Spatial ALD at Holst Centre

Holst Centre
Powered by imec & TNO

Holst Centre fundamentals

- Holst Centre is a R&D organisation managed by 2 reputed institutes: TNO and imec
  - TNO: biggest Dutch R&D organisation focused on applied research aimed at improving societal welfare coupled to economic growth
  - Imec: famous Belgian R&D institute aimed at advancing chip technology

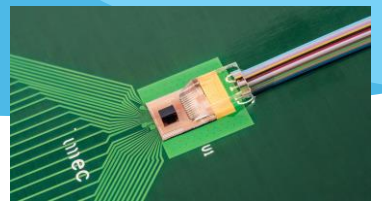
TNO innovation for life

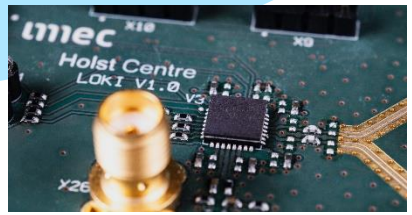
- Thin film and flexible electronics
- Energy storage

imec

- Health care technology
- Integrated photonics
- Low-power wireless communication
- Edge AI



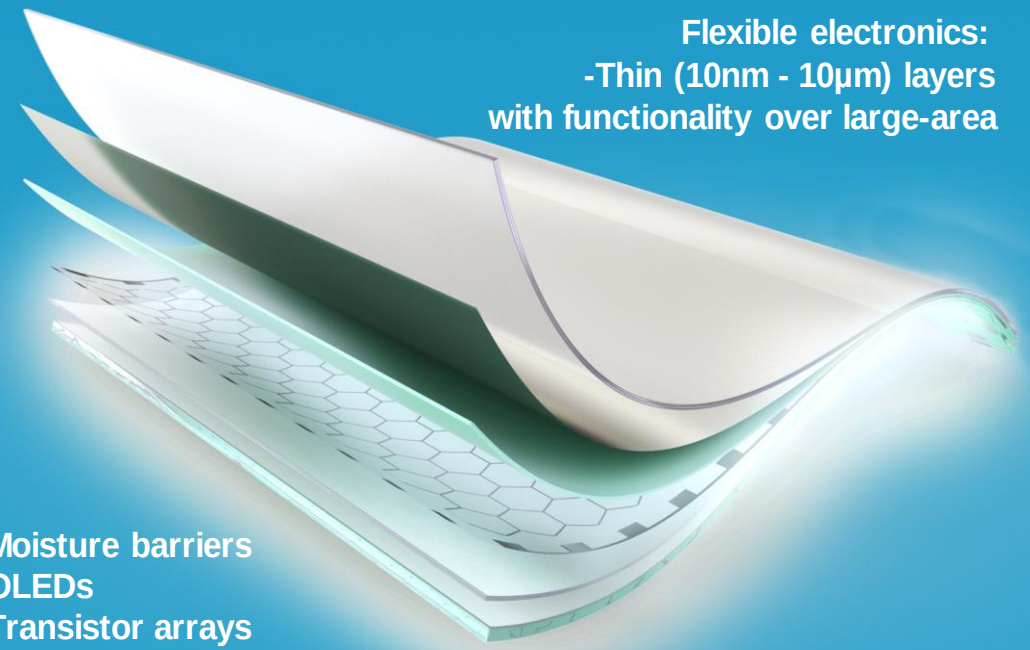


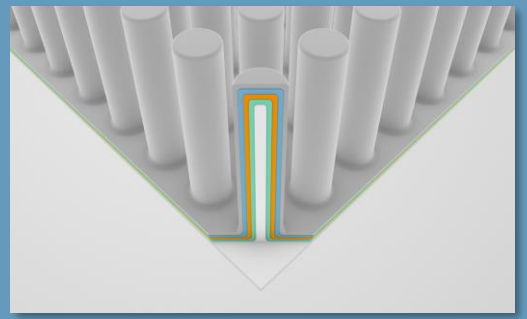



Thin-film Electronics ‘TFE’

- Core competences
  - Thin-film deposition and patterning technologies on flexible and conformable large substrates using new production methods
  - Large-area electronics

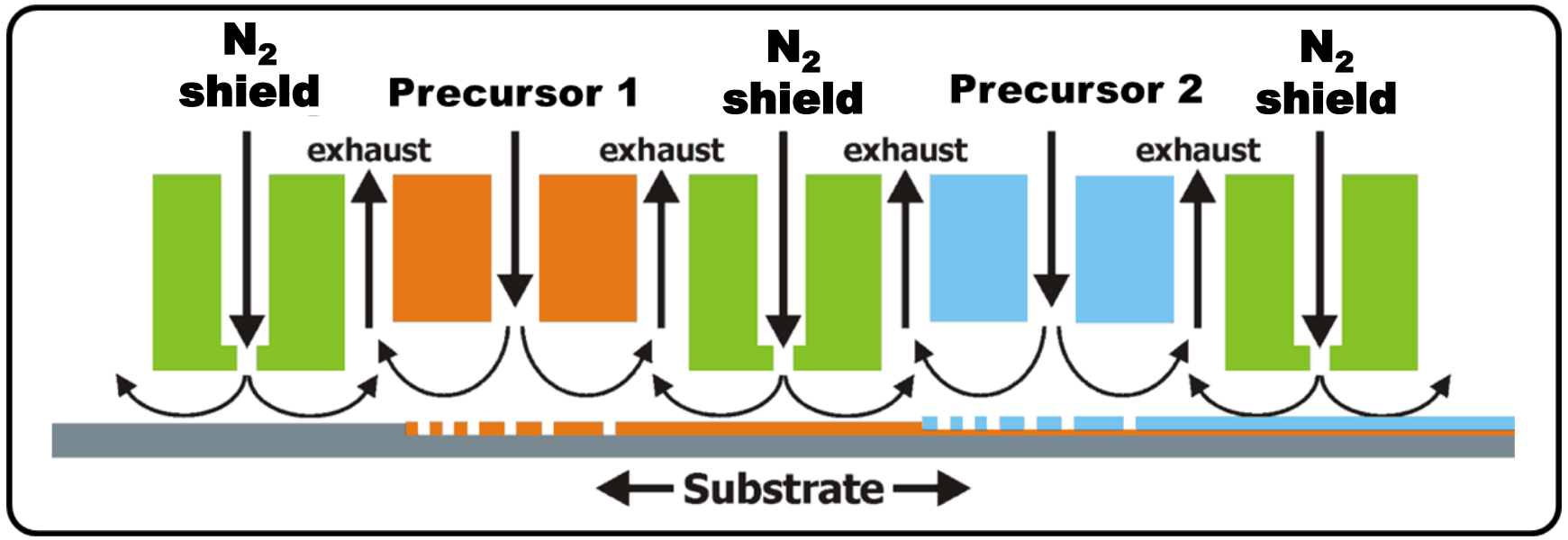
- Markets and Applications
  - Flexible thin-film device technology centered around **OLED displays** and large area **image sensors**
  - **Spatial atomic layer deposition** processes and equipment development
  - **Solid-state batteries** that are safer and have higher gravimetric and volumetric capacity
  - **Functional coatings for electrolysis**





Spatial ALD at TNO – Holst Centre

Atmospheric pressure, Spatial Atomic Layer Deposition



- **Spatial separation** of half reactions instead of time-separated
- **Nitrogen shields** to prevent precursor mixing and gas-phase reactions

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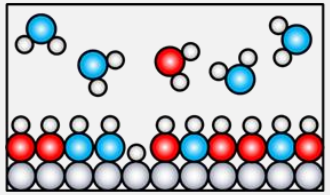
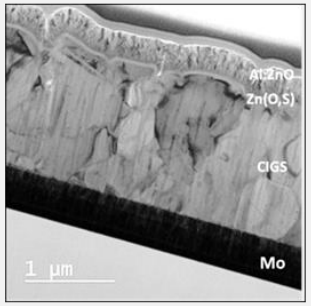
Spatial ALD at TNO – Holst Centre

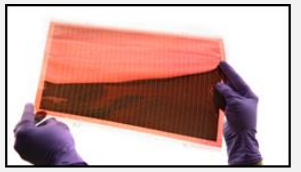
- In 2008: Spatial ALD was “invented” and patented at TNO
- In 2009: the first TNO Spatial ALD reactor was built (the so-called “PoP1”)
- In 2010: spin-out of Solaytec (now “SALD”)
- In 2011: the first R2R tool was built
- In 2013: the Spatial ALD research program at Holst Centre started
- Since then, another PoP reactor and the S2S reactor installed
- Worked with many local and international partners on developing Spatial ALD technology for e.g. solar cells, OLEDs, optical coatings, batteries, barrier coatings, electrolysers and many more
- In 2018: spin-out of SALDtech (now “SparkNano”)
- In 2021: Focus on energy applications

Spatial ALD at Holst Centre





Spatial ALD Process development



Spatial ALD in Applications

R2R ALD

Spatial ALD Equipment

Large area S2S ALD

Based on more than 13 years of experience in Spatial ALD technology development

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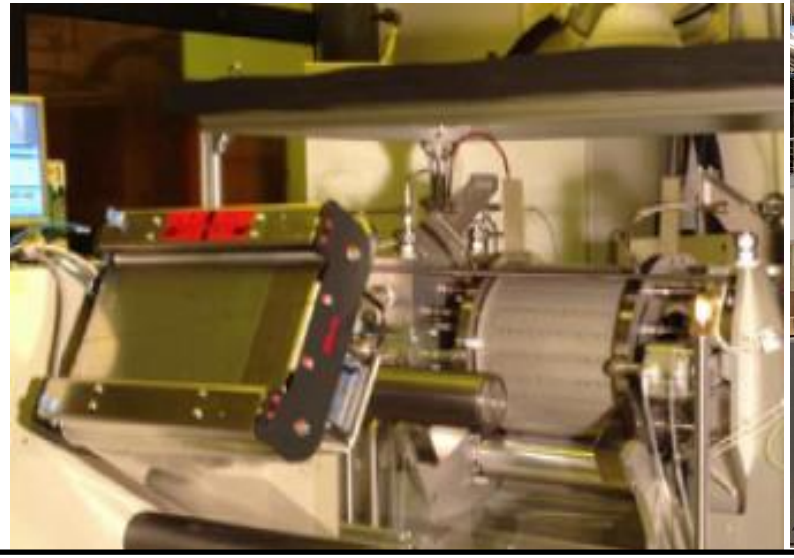


S2S, R2R and Rotary Spatial ALD equipment

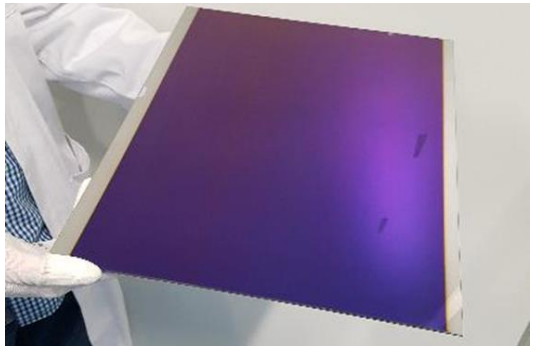
Spatial ALD at Holst Centre

- **Materials so far:**

Ta_2O_5, IrO_x, Ce_2O_3, $GdCeO_x$, Al_2O_3, ZnO, Zn(O,S), ZnS, ZnO:Al, ZnO:In, $ZnMgO_x$, $ZnSnO_x$, TiO_2, $Ti(O,N)_x$, SnO_x, ZrO_2, HfO_2, SiO_2, InGaZnO, Ga_2O_3, In_2O_3, In_2O_3:H, Ag, LiPON, Li_3PO, MLD(organic), and many other materials/ compositions

- ***Applications***: Photovoltaic, Polymer modifications, Sensors, Barriers, Electronics, Displays, **Batteries, Electrolyzers**

Our Current Focus



IGZO film on 30x40 cm^2 substrate by plasma enhanced Spatial ALD Non-uniformity ~1%!

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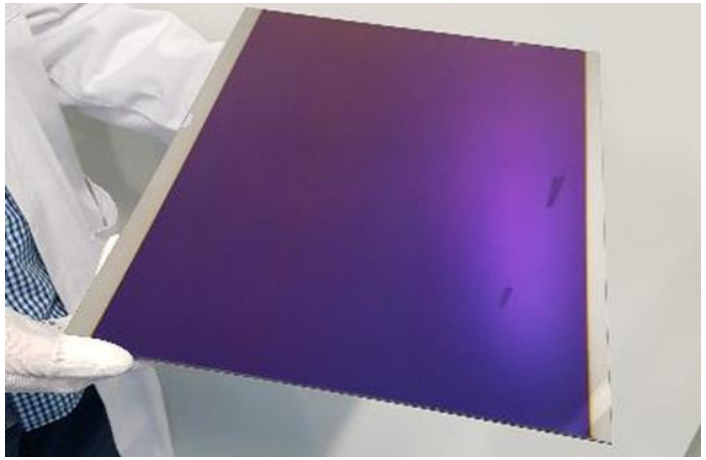
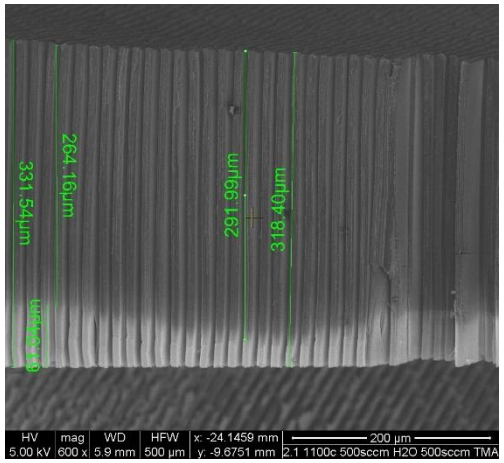
Spatial ALD at Holst Centre: nice examples

IGZO film on 30x40 cm^2 substrate by plasma enhanced Spatial ALD Non-uniformity ~1%



- Large area Spatial S2S ALD
- Multicomponent oxides by precursor co-injection
- Atmospheric plasma sources for S-ALD

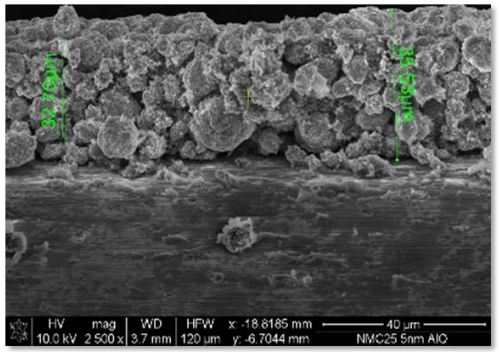
Al_2O_3 in a VACNT structure Individual CNT's conformally coated down to 300 micron depth

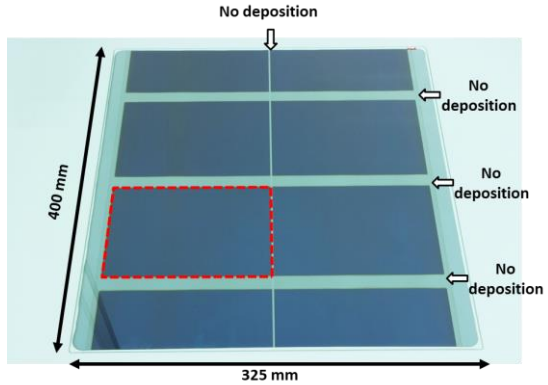


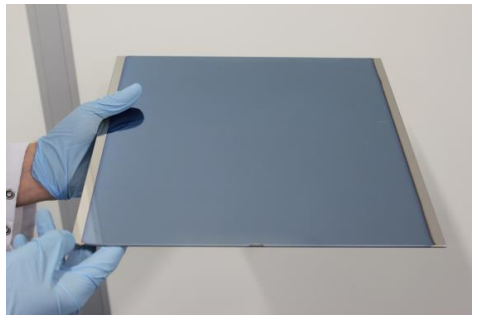
- High step coverage S-ALD
- S-ALD on complex surfaces

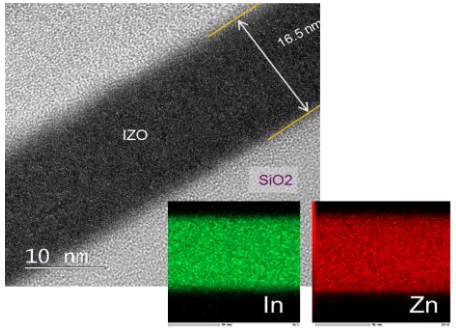
R2R S-ALD of Al_2O_3 and TiO2 on PET foil for moisture diffusion barriers

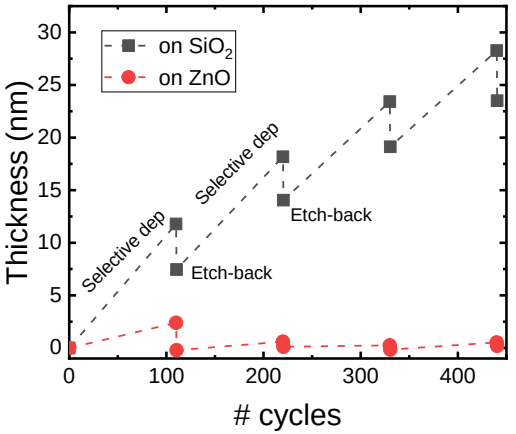
- R2R Spatial ALD
- Low temperature Spatial ALD processes

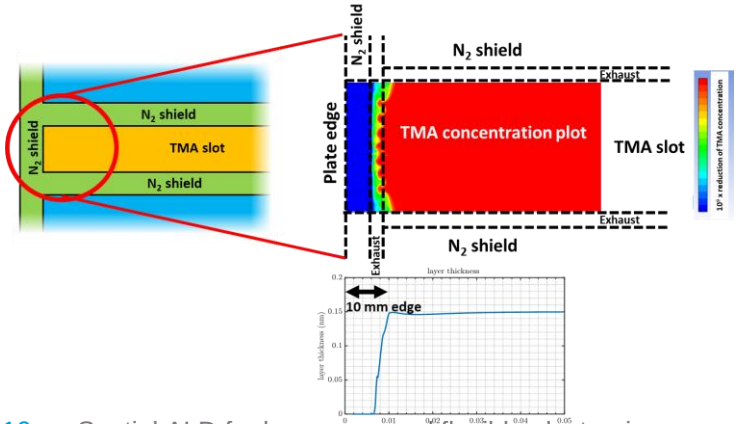


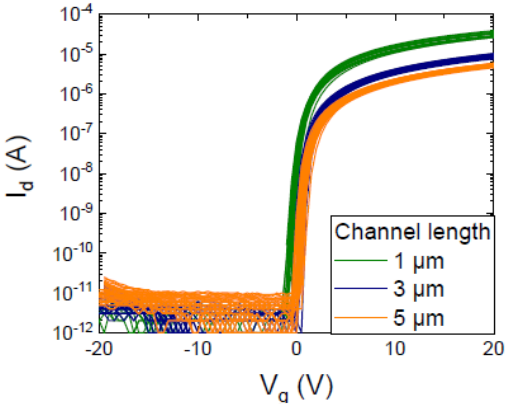


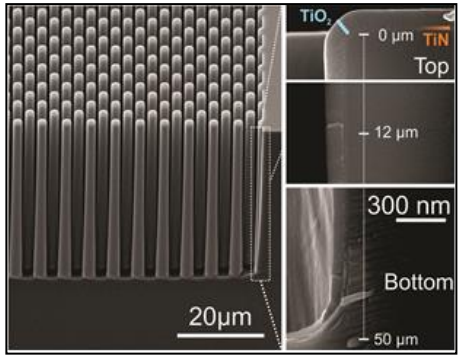


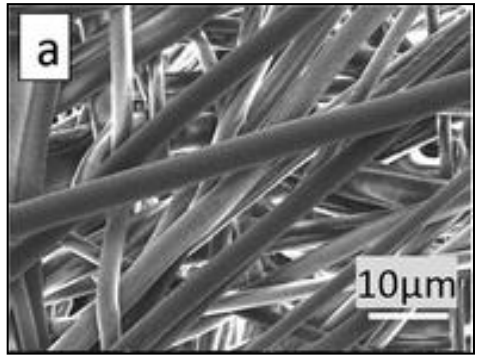












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Thank you for your attention!

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Open Innovation by imec and TNO