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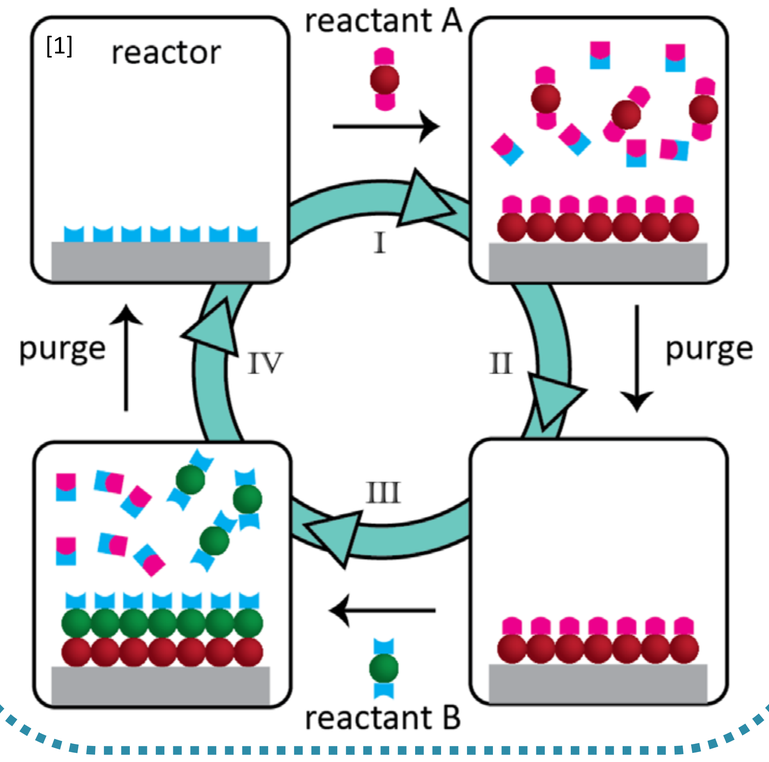
Atomic Layer Deposition for the study of catalysts for water splitting

Atomic Layer Deposition

Atomic Layer Deposition (ALD) is a high vacuum technique capable of conformally depositing a wide variety of materials in a layer by layer manner. The number of materials that can be deposited using ALD is ever increasing. This increase also guarantees an increase in the applications of ALD. Some examples researched at the CoCooN research group of UGent are battery materials and, recently, hydrogen catalysts.

ALD Basic Principle

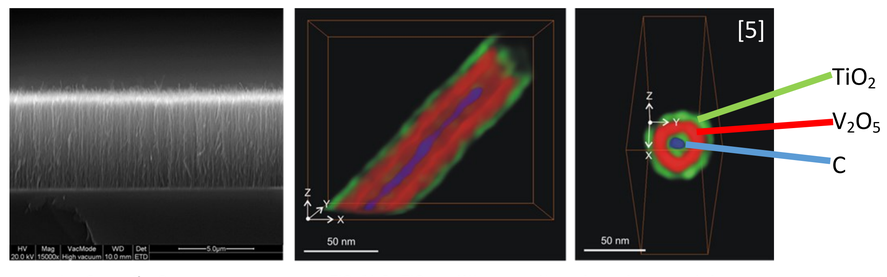


Advantages for H_2-catalyst/electrocatalyst research

- **Conformal** coating of high surface area electrodes/substrates
- Ultra-low loading with high dispersion
- Precise **control of the thickness** of the material (up to Å level)
- Wide selection of materials
- Low temperature working conditions (100-300°C)
- Multiple processes can be combined, allowing for **doped and multicomponent materials**

Conformality!

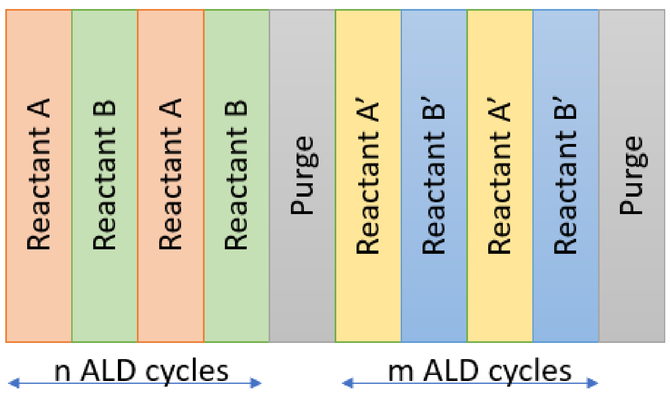
Image by EMAT, UA



L = 6 µm, Ø = 9 nm

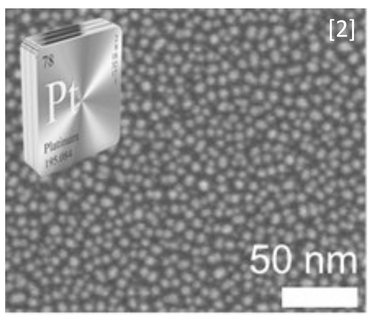
$TiO_2/V_2O_5/TiO_2$ multilayer coating of a carbon nanotube

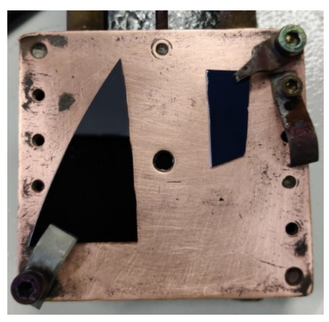
1. Deposition of doped, ternary and quaternary materials



The array of possible materials includes currently used H_2 catalysts (RuO_2, Pt, …) and upcoming H_2 catalysts (phosphates, sulfides, ...).

Both thermal and plasma enhanced processes are available.

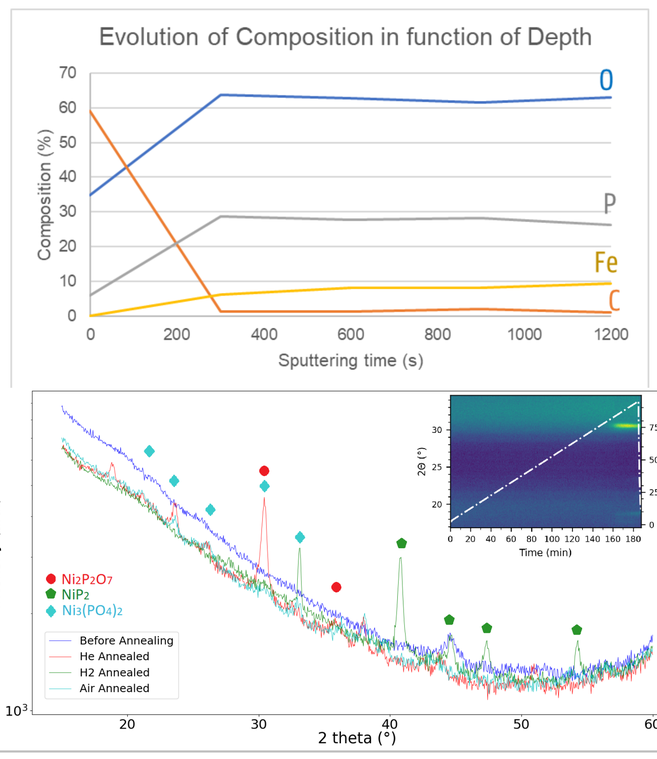




2. Characterisation

Extensive characterisation options are possible including structure, composition, surface characteristion, ...

E.g. XRD, XPS, SEM, EDX, XRR, XRF

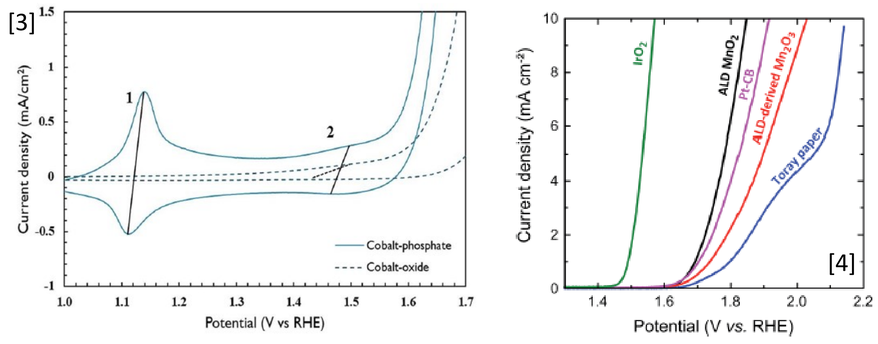


3. Testing for electrocatalytical properties

Broad optimisation possible:

- Thickness of the material
- Composition
- Phase

Activity and stability of thin film catalysts in 2-electrode and 3-electrode setups by AC/DC electrochemical measurements



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References

[1]Ramachandran, R. K., Detavernier, C., & Dendooven, J. (2017). Atomic Layer Deposition for Catalysis. *Nanotechnology in Catalysis* (335–358). doi:10.1002/9783527699827.ch14

[2]Dendooven, J.; Ramachandran, R. K.; Solano, E.; Kurttepeli, M.; Geerts, L.; Heremans, G.; Minjauw, M. M.; Dobbelaere, T.; Devloo-Casier, K.; Martens, J. A.; Vantomme, A.; Bals, S.; Portale, G.; Coati, A.; Detavernier, C. Independent tuning of size and coverage of supported Pt nanoparticles using atomic layer deposition, *Nature Communications* 8, 1074 (2017)

[3]Rongé, J.; Dobbelaere, T.; Henderick, L.; Minjauw, M. M.; Sree, S. P.; Dendooven, J.; Martens, J. A.; Detavernier, C. Bifunctional earth-abundant phosphate/phosphide catalysts prepared via atomic layer deposition for electrocatalytic water splitting, *Nanoscale Advances* 1, 4166 - 4172 (2019)

[4]Mattelaer, F.; Bosserez, T.; Rongé, J.; Martens, J. A.; Dendooven, J.; Detavernier, C. Manganese oxide films with controlled oxidation state for water splitting devices through a combination of atomic layer deposition and post-deposition annealing, *RSC Advances* 6, 98337-98343 (2016)

[5]Deng, S., Kurttepeli, M., Deheryan, S., Cott, D. J., Vereecken, P. M., Martens, J. A., … Detavernier, C. (2014). Synthesis of a 3D network of Pt nanowires by atomic layer deposition on a carbonaceous template. *Nanoscale*, *6*, 6939–6944. doi:10.1039/C4NR00982G