Oxides grown by Atomic Layer Deposition for applications in electronics, optoelectronics, biology and medicine

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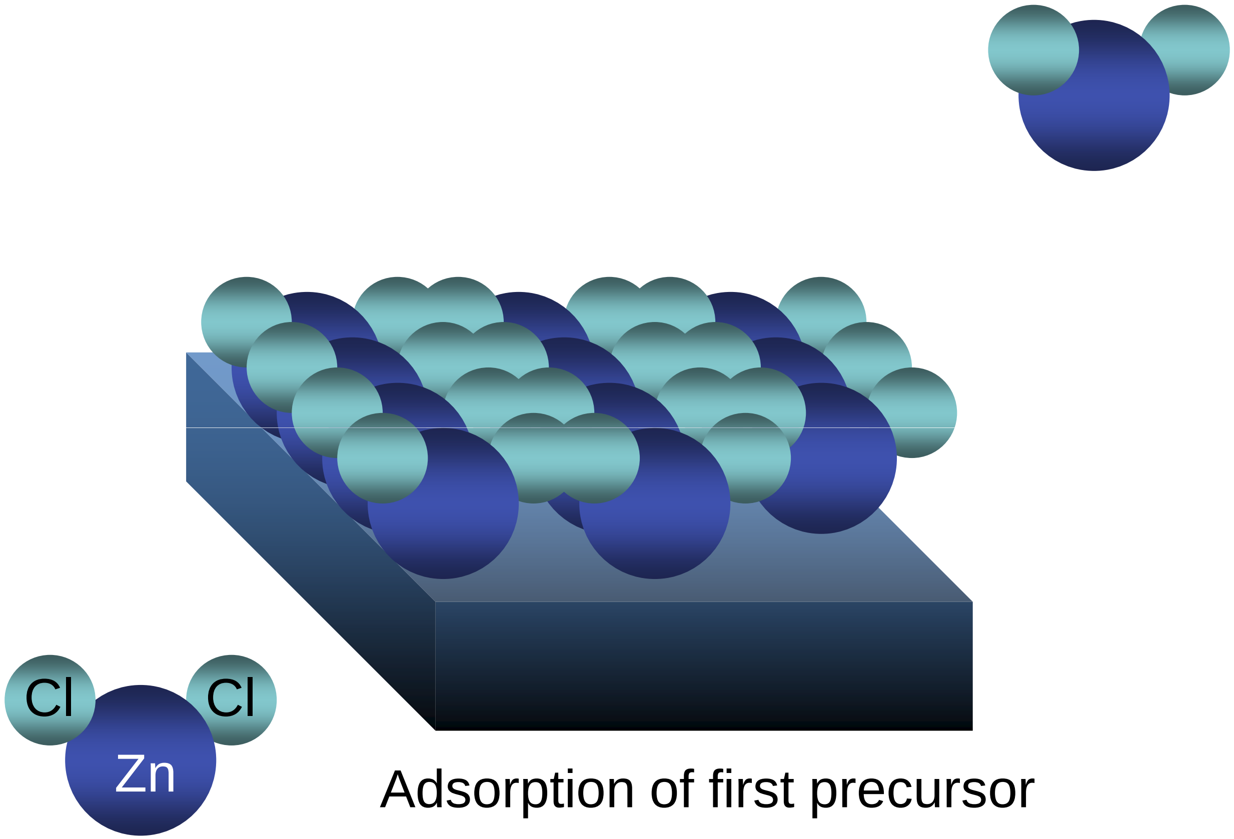
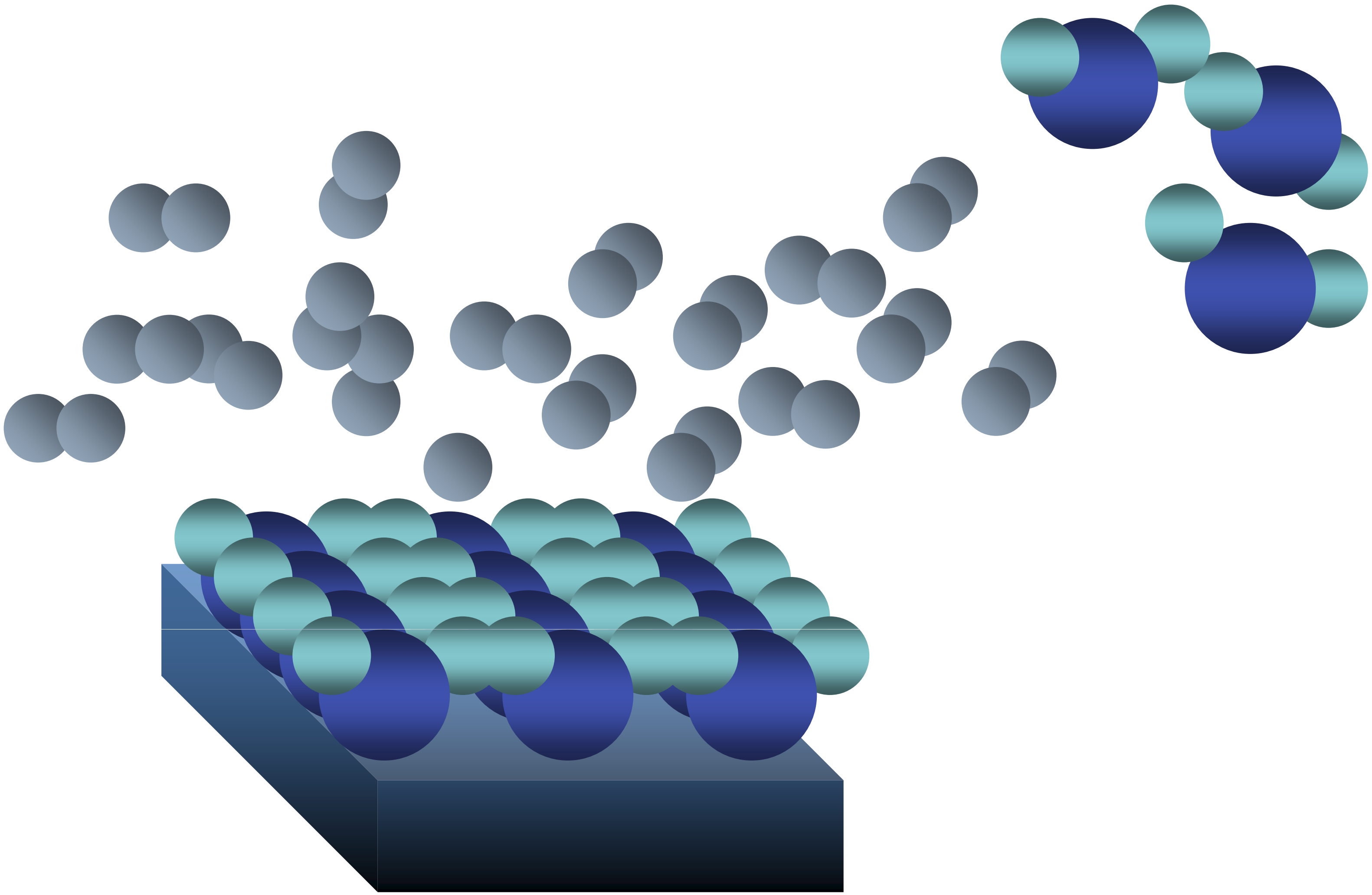
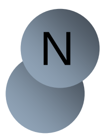
European Action towards Leading Centre for Innovative Materials

ALD growth process

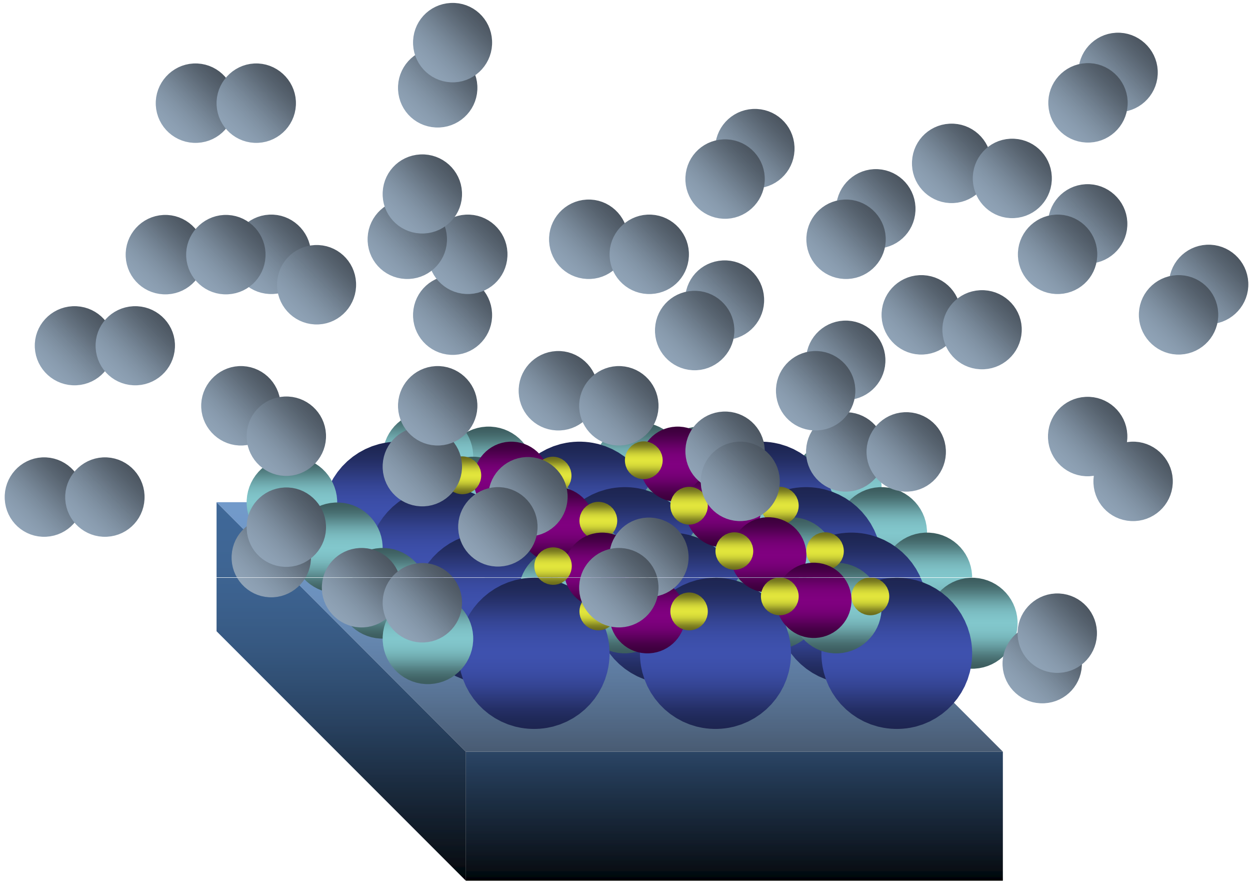


Adsorption of first precursor





Surface saturation followed by reactor purging



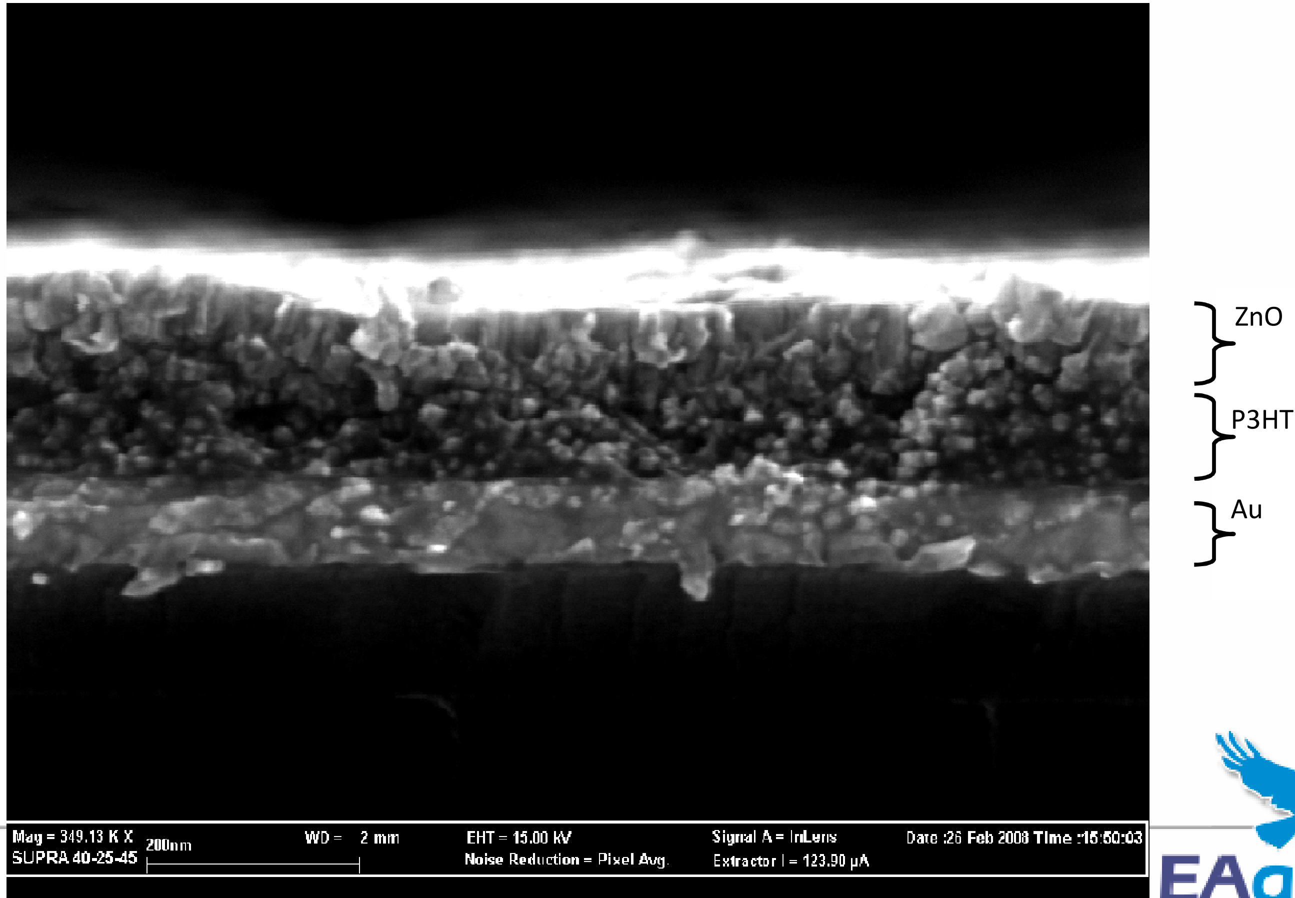
CVD

- Less reactive precursors
- Precursors react at the substrate but also before deposition
- Precursors can decompose at process temperature
- Uniformity requires uniform flux reactant and temperature
- Thickness control by precise process control and monitoring

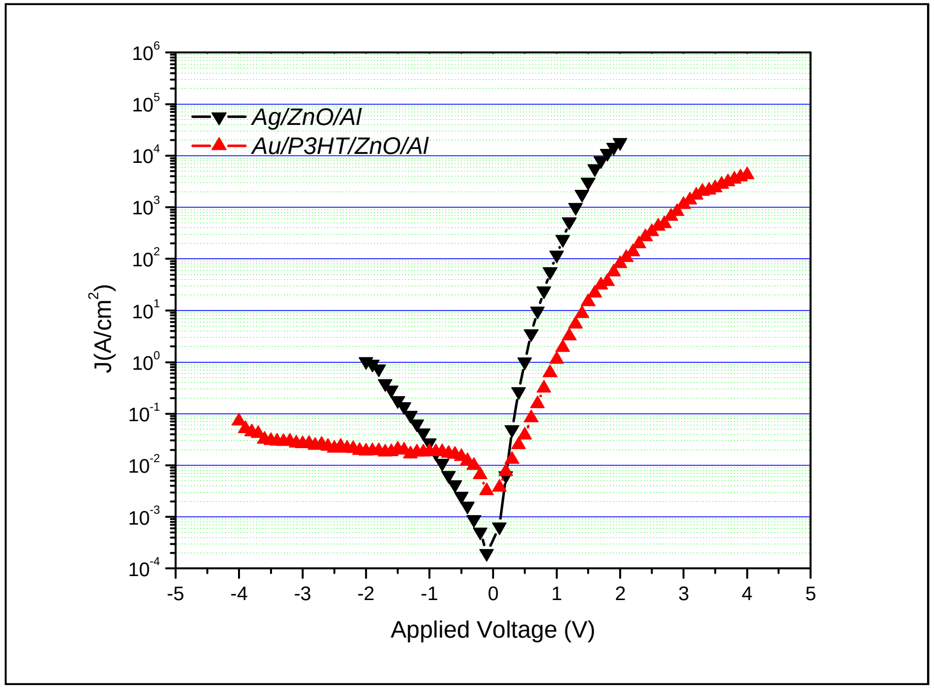
ALD

- Highly reactive precursors possible
- Precursors react only on the substrate of the film
- Precursors must not decompose at process temperature
- High uniformity of coating ensured by the saturation mechanism
- Good thickness control by selecting the number of ALD cycles
- Uniform doping of the layers possible
- Reactor scaling possible
- Multisubstrate deposition possible

Benefits of the LT growth – Hybrid structures



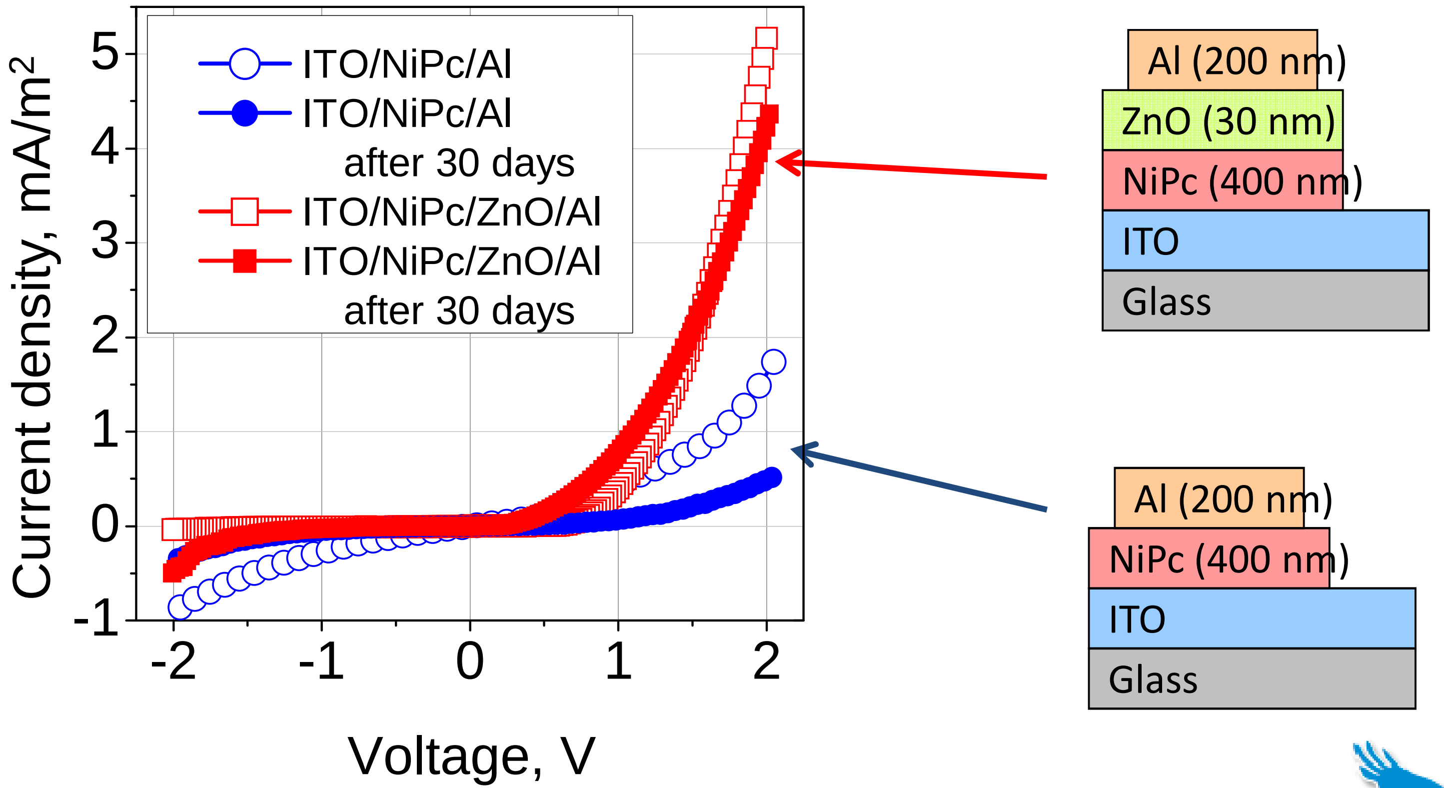
Electrical Characterization



- ***Improved junction behavior in terms of I_{off}***
- ***$I_{on}/I_{off} \sim 10^5$, I_{on}/I_{off}***
- ***High current density: $J = 10^4 A/cm^2$ at 4V ($J = 0.02\ A/cm^2$ for a P3HT diode)***

Photovoltaic diode based on ZnO/NiPc junction

Effect of ZnO layer on device stability



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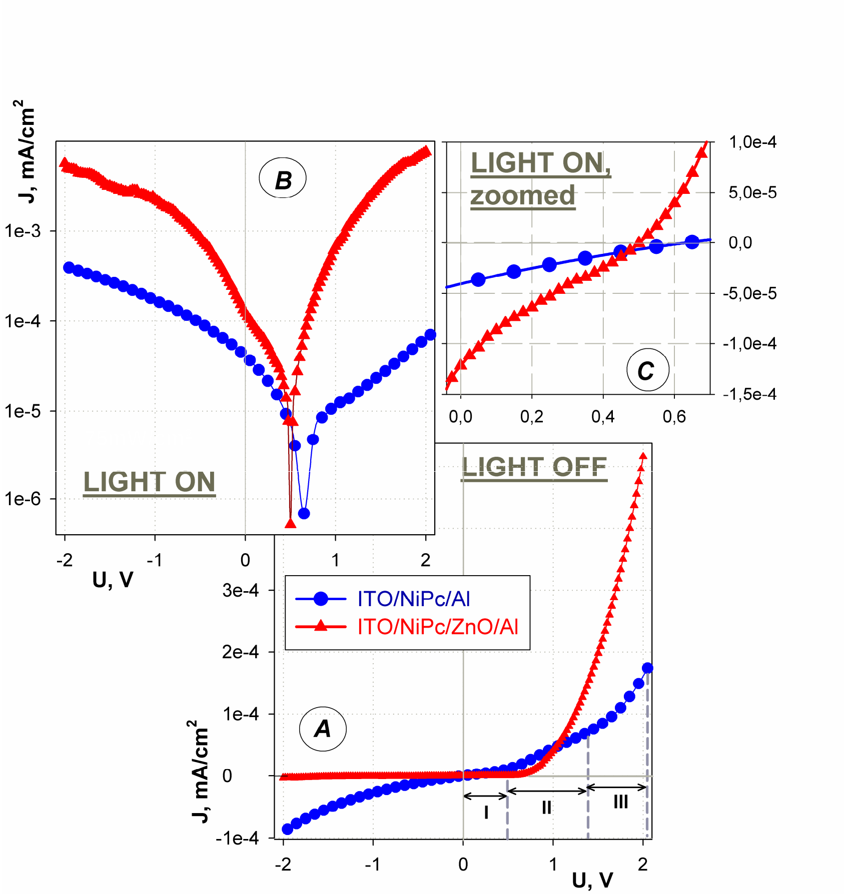
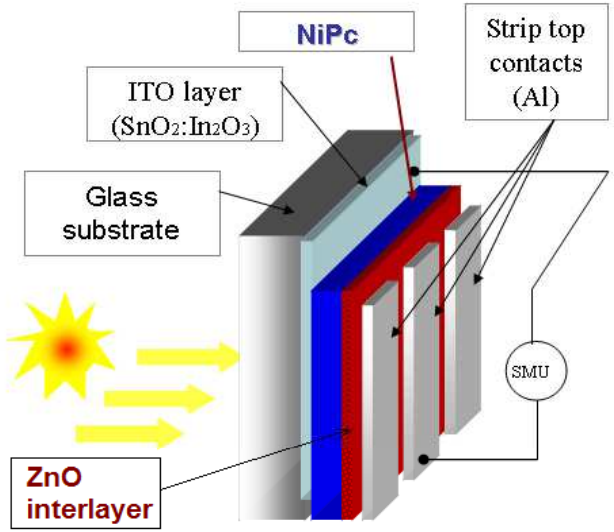
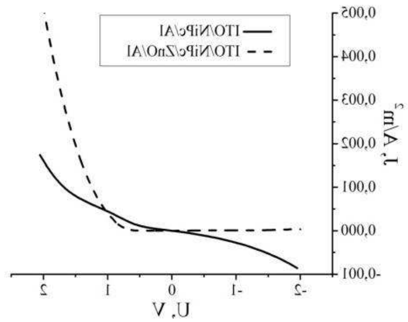
Mat. Sci. Eng. B **172,** 272 (2010).

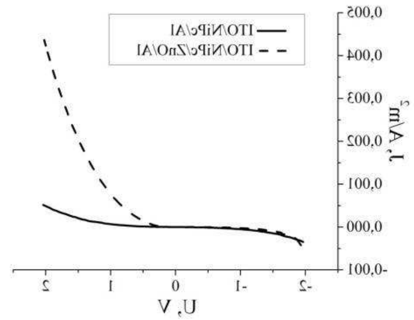
Time stability







As prepared



After 30 days

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Advantages of LT growth

Transparent electronics

APPLIED PHYSICS LETTERS **92**, 023502 (2008)

Electrical behavior of zinc oxide layers grown by low temperature atomic layer deposition

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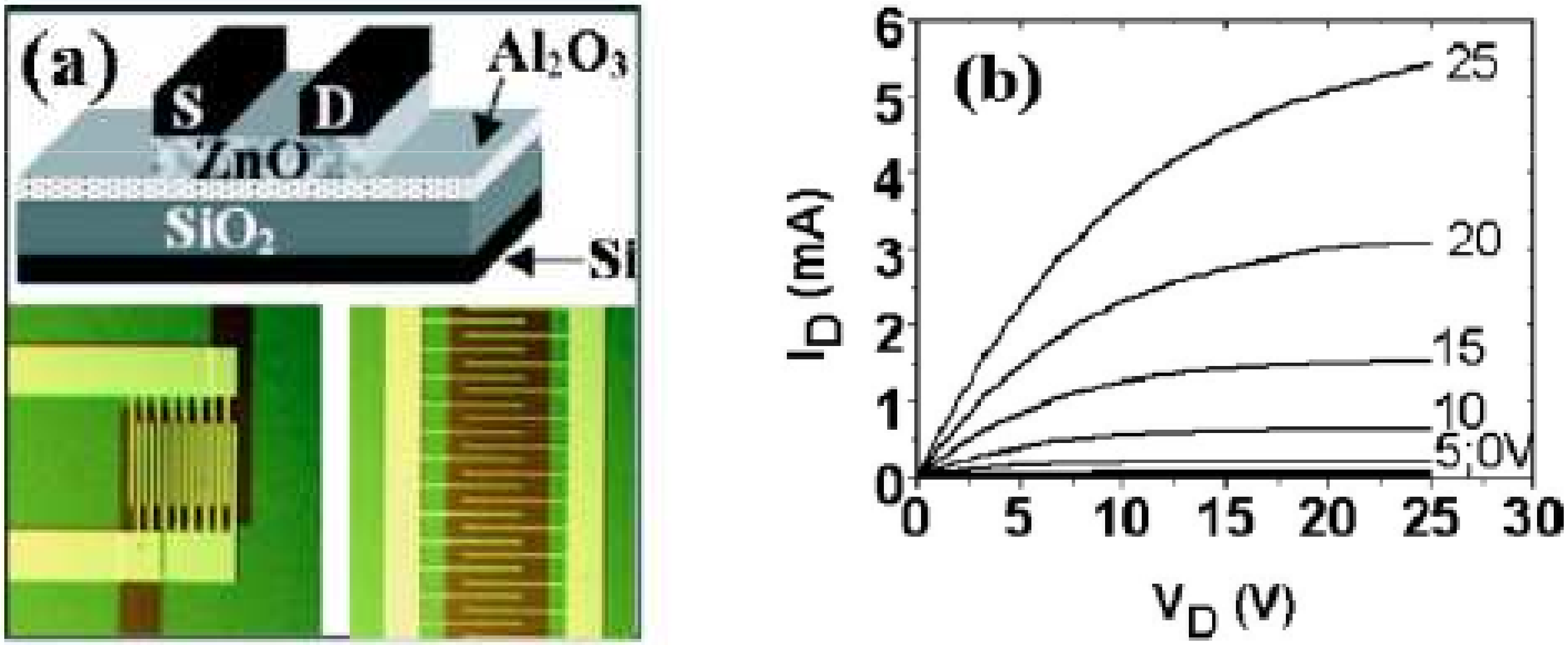
Institute of Physics, Polish Academy of Sciences, Warsaw 02668, Poland



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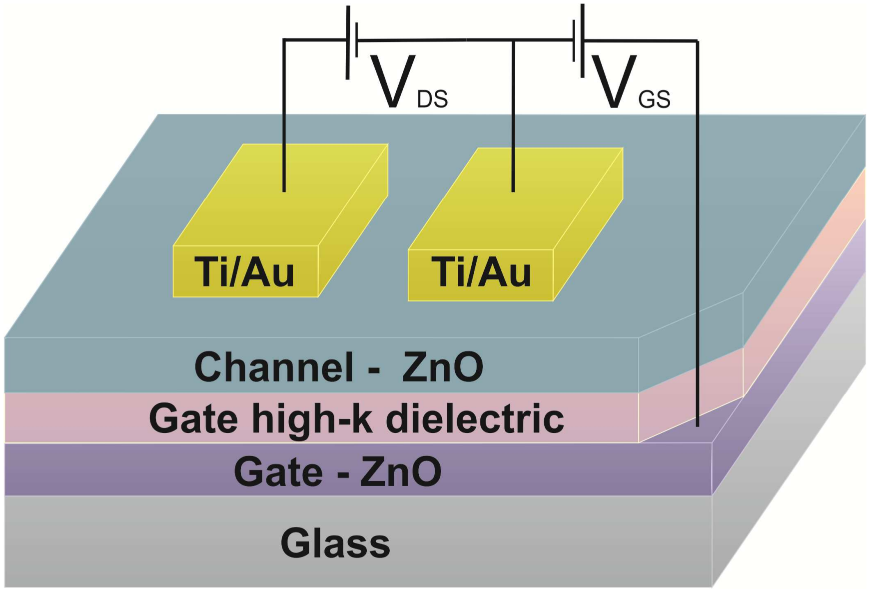
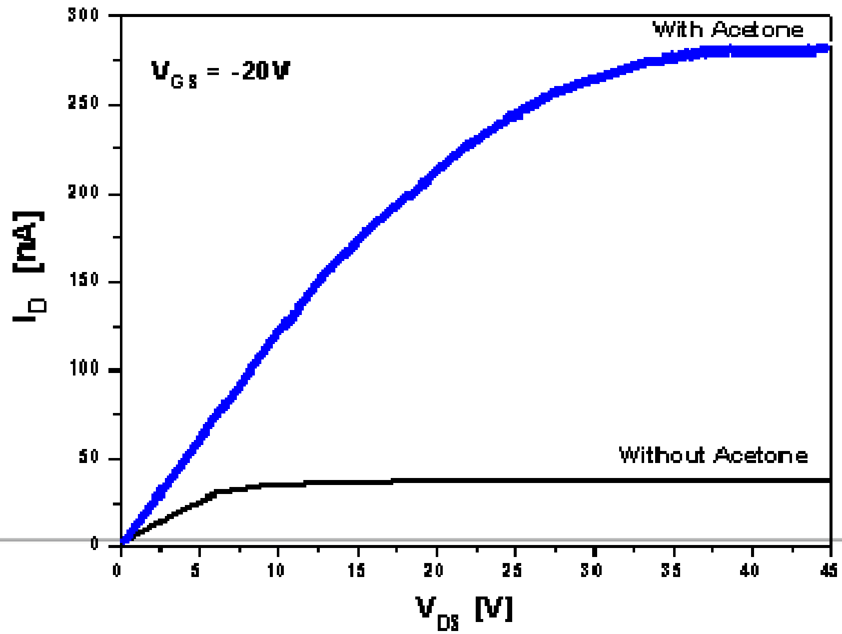


S. Gierałtowska



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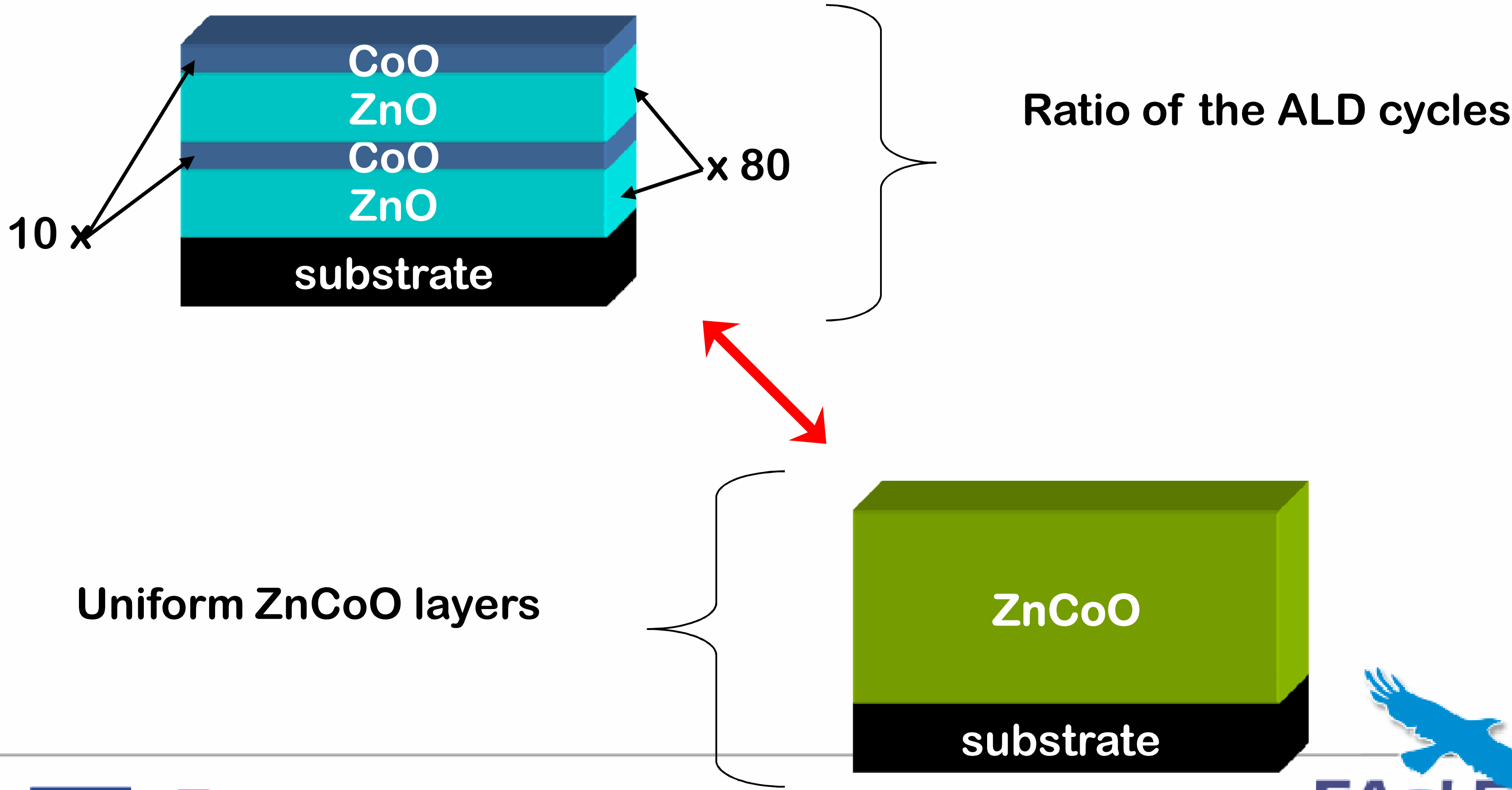
Spintronics

Uniformity of DMS samples
- the most critical issue

Uniform Zn(Mn,Co)O layers by ALD



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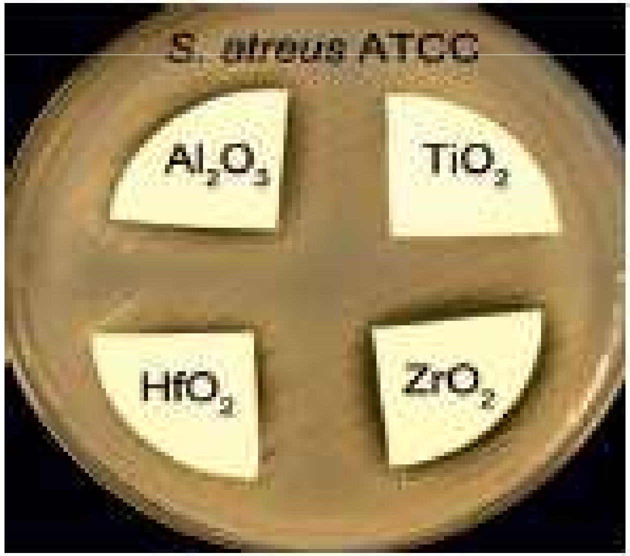
Antibacterial coating



Antibacterial coating

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Photovoltaics
TCO films based on ZnO:Al

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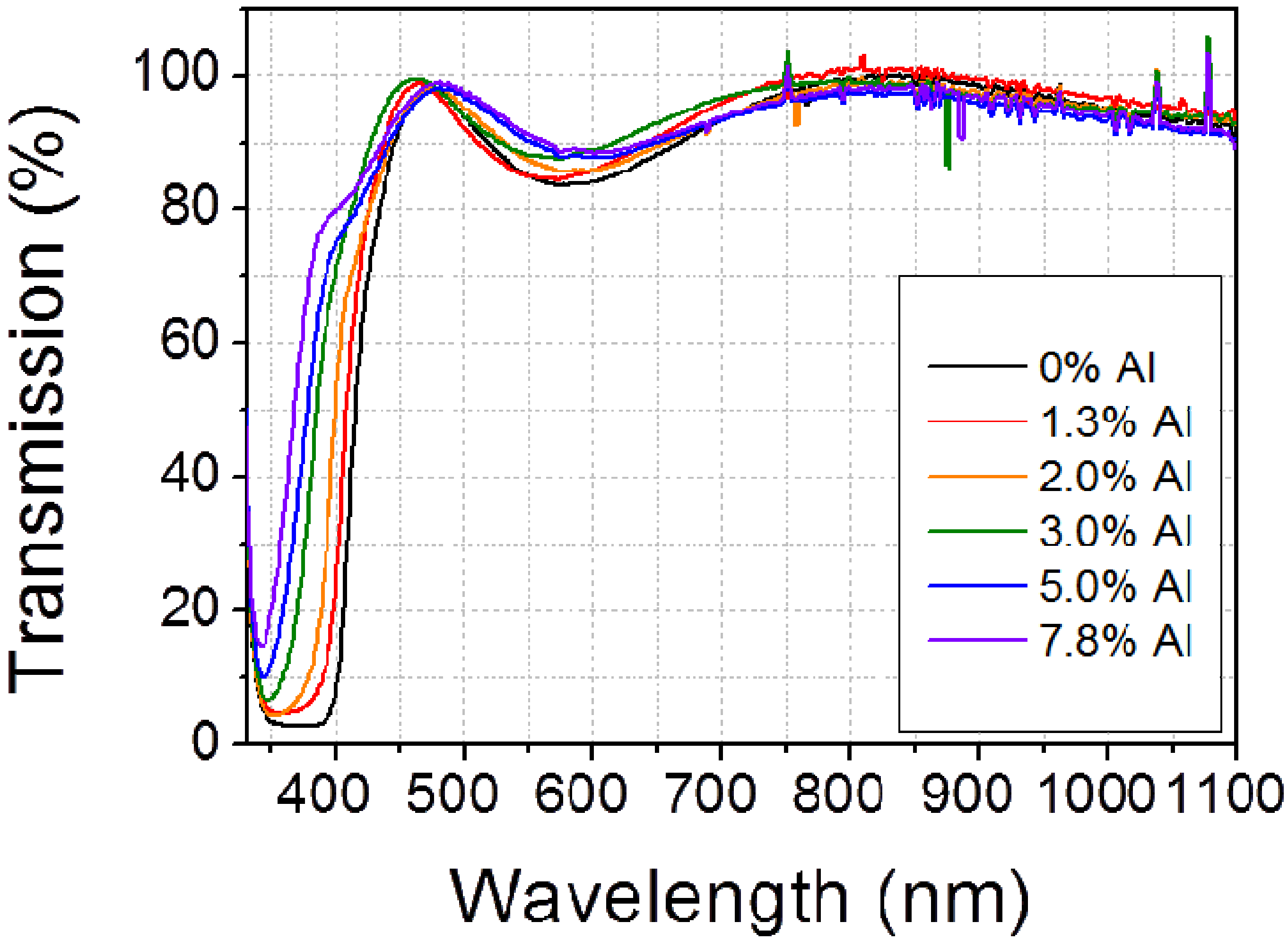
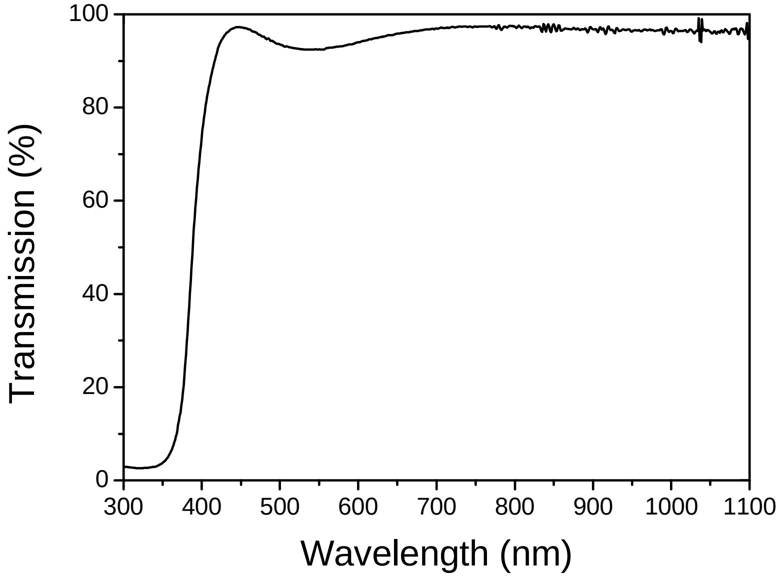
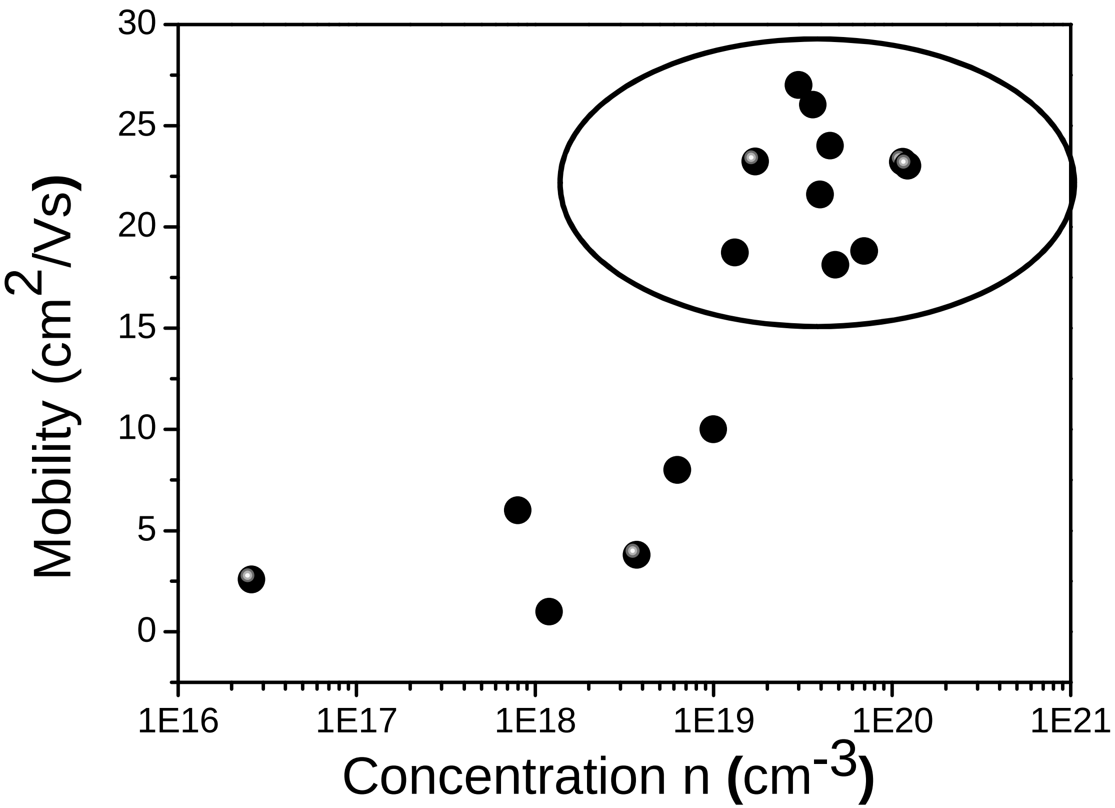

Transmission (%)
100
80
60
40
20
0
400
500
600
700
800
900
1000
1100
Wavelength (nm)
0% Al
1.3% Al
2.0% Al
3.0% Al
5.0% Al
7.8% Al

ZnO TCO metodą ALD

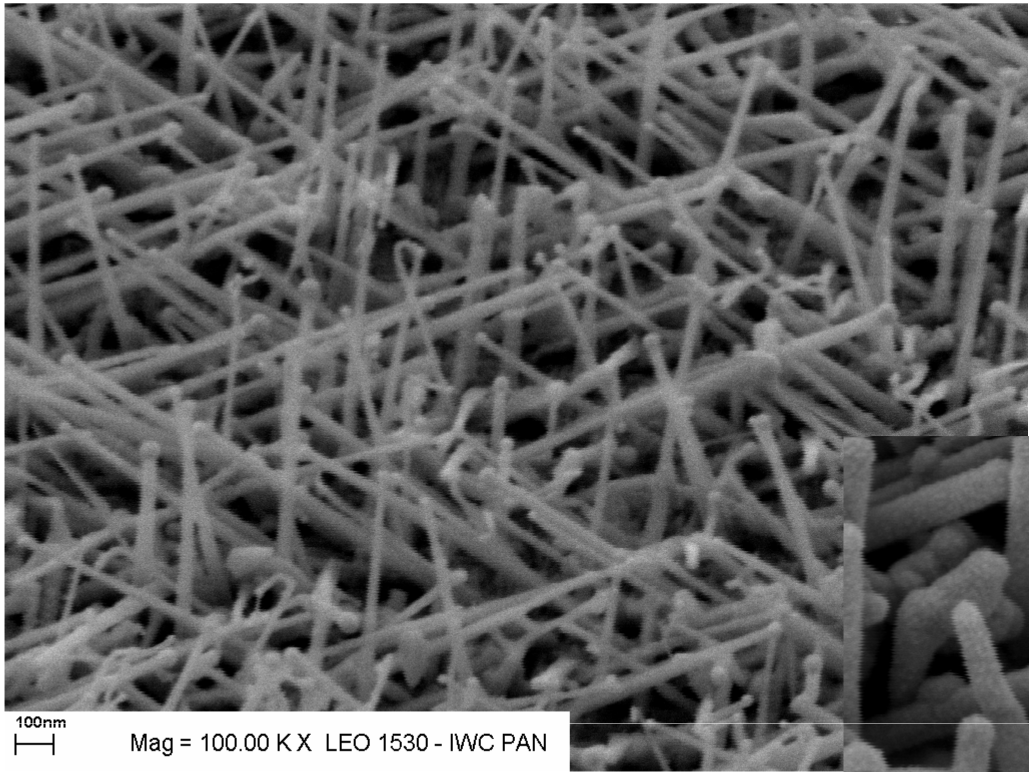




G. Łuka, R. Pietruszka, Ł. Wachnicki

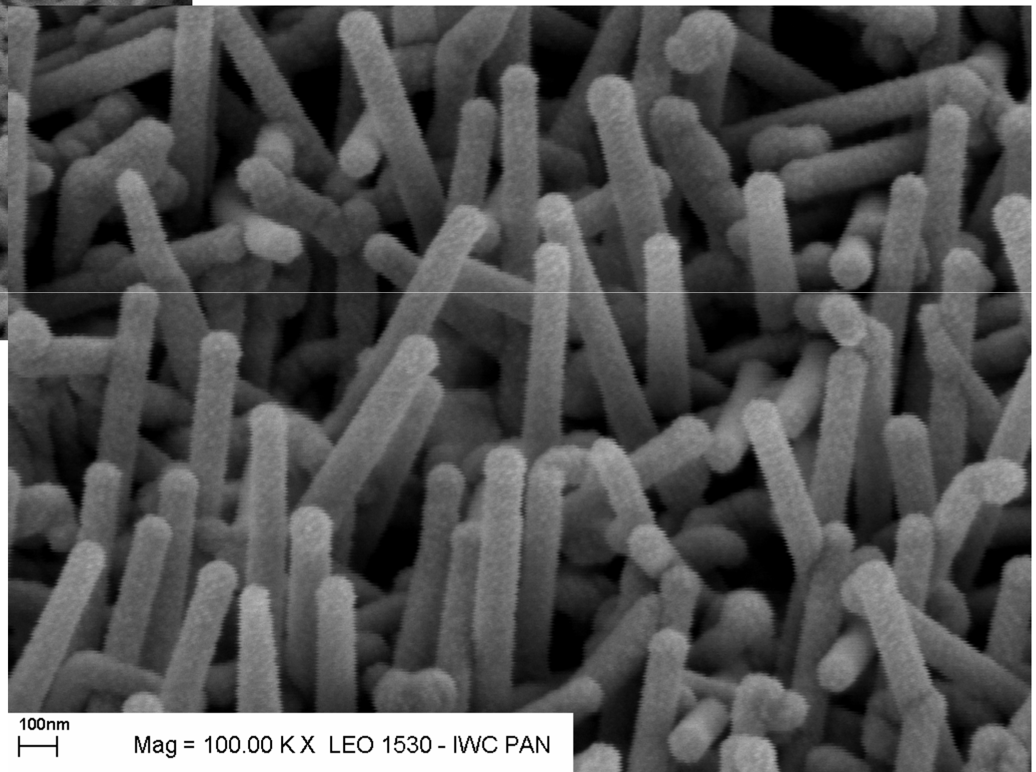
Photovoltaics
New architecture

Conformal coating of 3D structures-
Nanowires of ZnTe coated
with ZnO



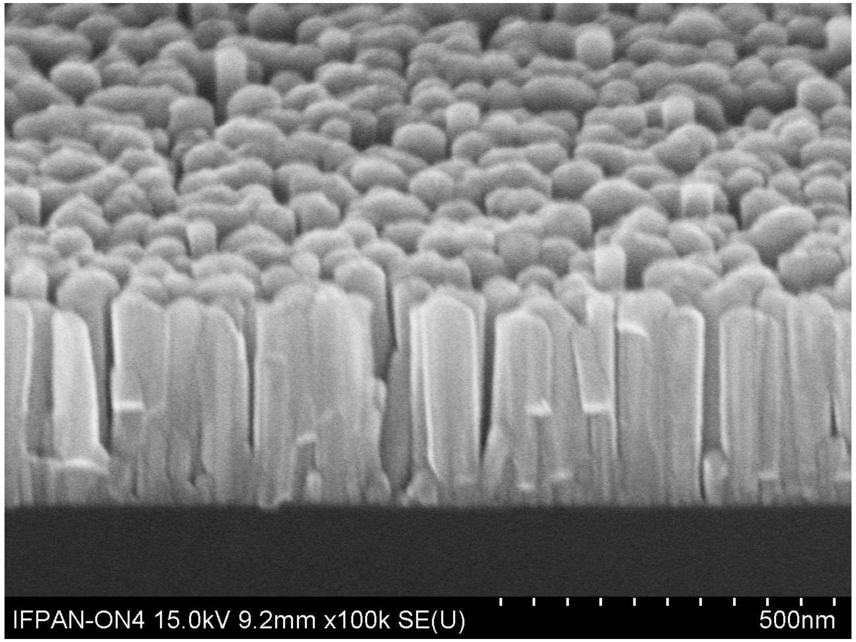
ZnTe nanowires on (100) oriented substrate

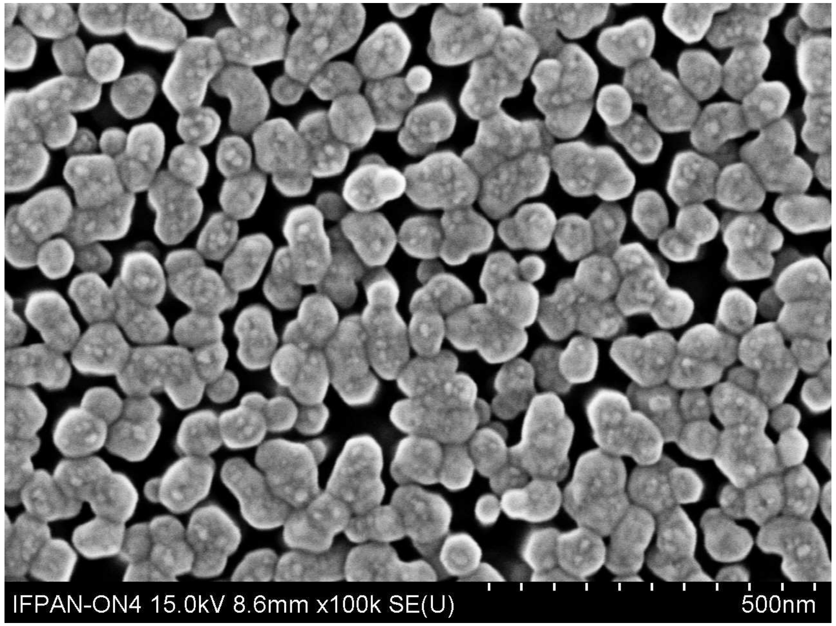
ZnO coated nanowires



Ł. Wachnicki

nanorods GaN on Si(111) coated with ZnO („shell” ALD)





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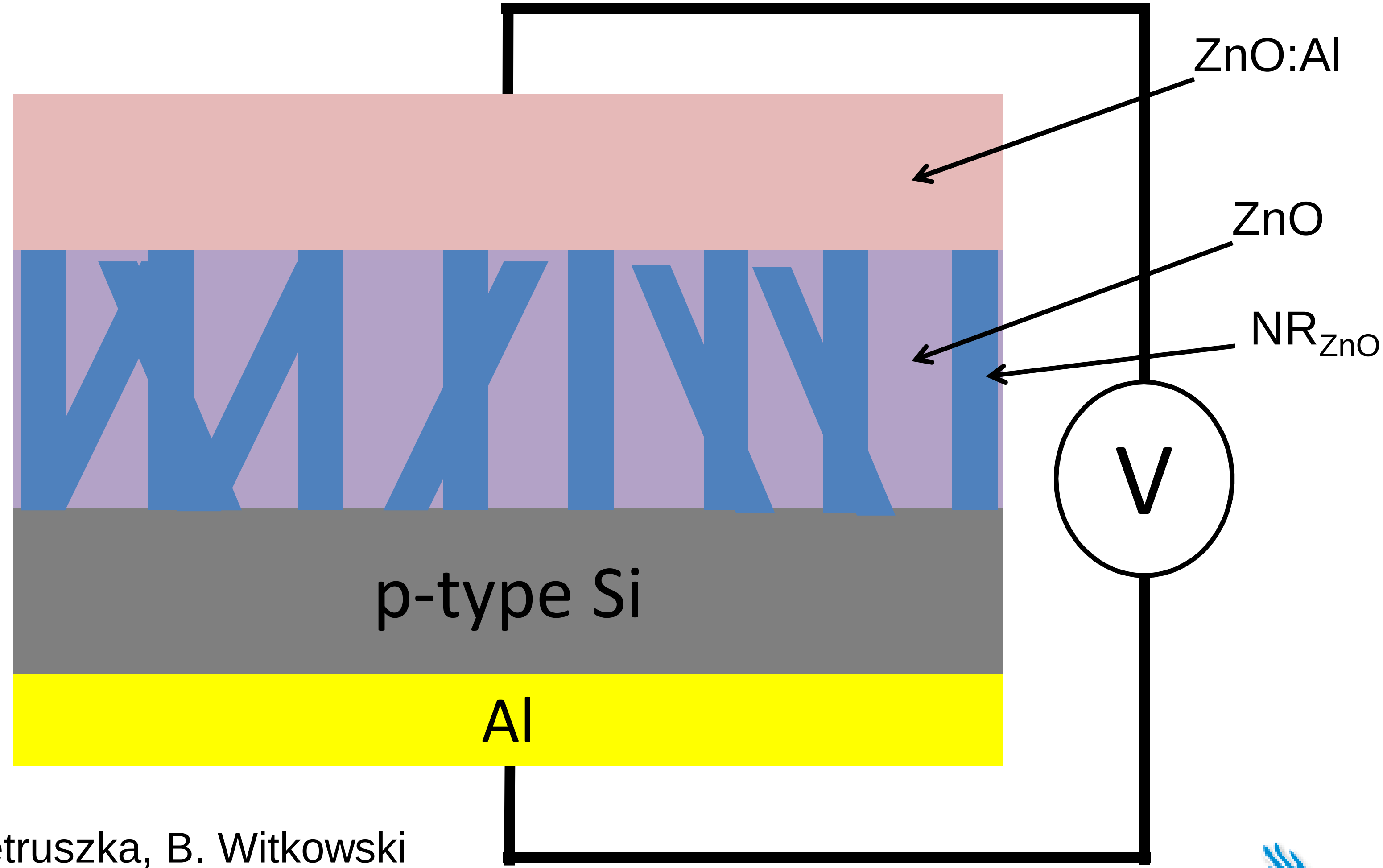

R. Pietruszka, B. Witkowski

Marek Godlewski

Summary:

1. Low temperature processes – range of hybrid structure possible
2. Conformal coating of developed surfaces – 3D structures
3. High quality of deposited material – High-k oxides with excellent properties