



## SCIENTIFIC AND METHOD MODULES

<b>Module name</b>	<b>Transparent Conductive Oxides – Fundamentals and Applications</b>
<b>Number</b>	2024-A3
<b>Aims</b>	The material class of transparent conductive materials has been discovered 1907 by Karl W. Bädeker in Leipzig. This module focuses on modern transparent functional materials, from fabrication through material physics to applications.
<b>Basics</b>	covered in basic modules B1–B3, solid state physics, wide gap materials
<b>Contents</b>	The fundamental solid state aspects include defect formation in such materials, the electronic band structure theory (LDA is not a good approximation for such metal oxides) and p-type doping (which is notoriously difficult for many oxides). Research on bulk properties has been promoted by the availability of substrates and/or bulk crystals for a number of oxides (ZnO for a while, recently Ga <sub>2</sub> O <sub>3</sub> ). From an application point of view, materials with larger mobility (at high carrier concentration), materials from earth abundant materials (avoiding expensive and noble metals), materials suitable for low temperature fabrication (in order to reduce the energy budget of industrial processes, process compatibility with flexible electronics), and amorphous materials (for flexible electronics and also room temperature deposition) are desirable.
<b>Methods</b>	Thin film deposition, optical and electrical characterization, device processing, however module has no focus on methodological aspects.
<b>Type</b>	Two-day block course
<b>Date (month/year)</b>	23 to 27 September 2024 (two days, 3-5 days optional)
<b>Time</b>	exact schedule t.b.a.
<b>Work load</b>	15 hours presence/ 45 hours self-study
<b>Examination</b>	
<b>Credit points</b>	
<b>Responsible scientists</b>	Prof. M. Grundmann, Dr. Holger von Wenckstern
<b>International guest lecturers</b>	Darrell Schlom, Cornell Univ.; Keith Butler, Rutherford Appleton Lab.; Jonas Deuermeier, Univ. Nova Lisbon; Andrew J. Green, Air Force Res. Lab; Yasushi Hirose, Tokyo Metropol. Univ.; Takuya Hosokai, AIST, Tsukuba; Toshio Kamiya, Tokyo Inst. Techn.; Kentaro Kaneko, Kyoto University; Piero Mazzolini, Parma University; Julia Medwedeva, Univ. of Missouri; Monica Morales Masis, Univ. Twente; Luis Pereira, Univ. Nova Lisbon; Robin Perry, Univ. College London; Wolfgang Tress, ZHAW School of Eng.
<b>Industrial partners</b>	Malvern Panalytical, Coherent
<b>Recommendations for literature, e-learning</b>	Transparent Electronics: From Synthesis to Applications, Editor: ANTONIO FACCHETTI and TOBIN J. MARKS, John Wiley & Sons Ltd, 2010; Handbook of Transparent Conductors, Editor: David S. Ginley, Hideo Hosono, David C. Paine, Springer Science and Business Media, 2010; Transparent Electronics, Autor: J.F. Wager, D.A. Keszler, R.E. Presley, Springer Verlag, 2008; Springer Series in Materials Science 104, Transparent Conductive Zinc Oxide, Basics and Applications in Thin Film Solar Cells, Editor: Klaus Ellmer, Andreas Klein, Bernd Rech, Springer Verlag 2008