

Tutorial 3 - SVC Tutorial C-337

ITO and Alternative TCO: From Fundamentals to Controlling Properties

**Thursday, September 20th, 2018
9:25 – 18:55, Room Dreitorspitze**



This tutorial is intended for scientists, engineers, technicians, and others, interested in understanding the fundamentals, materials, deposition, manufacturing, properties and applications of TCO.

The tutorial explains doping and conductivity in Transparent Conductive Oxides (TCO) including, indium tin oxide (ITO), indium zinc oxide (IZO), and zinc oxide with various dopants, particularly aluminum (AZO) and gallium (GZO). Other alternative TCO, e.g., SnO₂:F and IGZO, are included in examples. TCO deposition by magnetron sputtering is emphasized, although other methods, e.g., evaporation, CVD/pyrolysis and Pulsed Laser Deposition (PLD) are briefly described, but can be expanded based upon class interest. Specific examples of the TCO Optical/Electrical (O/E) properties achieved with various processes are shown. Developing a robust deposition process for TCO is explained. The importance of substrate temperature and the effect of post-deposition processing also are discussed. TCO properties achieved with high temperature processes, e.g., on glass substrates, and low temperature processes, e.g., roll-to-roll on flexible plastic substrates, are compared and the large differences explained. Designing and engineering of TCO O/E properties for specific applications by controlling deposition process parameters are explained. Many application examples are presented.

Topical Outline:

- Introduction; history and review
- Conductivity and transparency in metal oxides
- Optical properties related to conductivity
- TCO Performance expectations; Theory and ITO baseline
- ZnO-based TCO
- Performance of TCO grown by major deposition methods
- Control of TCO film properties
- Developing a robust deposition process; the “Resistivity Well”
- Other TCO host materials and dopants
- Designing and engineering TCO Optical/Electrical (O/E) properties: Application examples
- Appendix I; Thin film optics
- Appendix II; Advanced doping techniques

Instructor: Clark Bright, Bright Thin Film Solutions, LLC (retired 3M)