Plasma enhanced Atomic Layer Deposition of zinc sulfide

Jakob Kuhs[1], Zeger Hens[2], Christophe Detavernier[1]

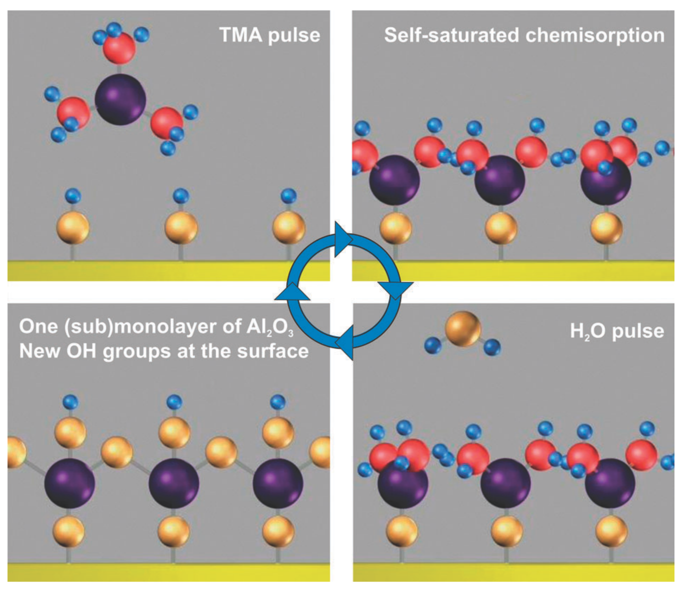
[1]Dept. of Solid State Sciences, Ghent University, Krijgslaan 281/S1, 9000 Gent, Belgium
[2]Dept. of Inorganic and Physical Chemistry, Ghent University, Krijgslaan 281/S3, 9000 Gent, Belgium

Indroduction

Zinc sulfide

Zinc sulfide is a wide band gap semiconductor which can be doped n- and p-type. These porperties make it an ideal material for p-type tranparents conductive films (TCF). The main applications for ZnS are as buffer layers in solar cells or as TCFs for photonics applications such as LEDs.

Atomic Layer Deposition



Atomic layer deposition (ALD) is a selflimited growth method that is characterised by alternating exposure of the growing film to chemical precursors, resulting in the sequential deposition of (sub)monolayers. The key advantages of ALD are the atomic-level thickness control and the excellent conformality, even on complex 3D nanostructures.

Growth of ZnS

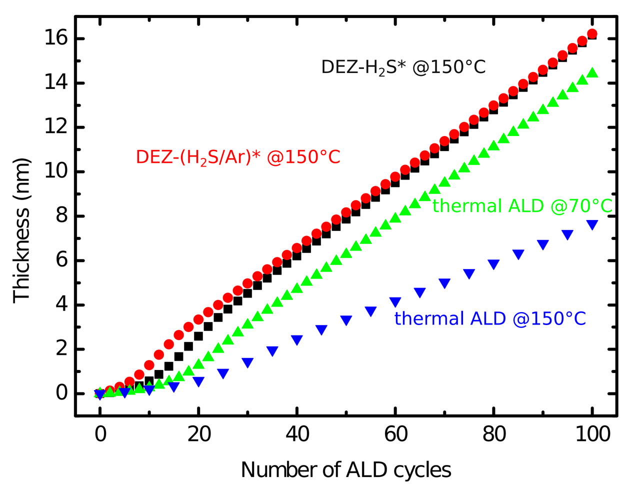
Growth method

Repeating cycles: DEZ - H_2S/Ar plasma or DEZ - H_2S

Argon diluted H_2S plasma was used instead of a pure H_2S plasma in order to minimize the exposure of the ALD reactor to the highly reactive S radicals.

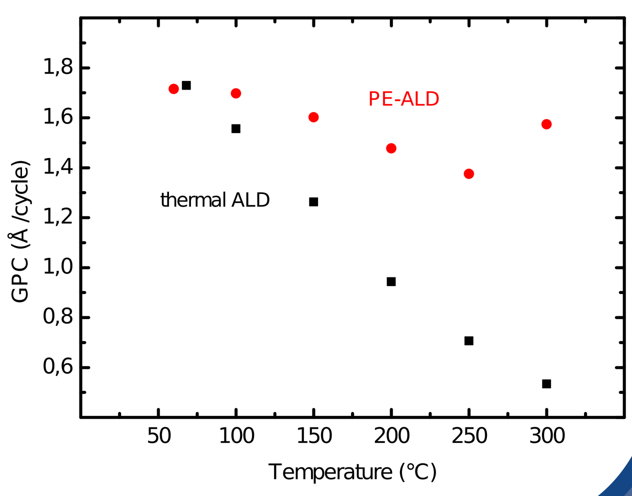
Growth linearity

Saturation and linearity was observed for both the thermal and plasma enhanced (PE) process. The PE-ALD process nucleates slightly earlier than the thermal process.



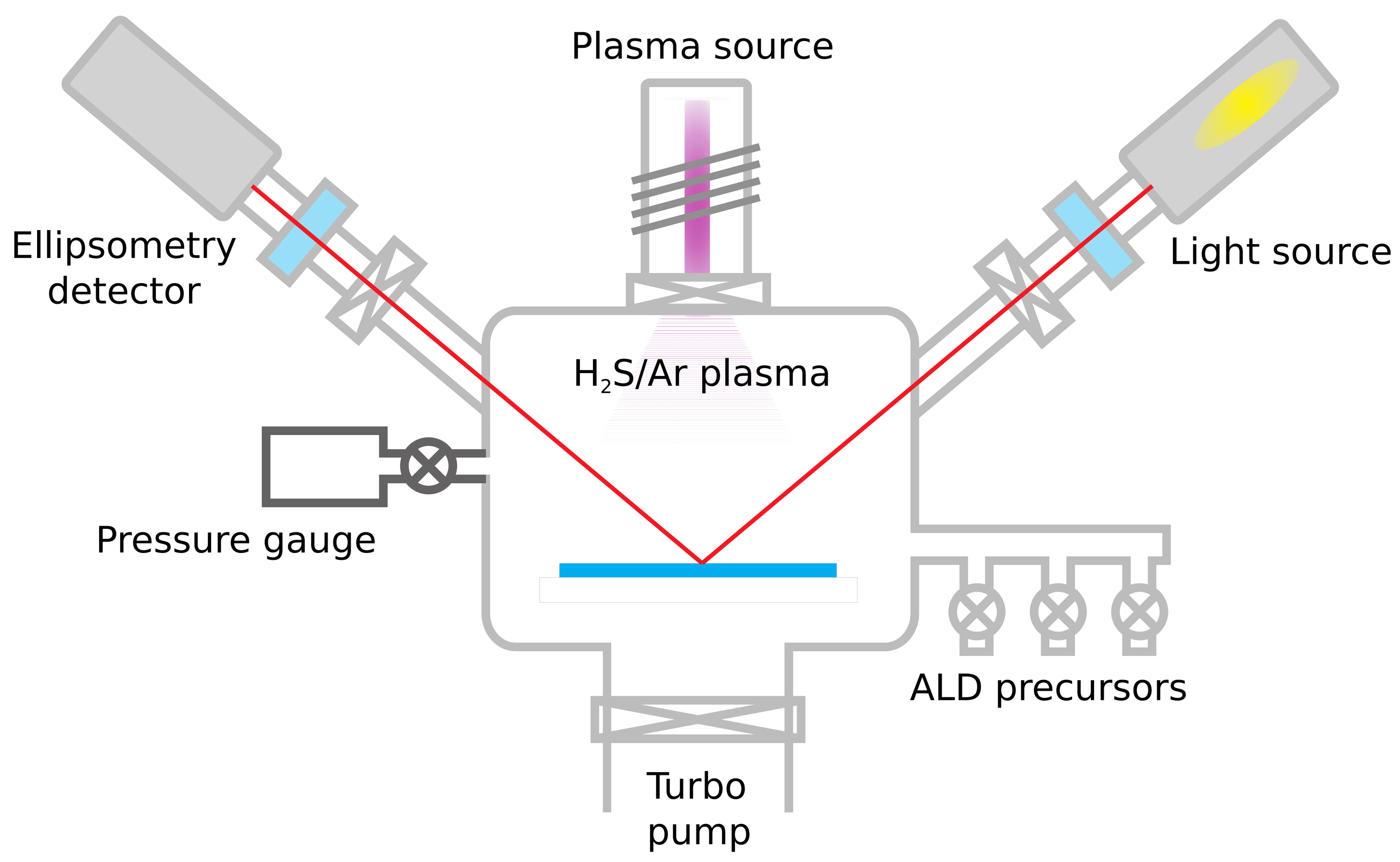
Temperature dependency

The growth per cycle (GPC) of the thermal ALD process decreases by more than 75% over the temperature range from 60°C to 300°C while the GPC of the PE-ALD process is much less dependent on the substrate temperature.



Experimental setup

ALD setup



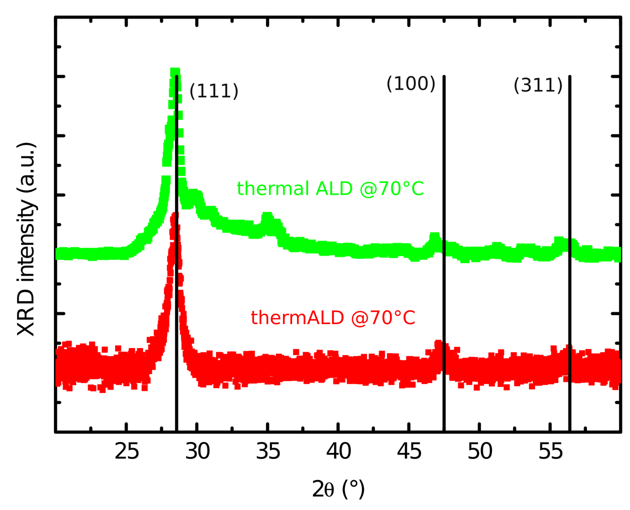
A home-bulit ALD reactor equipped with a plasma source and an *in situ* spectroscopic ellipsometer was adapted for H_2S compatibility.

Characterisation methods

Thin film growth rate was monitored *in situ* by spectroscopic ellipsometry while the structural and optical properties were characterised *ex situ* using X-ray diffraction (XRD), X-ray fluorescence (XRF), X-ray reflectivity (XRR), X-ray photoelectron spectroscopy (XPS) and UV/Vis spectroscopy.

X-ray diffraction

Both thermal and PE-ALD ZnS thin films are already crystalline as deposited at 70°C and show similar XRD patterns, indicating mainly the cubic zinc blend phase.



Summary

- A new plasma enhanced ALD process for ZnS was developed.
- The wide deposition window of the the PE-ALD process can lead to a better device integration or better matching of temperature windows for ALD of ternary compounds.
- Both thermal and PE-ALD ZnS thin films have similar optical and structural properties.

Acknowledgements

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Jakob Kuhs
jakob.kuhs@ugent.be

CoCooN group
Krijgslaan 281/S1
9000 Ghent
www.cocoon.ugent.be