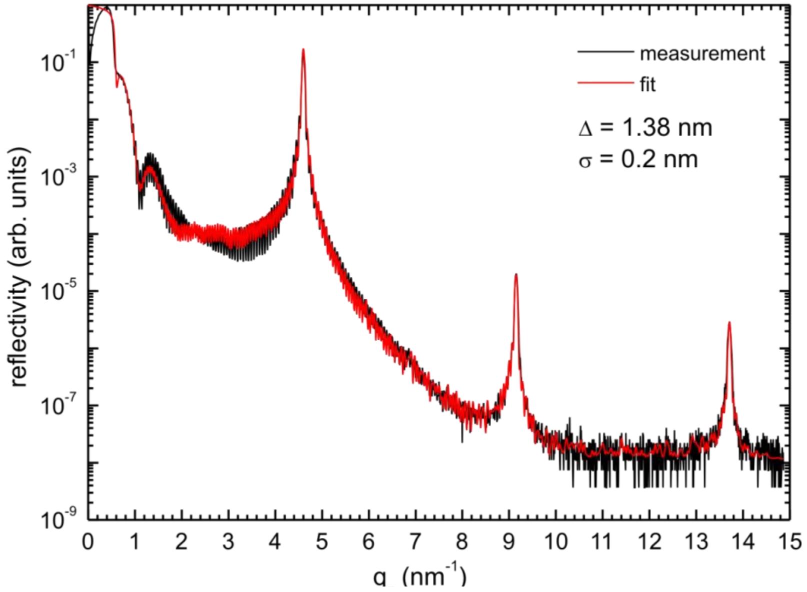
- **Introduction into Multilayers and Nanoparticles**
- **Innovations harvested from the applied research**
- **Summary**

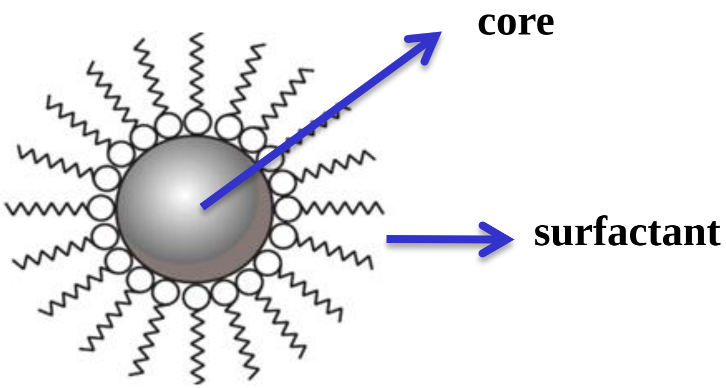
Applied Research of Multilayers and Nanoparticles

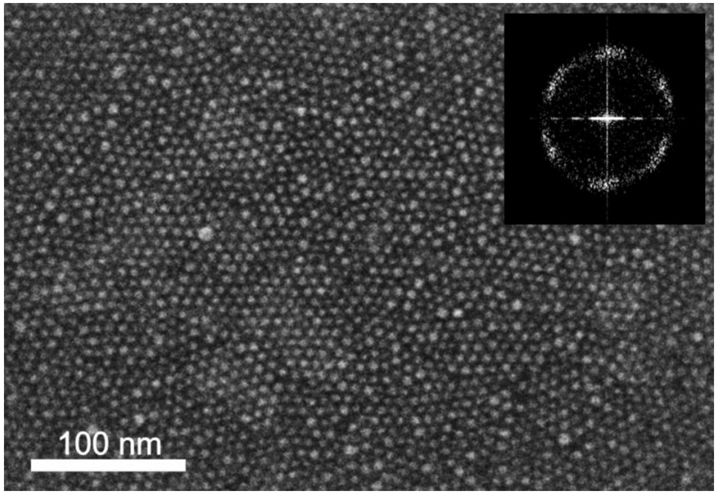




P. Siffalovic et al., in *X-Ray Scattering*, C. M. Bauwens, Ed. (Nova Science Publishers, New York, 2011).

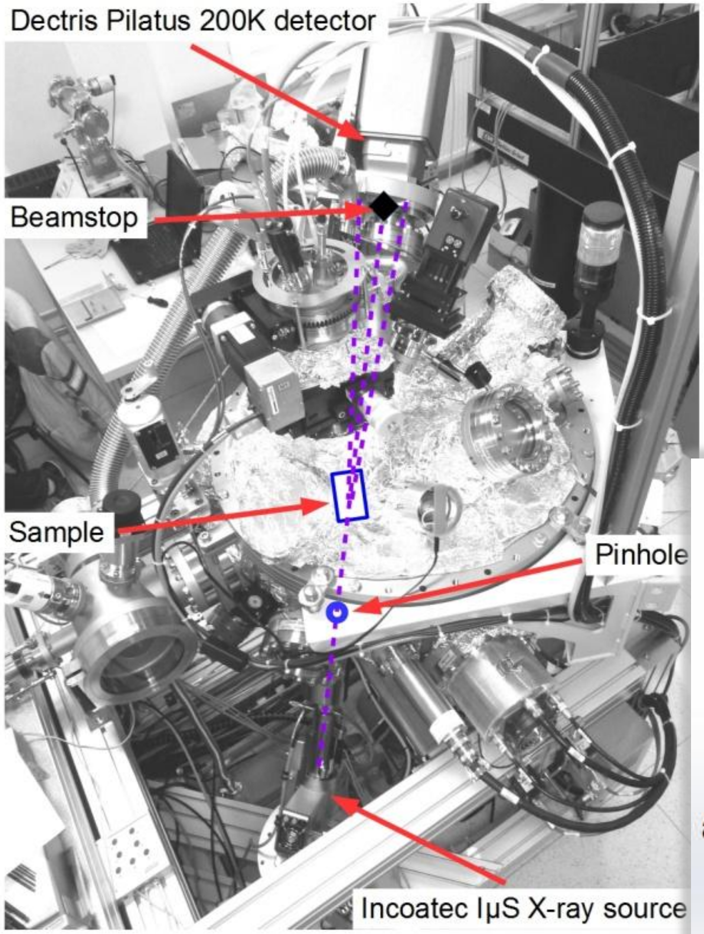
Nanoparticles - metal or oxide core
organic envelope (oleic-acid, oleylamin)



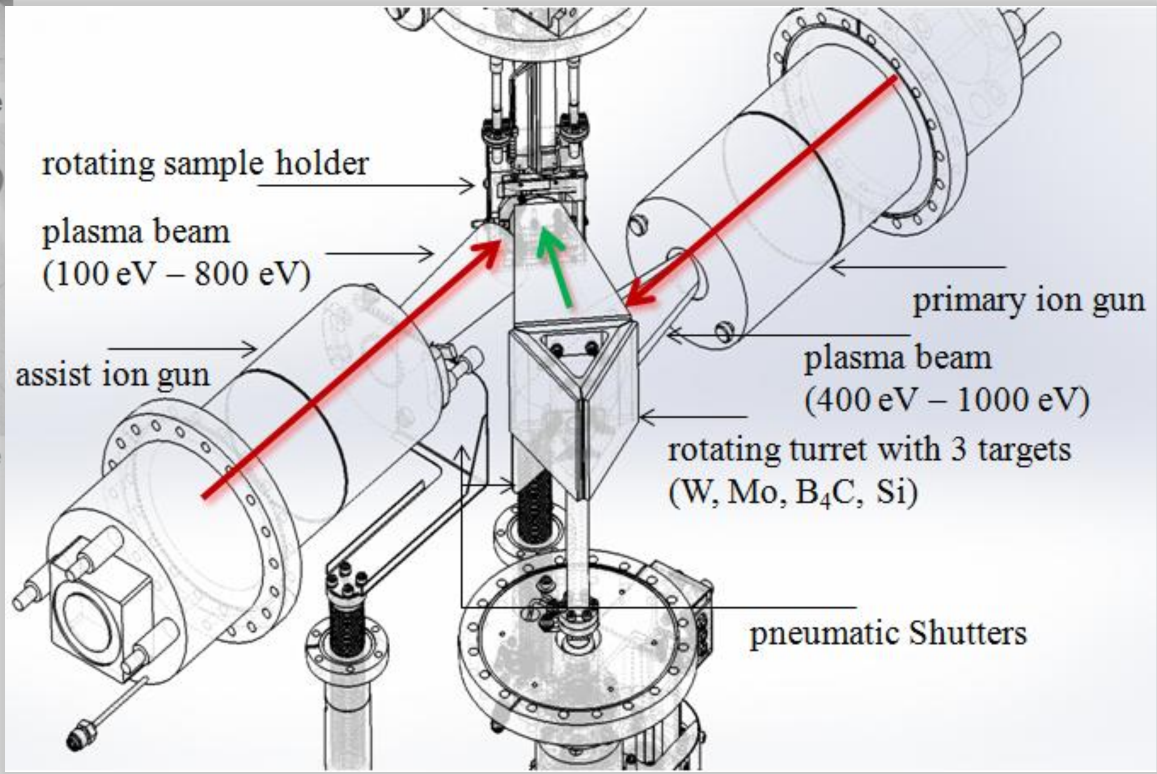


P. Siffalovic *et al.*, in *Smart Nanoparticles Technology*, A. Hashim, Ed. (INTECH, Rijeka, 2012).

Advanced X-ray Optics and Nanoscale Metrology



Fabrication of dedicated EUV and hard X-ray mirrors for research facilities

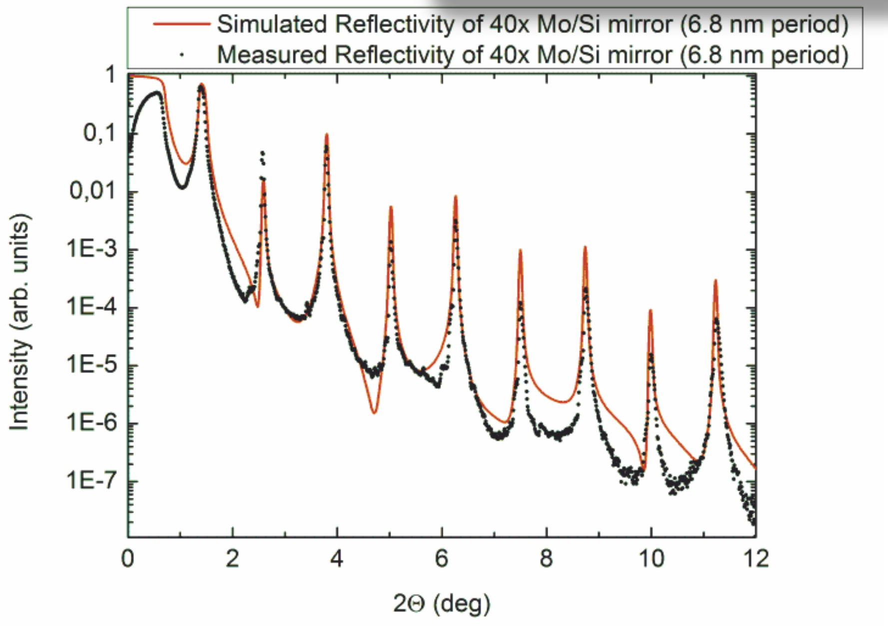


Parameters of sputtering:

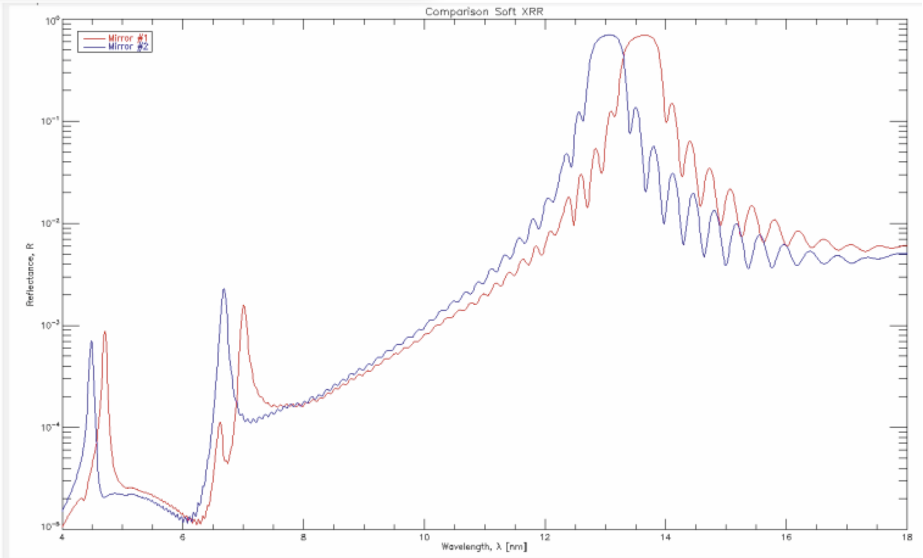
- vacuum base pressure $2x10^{-8}$ mbar
- working pressure $4x10^{-4}$ mbar
- total current density 1.83 mA/cm^2
- sputtering rates 0.014 nm/s for W
  0.005 nm/s for B_4C

Advanced X-ray Optics and Nanoscale Metrology

Fabrication of dedicated EUV and hard X-ray mirrors for research facilities

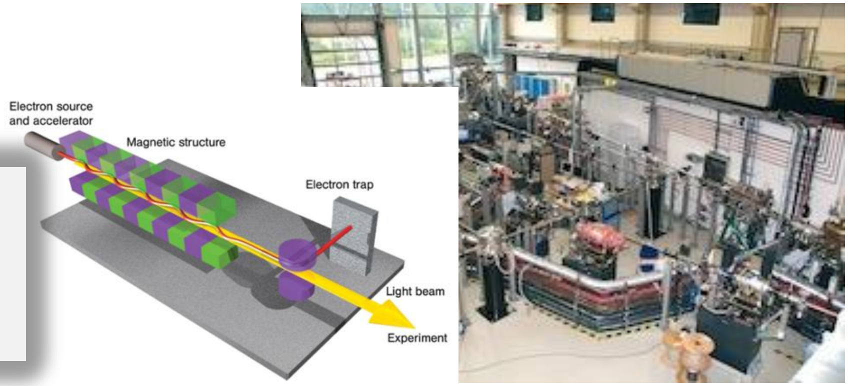


Comparison of the measured and simulated reflectivity of the 40x Mo/Si multilayer mirror of 6.9 nm period.

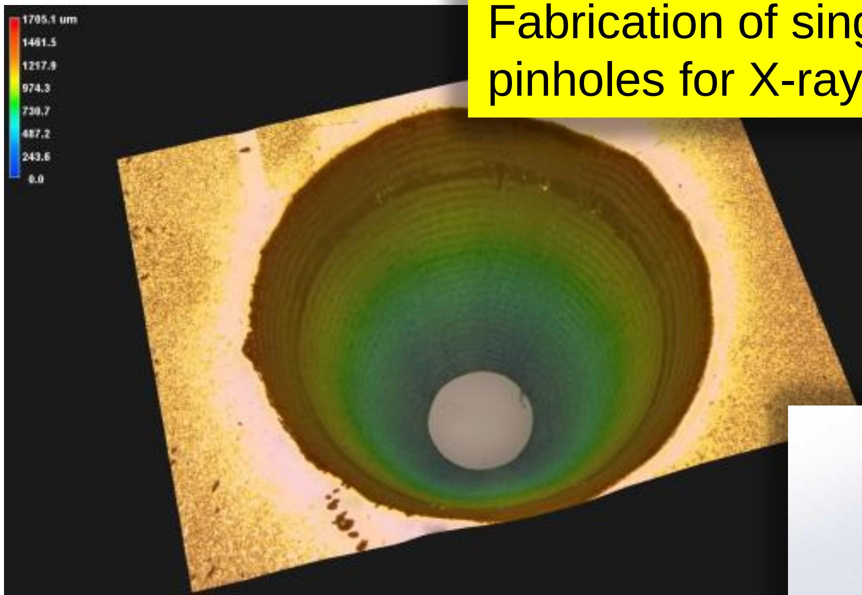


Comparison between two simulated soft X-ray Mo/Si mirrors with small differences in the period thicknesses (6.75 nm and 7.05 nm respectively).

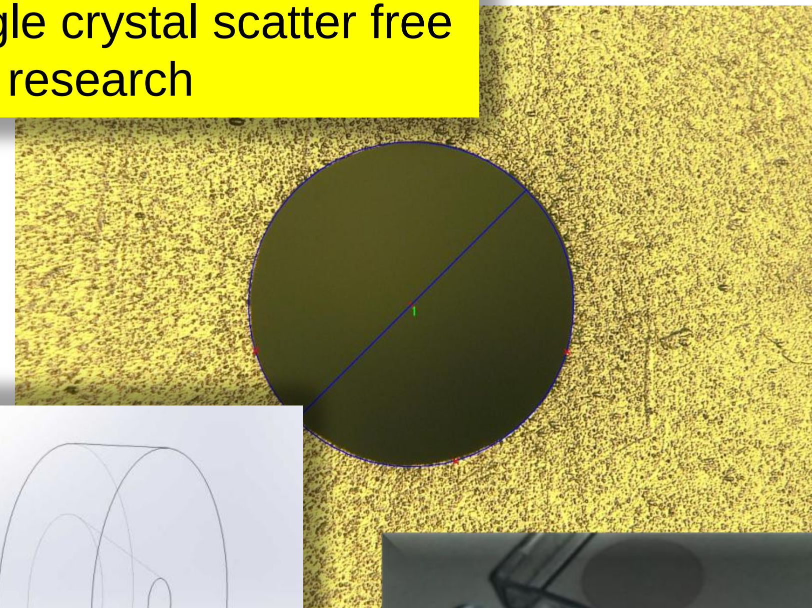
X-ray mirrors developed and delivered to Free-electron laser facility in Hamburg, Germany

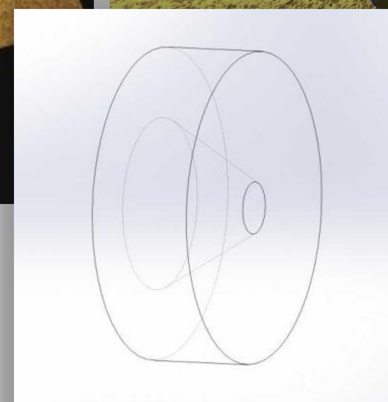


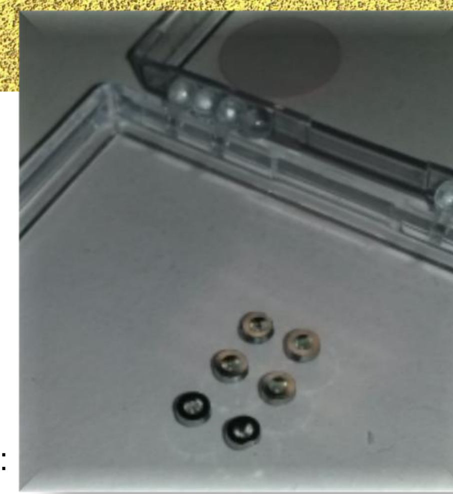
Advanced X-ray Optics and Nanoscale Metrology



Fabrication of single crystal scatter free pinholes for X-ray research







Fabrication method:
- masking of Ge using washable polymers
- UV nanosecond laser ablation
- Ultrasound cleaning
- Two step chemical SSD removal
    - pre-etch in isotropic etchant ($HF:HNO_3:H_2O$)
    - final etch in anisotropic etchant ($HCl:H_2O_2:H_2O$)

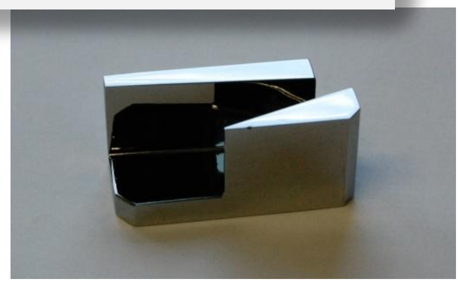
Advantages over ion-beam processing:
- no vacuum
- ability to scale-up the production
- cost-effective solution

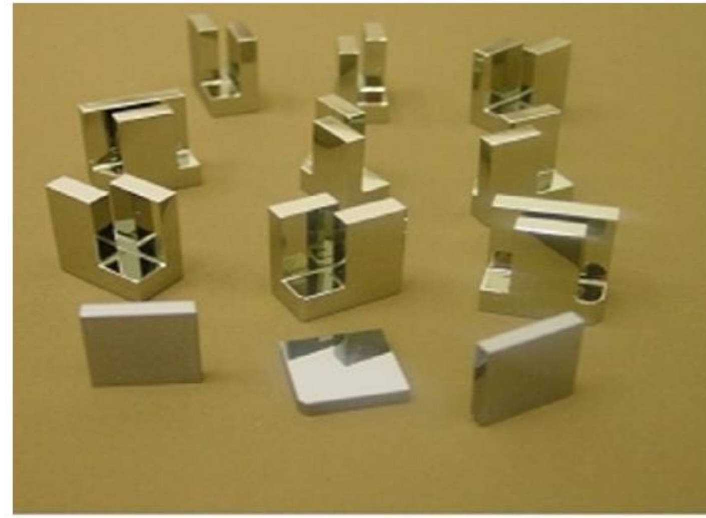
Customers:

- University Leoben, Austria
- NSRRC, Hsinchu, Taiwan
- Institute of Physics and Material Science, Vienna

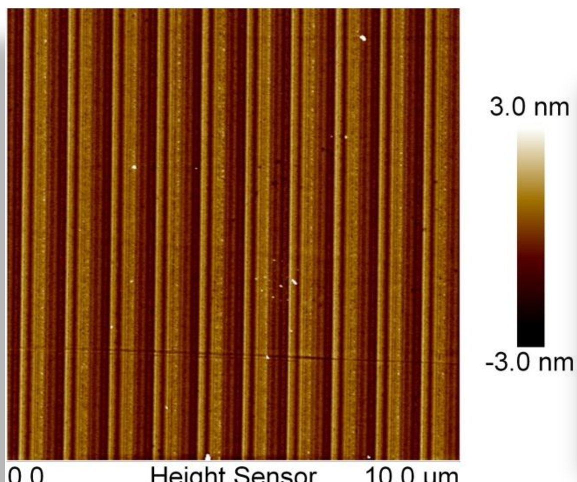
Advanced X-ray Optics and Nanoscale Metrology

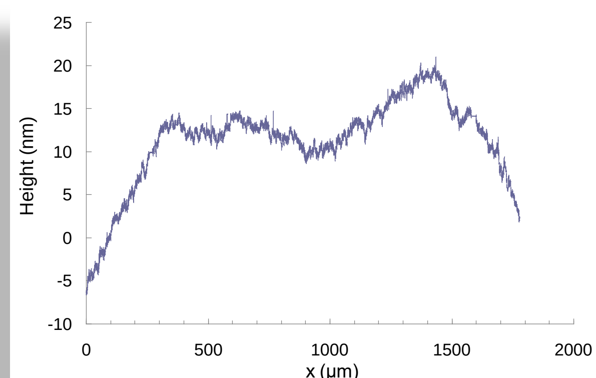
Application of single point diamond turning technology (SPDT) technology for cutting-edge X-ray optics

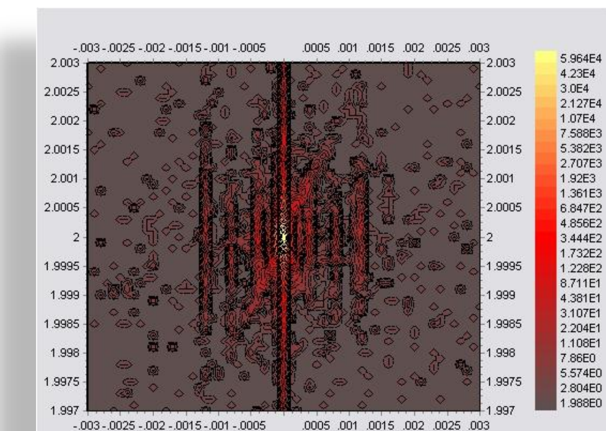




- Single-bounce FzSi (100) and (111) reference crystals
- Symmetrical two-bounce Ge(220)/(440) monochromators
- Three-bounce Ge(220) analysers







a) surface roughness - by AFM. b) surface height profiles - better flatness in SPDT. c) RSM showing grating truncation rods - surface texture seen by AFM.

Integra TDS, s.r.o.

Network of Applied Research of Diffractive X-ray Optics

Direct impact: delivery of new improved optics to world known companies.

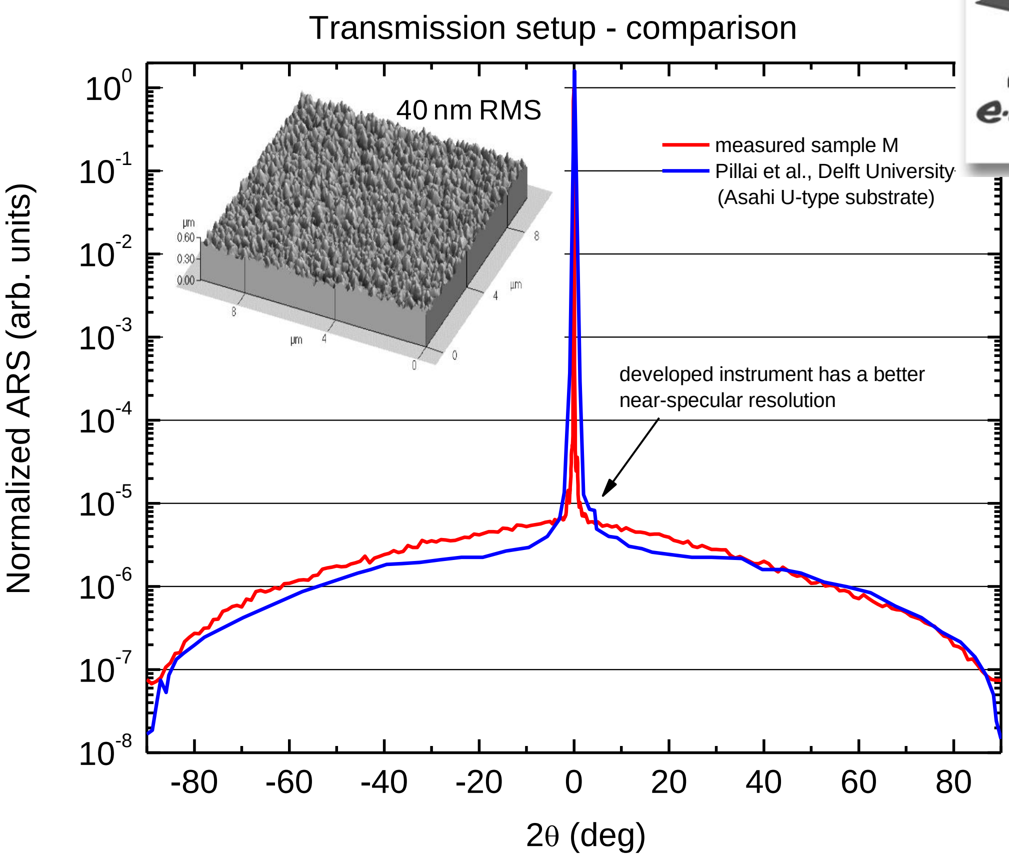
INCOATEC innovative coating technologies gmbh

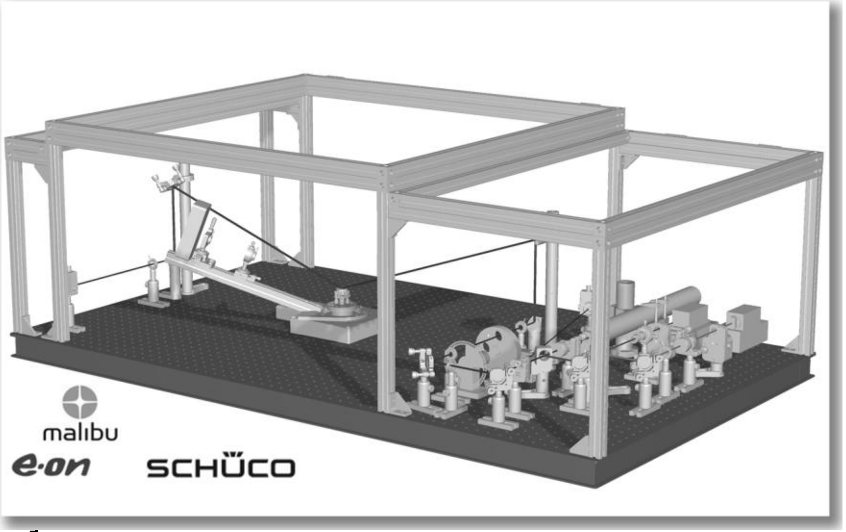
BRUKER

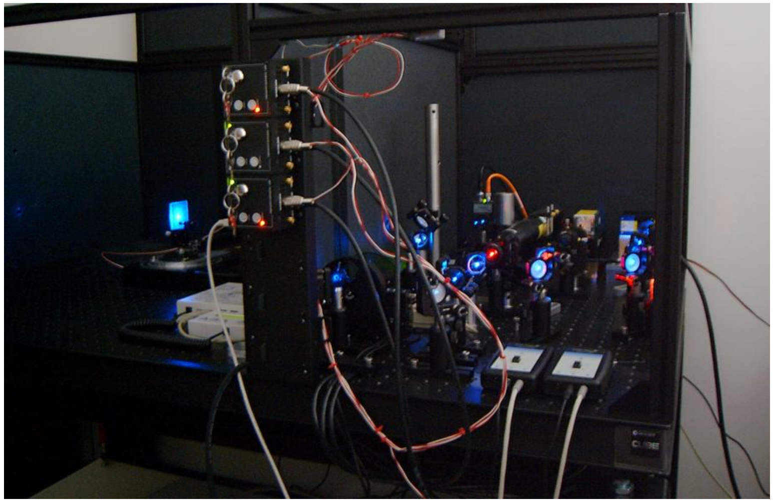
Anton Paar

Surface Metrology for Solar Cell R&D

Triple-laser Scatterometer developed for thin film Si solar cell research (delivered to Malibu GmbH)



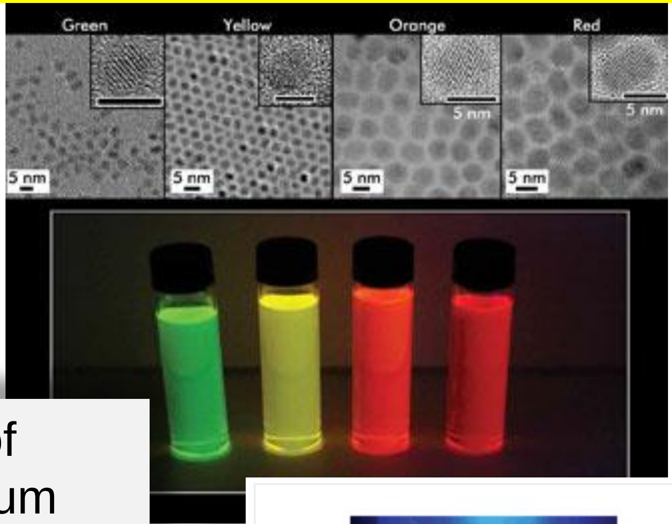




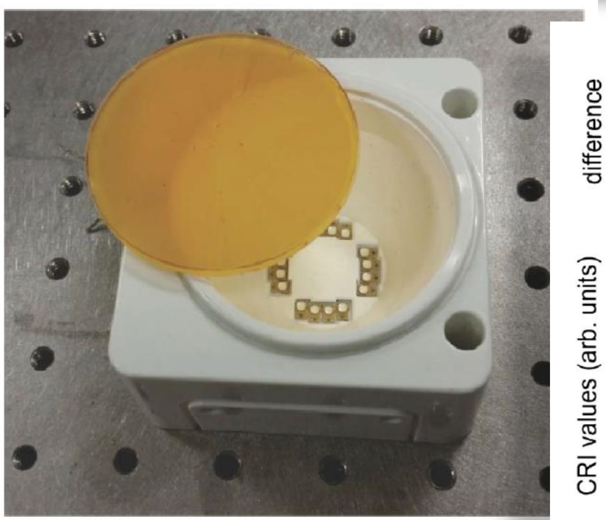
Quantum dots for applied lighting research

Innovations driven research of advanced solid state lighting solutions

oms



Cost effective combination of remote phosphor and quantum dots allows fabrication of high quality (CRI 90+) LED luminaries



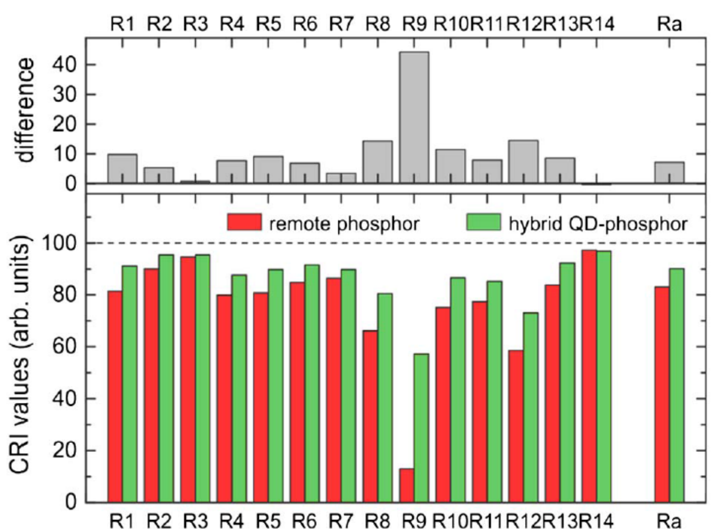
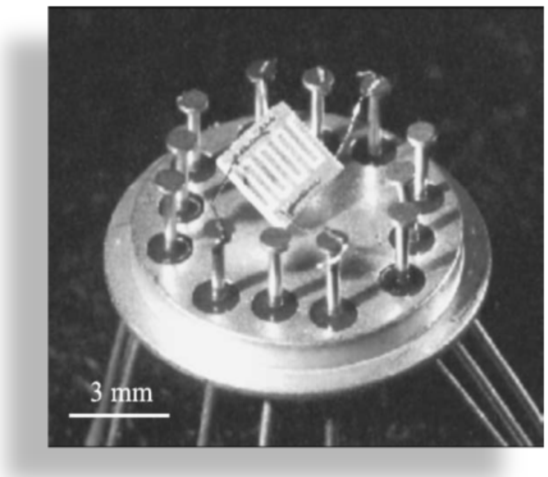


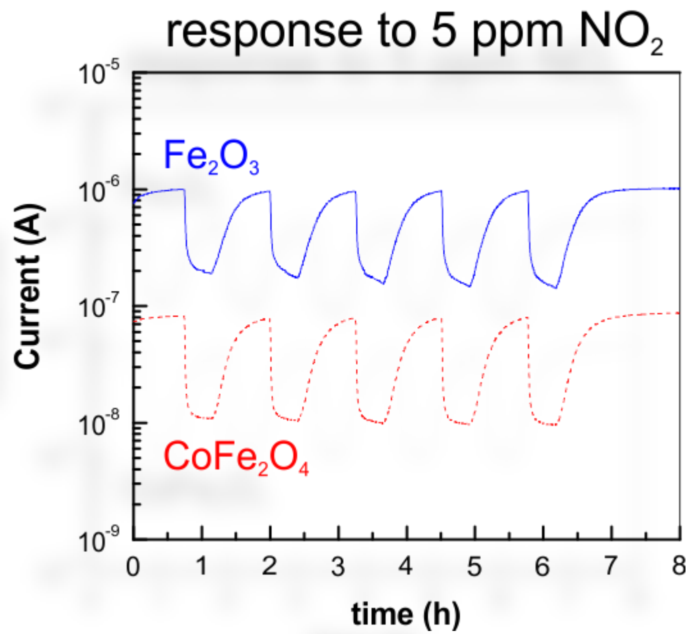
Fig. 5. Calculated CRI values for remote phosphor and hybrid QD phosphor. Top chart shows the absolute differences of CRI values.

Thin layer of low-cadmium ZnCdSeS alloyed quantum dots deposited onto a commercial remote phosphor module Fortimo LED manufactured by Philips that offers a cost-effective LED solution with 90+ color-rendering index. For details, see Siffalovic *et al.*, pp. 7094–7098.

Metal oxide nanoparticles as sensors for explosives

LS deposited nanoparticle multilayers for gas sensing

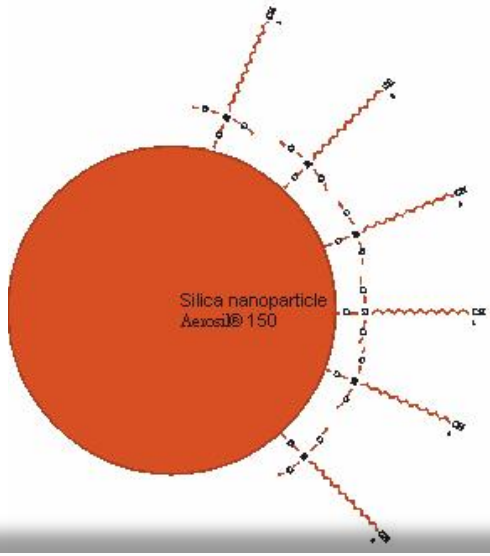


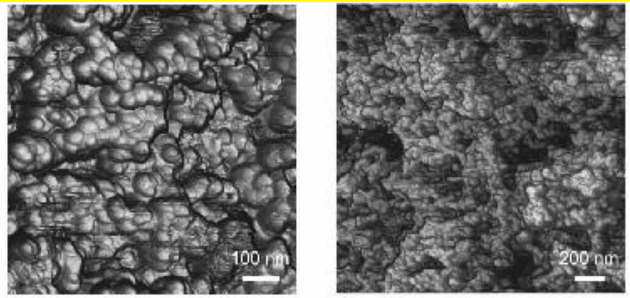


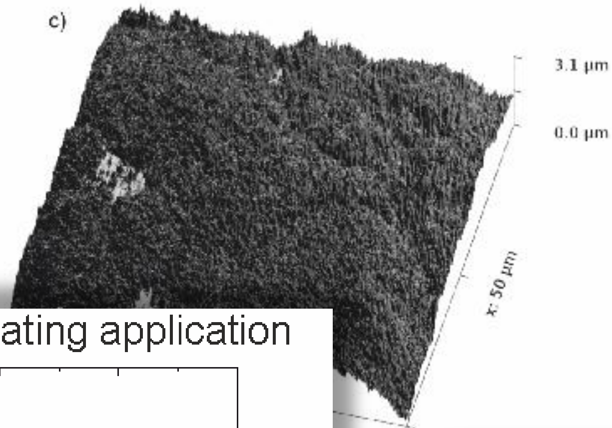
Application of the conductive layers composed of metal oxide nanoparticles can be exemplified on the latest generation of the Fe-O nanoparticle-based gas sensors like SO_2, NOX, CO, O_3 and CH_4. The NO_2 sensors are of primary importance for public security as they detect trace amounts of the explosives like EGDN, TNT, PETN, RDX, etc.

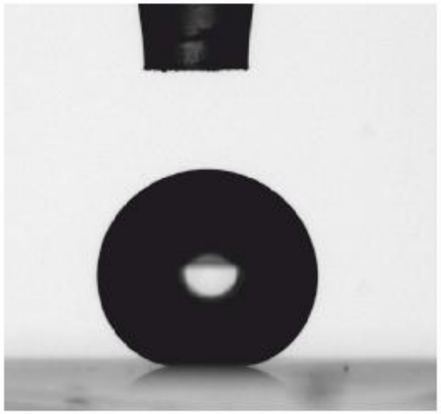
Luby, S., et al. Oxide nanoparticle arrays for sensors of CO and NO2 gases. In *Vacuum (2011)* and *Physics Procedia* (2012)

Superhydrophobic Smart Layers for Thin Film Solar Cells

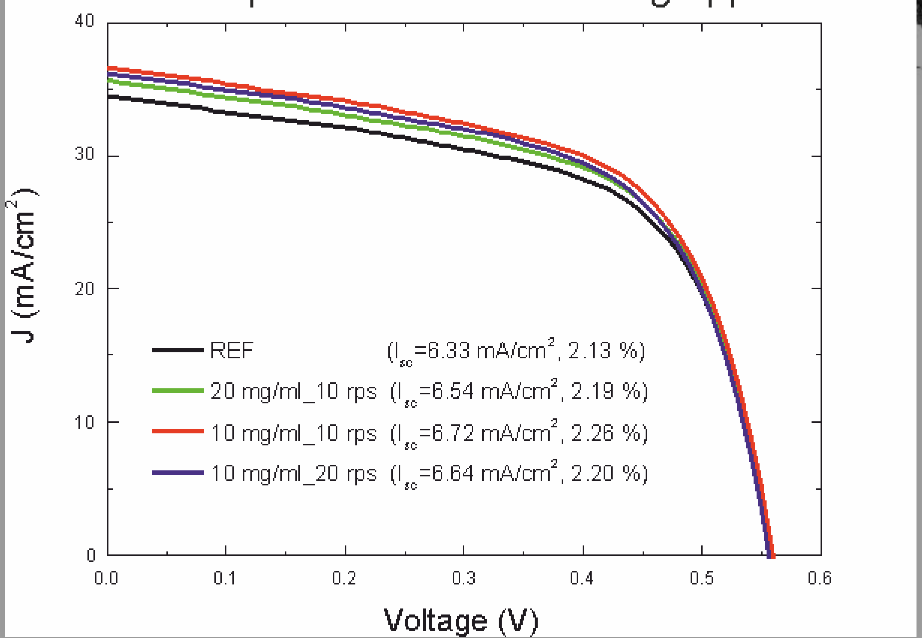








6% PCE improvement after coating application

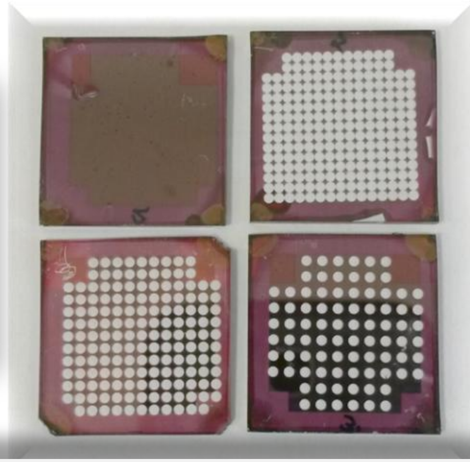


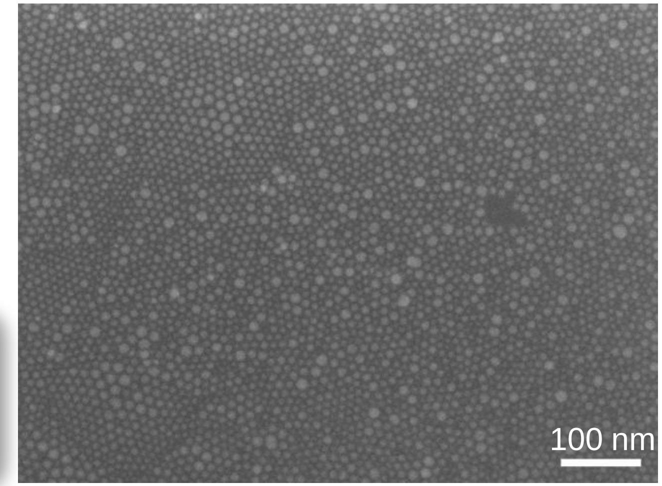
Nanoparticle Smart Layers:

- prolong the maintenance interval
- increase the power conversion efficiency

P. Siffalovic *et al.*, Towards new multifunctional coatings for organic photovoltaics. *Solar Energy Materials and Solar Cells* 125, 127 (2014).

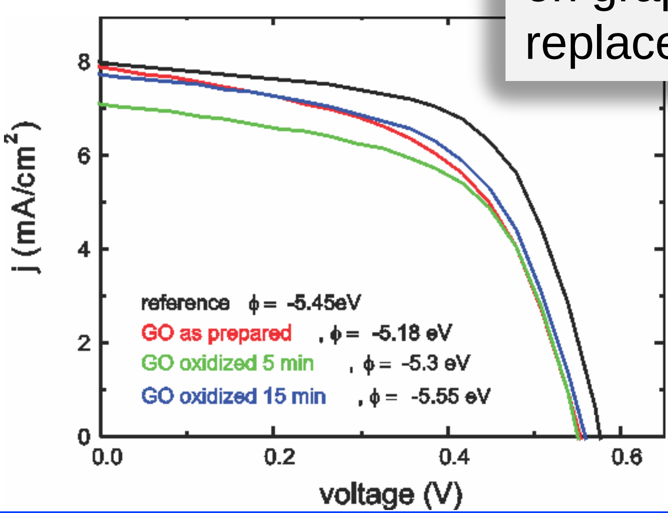
Plasmonic Nanoparticles Imbedded Into Semi-transparent OSC

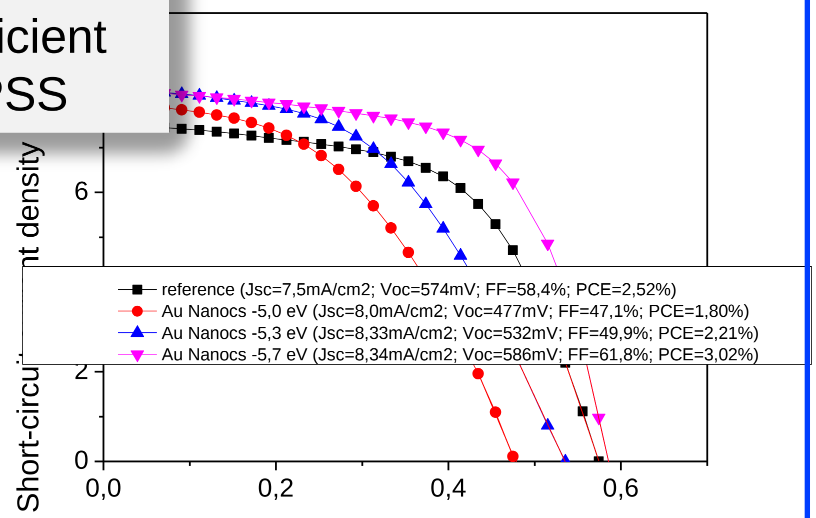




plasmonic and semitransparent polymer solar cells

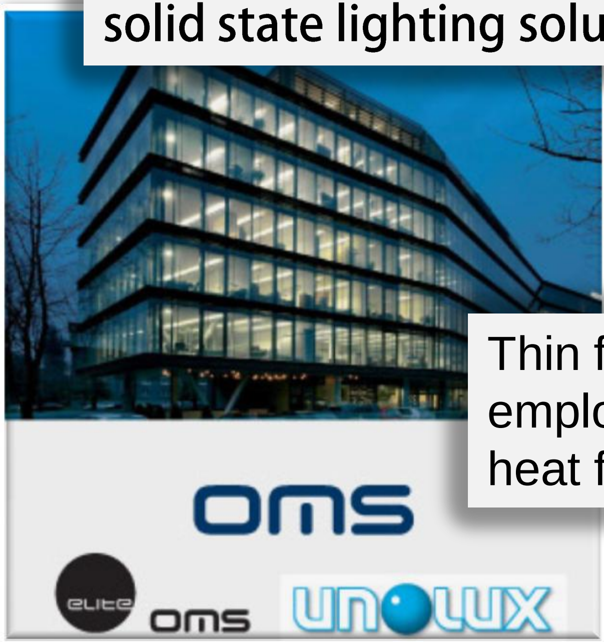
new hole transport layer based on graphene oxide as efficient replacement of PEDOT:PSS

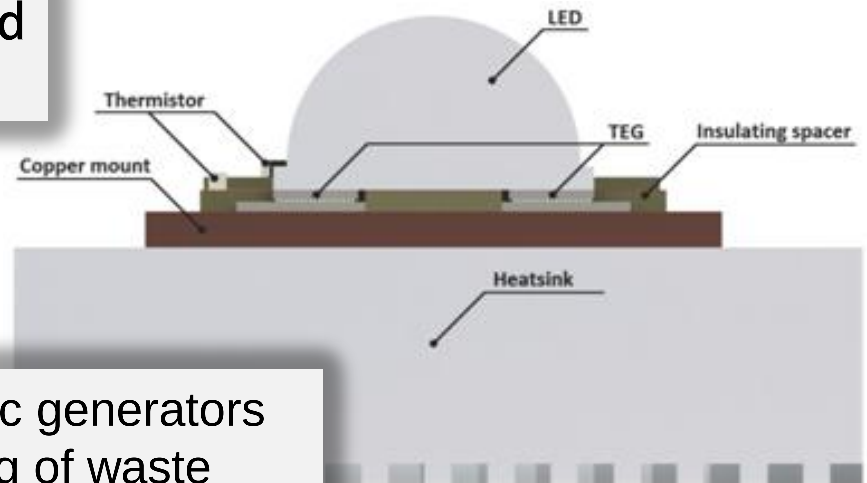




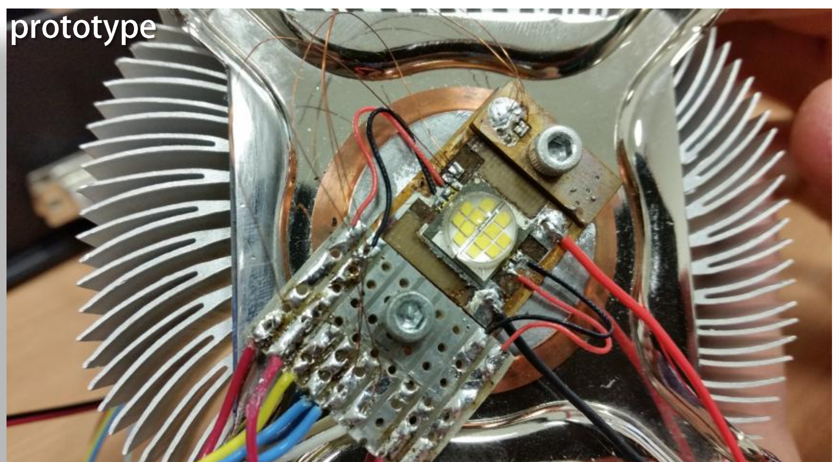
Thin films in applied lighting research

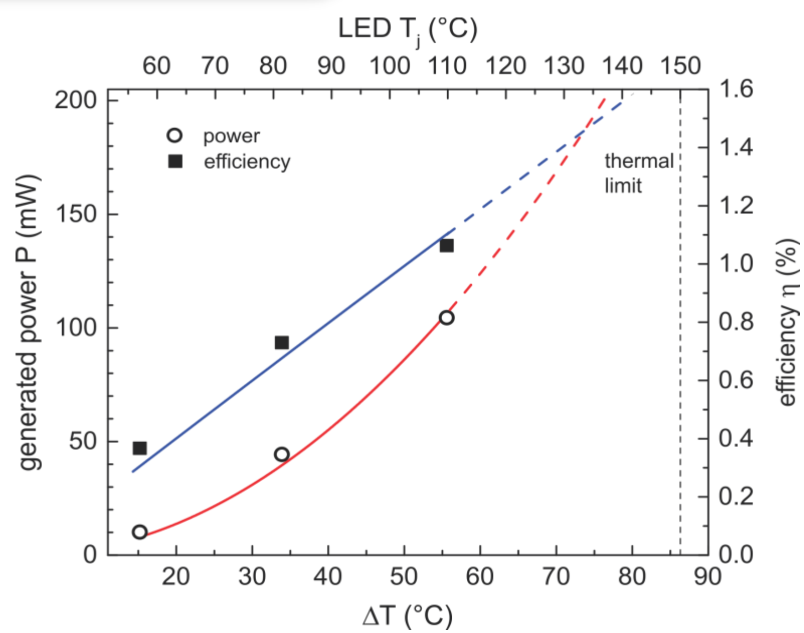
Innovations driven research of advanced solid state lighting solutions





Thin film thermoelectric generators employed in harvesting of waste heat from high power LED sources





R. Szobolovszky *et al.*, submitted to Renewable Energy (2015).

Summary

The Department of Multilayers and Nanostructures is active in the following fields of applied research

- Self-assembled nanoparticle layers for sustainable future technologies including gas sensors, solar cells, solid state lighting, construction materials ...

- Innovative reflective and diffractive X-ray optics for research facilities and industry

Thank you for your attention

- **PhD positions available in our research group in Bratislava**