

FRAUNHOFER INSTITUTE FOR SILICATE RESEARCH ISC

TRANSPARENT CONDUCTIVE OXIDES (TCO)

WET CHEMICAL PROCESSING OF THIN FILMS

Solar applications, display technology and the emerging field of transparent electronics require thin films of transparent conductive oxides (TCO). Even though vacuum-based deposition processes are economically dominating, the preparation from the liquid phase offers highly attractive features. Compared to physical vapor deposition (PVD) only moderate investment costs arise from the so-called sol-gel processing under atmospheric conditions. Complex material compositions and doping are easily achieved. Thin film deposition on large areas with high uniformity is possible. Even though the resulting final conductivities may be below PVD results, direct micropatterning is feasible by e. g. ink-jet or pad-printing technology.

Film compositions

Crystalline n-type TCOs:

- Indium Tin Oxide (ITO)
- Aluminium-doped Zinc Oxide (AZO)
- Antimony Tin Oxide (ATO)

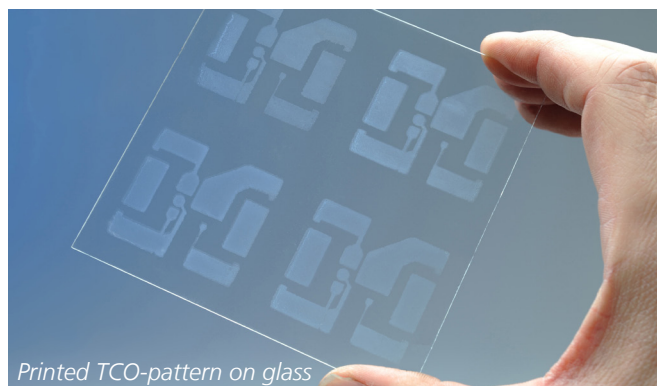
Crystalline p-type TCOs:

- Delafossites (CuAlO_2 , CuCrO_2 , $\text{CuAl}_{0.5}\text{Cr}_{0.5}\text{O}_2$, Mg-doped systems)

Amorphous TCOs:

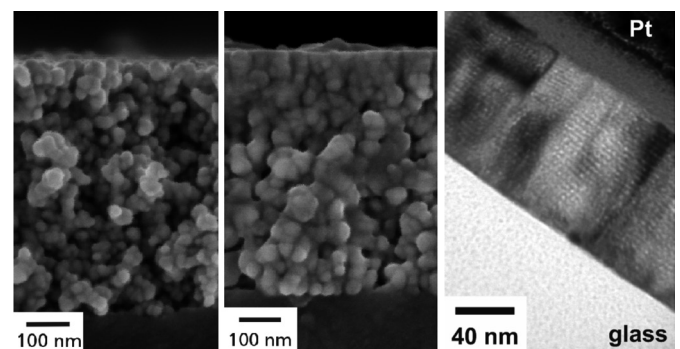
- Zinc-Tin Oxide (ZTO)
- Indium-Gallium-Zinc Oxide (IGZO)

For material optimization the control of grain size, porosity and material interfaces is essential. Fraunhofer ISC offers a variety of technologies to characterize and evaluate sol-gel derived TCO layers. We are highly experienced in the interpretation of structure-sensitive properties of conductive MO_x materials.



We offer

- Development of wet processing routes for different TCO compositions, variation of chemical precursors and solvent composition, tailoring of dopant concentrations
- Optimization of film microstructure and performance, adaption of processing parameters and multiple coatings
- Up-scaling of synthesis and deposition processes to industrial level, consideration of costs, cycle times and operational safety
- Advanced characterization of film microstructures and multilayer assemblies, including high-resolution electron microscopy, X-ray diffraction and ellipsometric porosimetry (EP)
- Spectral and electronic analysis, including transmittance, angle-resolved scattering, conductivity and dielectric parameters
- Patterning of TCO films by ink-jet, pad-printing, dispensing and microspray coating, adjustment of printing accuracy



Different microstructures of TCO films prepared by sol-gel processing

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