Direct-write ALD of In_2O_3:H and ZnO at the micro- and nanoscale

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Abstract

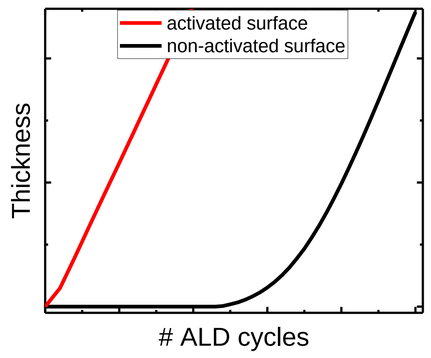
We demonstrate area-selective ALD (AS-ALD) of transparent conductive oxides at both the microscale (In_2O_3:H)[1] and at the nanoscale (ZnO).

Since no subtractive steps are used to pattern H-terminated Si (10 nm a-Si:H) we refer to these processes as *direct write* ALD.

An O_2 fed µ-plasma printer or an electron beam induced deposition (EBID) of a SiO_2 seed layer are used to activate the surface for the subsequent thermal ALD.

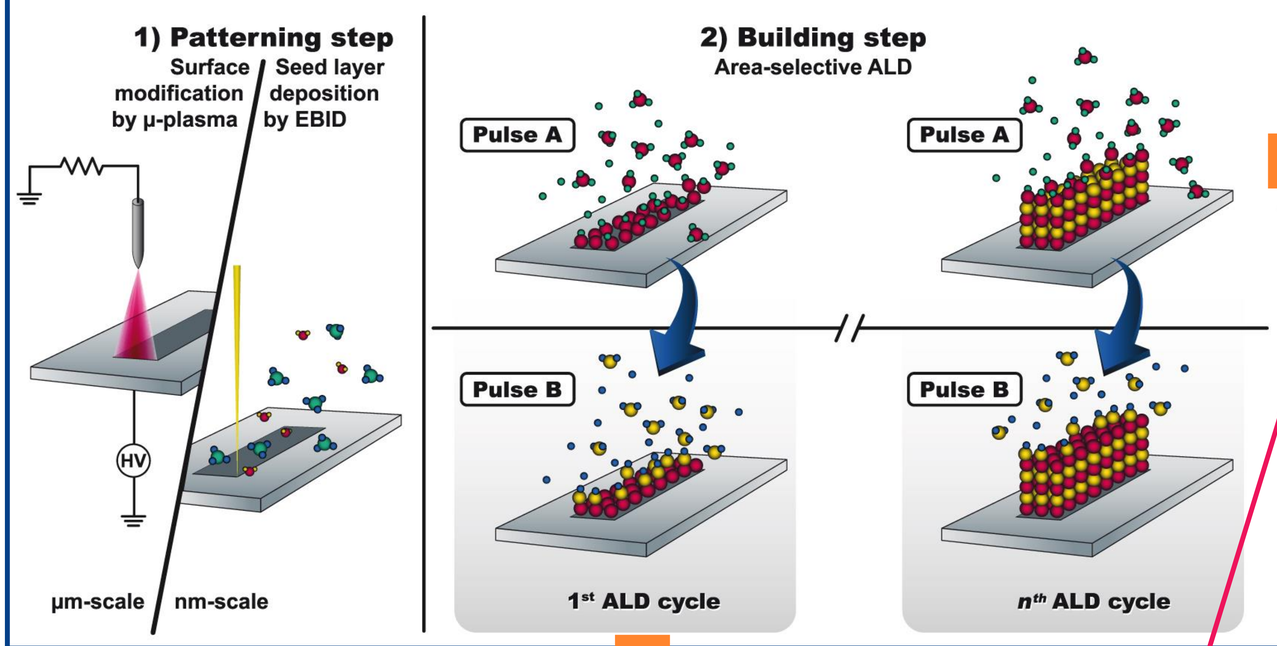
Nucleation delay

A nucleation delay is observed on a-Si:H for thermal ALD of In_2O_3:H and ZnO. This is exploited for AS-ALD.



Methods

- Local substrate activation is obtained using an O_2 fed µ-plasma printer[2] for microscale dimensions.
- SiO_2 EBID seed layer (TEOS + H_2O) are used to activate the surface for nanoscale dimensions

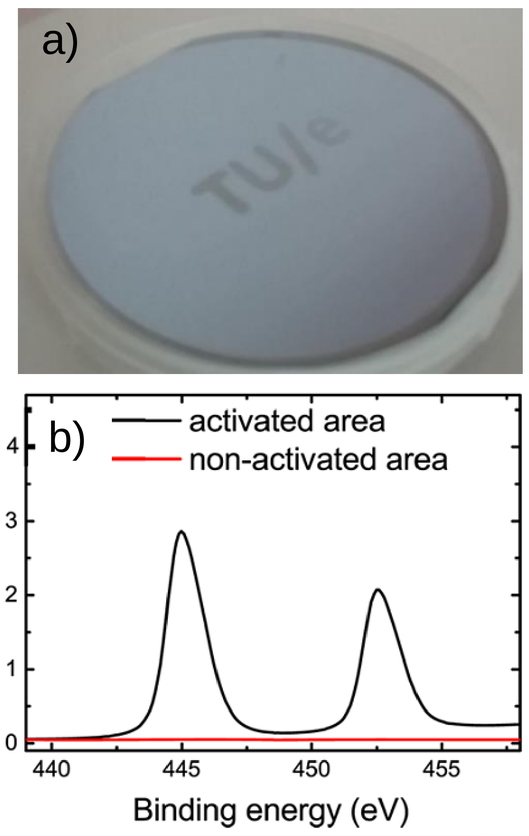


µm-scale

Microscale In_2O_3:H

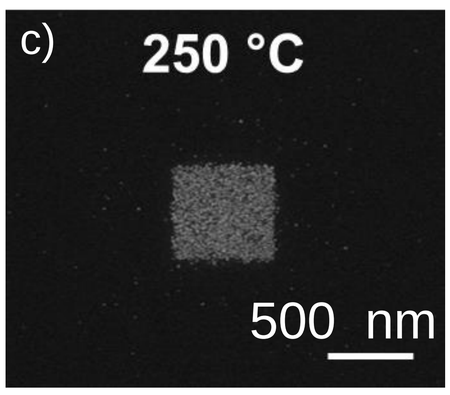
a) 4” wafer with the letters TU/e created using the µ-plasma printer to locally activate the surface and 400 ALD cycles of In_2O_3:H

b) XPS In3d doublet on the activated (black) and non-activated area (red)

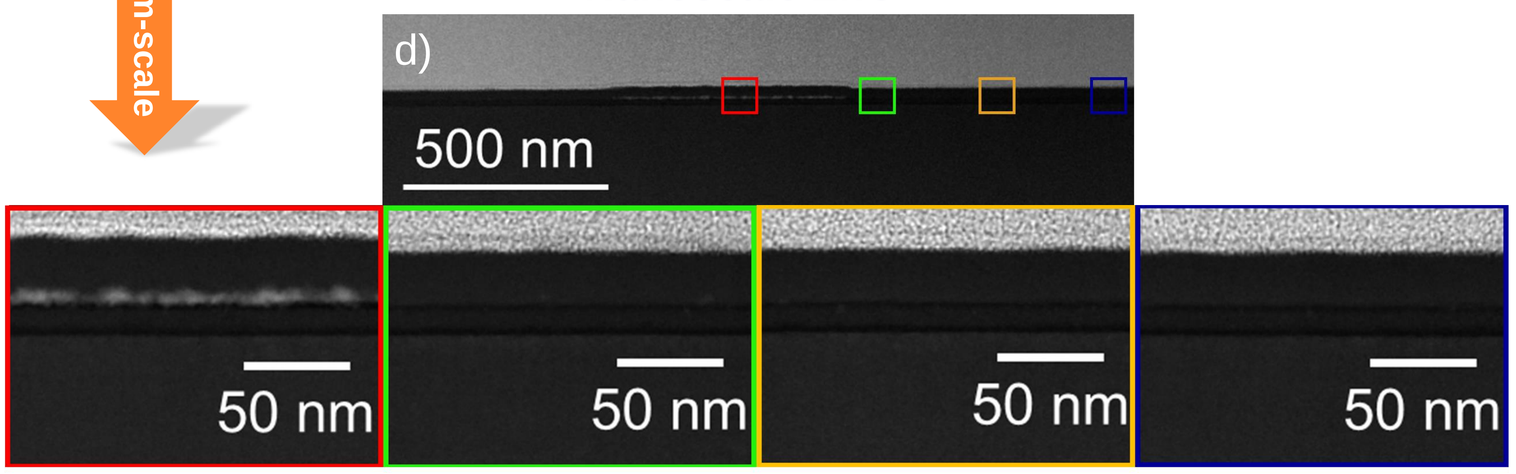


nm-scale

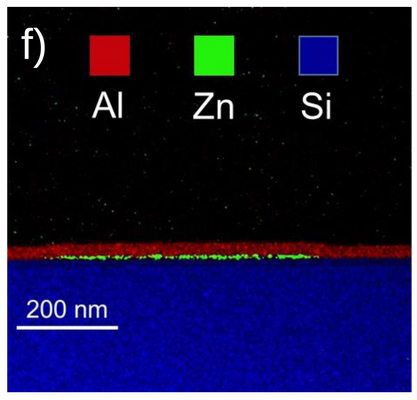
Nanoscale ZnO



c) Top-view SEM of ZnO AS-ALD on an ultrathin ~1 nm EBID SiO_2 seed-layer

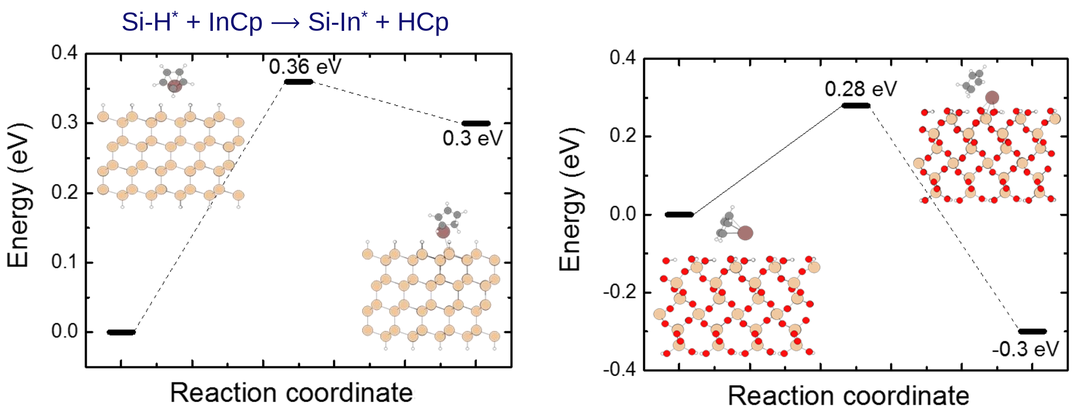


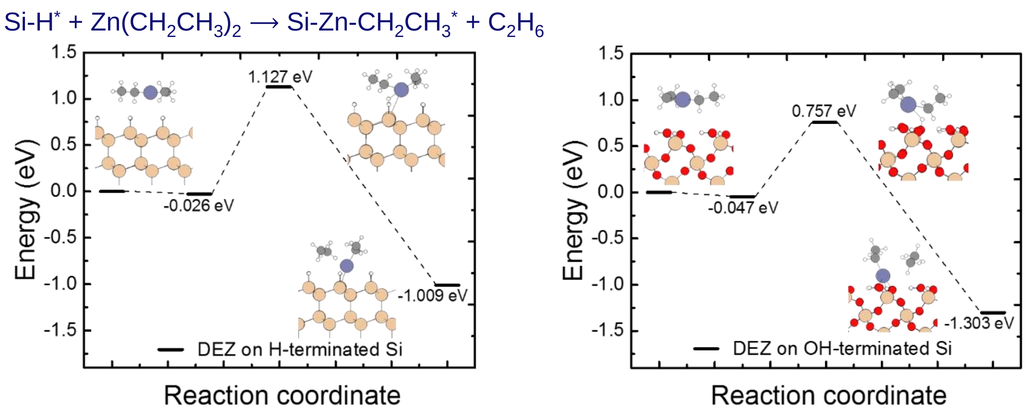
d) Cross-sectional TEM analysis confirming robust selectivity after 80 ALD cycles at 250 °C. High magnification TEM for different locations



f) EDX analysis shows no ZnO deposition outside the patterned area

Underlying Surface Chemistry as Calculated by Density Functional Theory (DFT)





[1] A. Mameli, *et al.*, Chem. Mater., **29**, 921-925 (2017) [2] J. R. G. Schalken *et al.*, Nanoscience Nanotechnol. Letters **7**, 62−66 (2015)