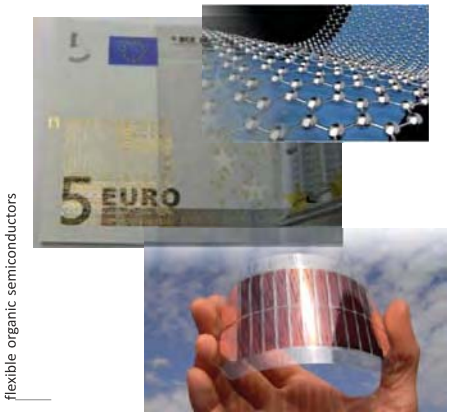
Hybrid Inorganic / Organic Systems for Optoelectronics in Daily Life

Optical properties of hybrid systems depend on their nm level structural properties



flexible organic semiconductors

Nanocrystalline ZnO is provided in an inorganic/organic system of ZnO deposited on sexiphenyl (6P).Initially 6P was deposited on a-plane ZnO substrate at room temperature forming mesoscopic 1-dimensional islands of 6P. In a second step, the islands were capped with ZnO via molecular beam epitaxy at 373 K.

Information on the nanostructure of ZnO grown atop 6P was provided by high-resolution TEM. Imaging was performed along the [00.1] direction of the ZnO substrate which showed that ZnO exhibits a perfect crystal structure when directly grown on the substrate. This was confirmed by Fourier transformation (FT) which also confirmed that ZnO grown atop 6P undergoes an imperfect growth.

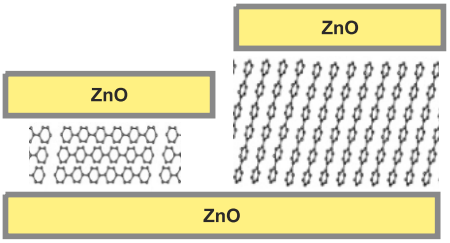
Identification of the orientation of the nanocrystals and indexing of the lattice planes only based on FT is rather ambiguous and must be handled with care. For this reason, ASTAR was used to uncover any specifics of the overgrowth regime of ZnO on 6P at nm scale.

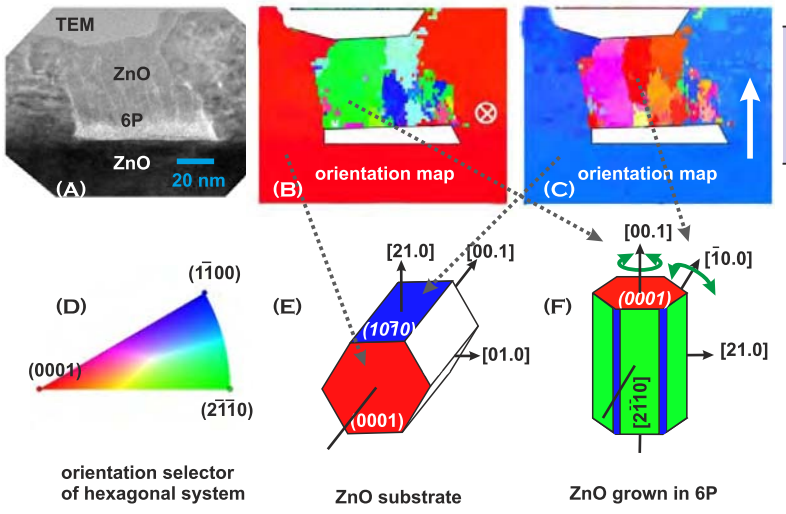
With ASTAR scanning the electron beam in nanobeam diffraction mode (probe diameter 1 nm) across an area of 100 nm in width and 80 nm in height provides the orientation maps depicted below. The maps were derived by comparing the diffraction pattern recorded at each individual position with a set of about 1000 calculated diffraction patterns of hexagonal ZnO. Focussing on ZnO atop 6P, columnar grains are identified that extend even up to the surface as signified by green and red areas.

The challenge:	Identify precise orientation texture between ZnO substrate - sexipephenyl (6P) - ZnO deposited layer at nm scale
Solution:	ASTAR technique coupled with precession electron diffraction

From the ASTAR orientation map it is evident that the [00.1] wurzite axis is well-aligned along the vertical growth direction indicating a strong texture. Electrostatic forces originating from the 6P molecules have to be considered as the origin of this texture. In addition, a significant lateral texture within the (0001) plane cannot be excluded, as it cannot be distinguished which of the six prismatic facets contribute to the diffraction pattern.

Research on ZnO is of immediate practical importance as this semiconductor has several favorable properties, including good transparency, high electron mobility, wide bandgap, and strong room-temperature luminescence. These properties are used in emerging applications for transparent electrodes in liquid crystal displays, in energy-saving or heat-protecting windows, and in electronics as thin-film transistors and light–emitting diodes (LEDs).





Crystal Structure

ZnO: Hexagonal, $P6_3mc$
a = 3.22 Å, c= 5.20 Å

Experimental Data

TEM type: Jeol 2200 FS
Map resolution: 1 nm
Scanned area: 100 x 80 nm

figure 1

Crystallographic orientation mapping of ZnO as revealed by scanning nanobeam diffraction (SNBD):
a) TEM image of the region analyzed by SNBD.
b) and c) crystallographic orientation maps of ZnO. The white arrow markers represent the lattice planes color coded by the orientation triangle of d).
e) alignment of a representative ZnO unit of both, ZnO substrate and low temperature grown homoepitaxial ZnO,
f) alignment of a representative ZnO unit for the textured growth atop sexiphenyl.

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