Field Effected Aerosol Assisted Chemical Vapour Deposition (FE-AACVD) of Thin Film Materials

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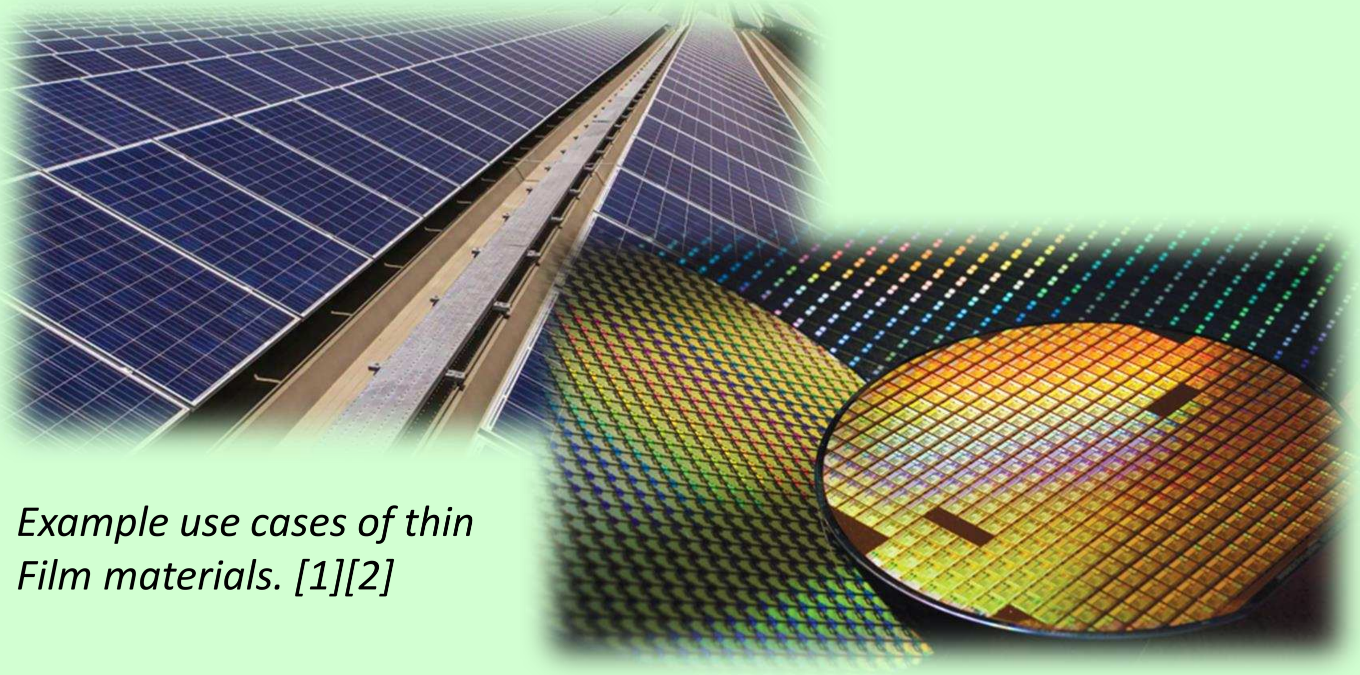


Example use cases of thin Film materials. [1][2]

1) Thin Film Materials

With uses ranging from transistors to solar cells, this class of often semiconducting material is vital for modern society. The electronic band gaps of thin films must be carefully tailored to their use cases – this can be achieved through control over morphology (crystal packing) during synthesis.

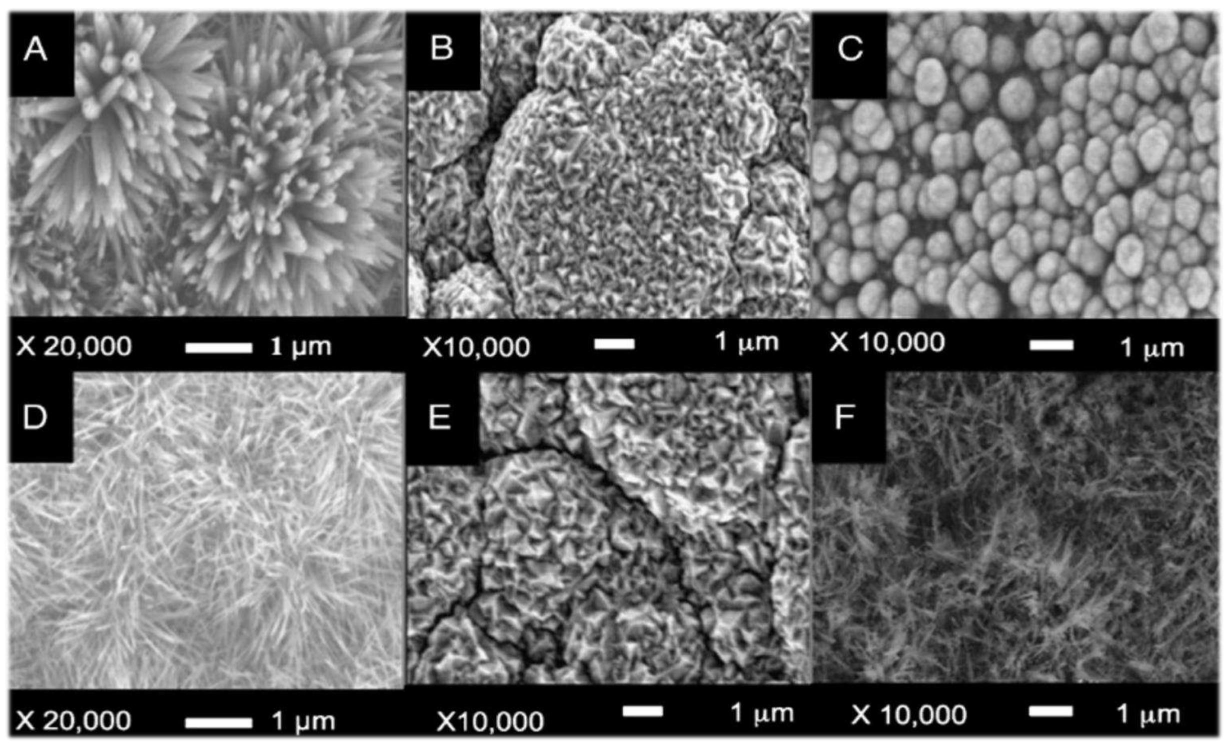
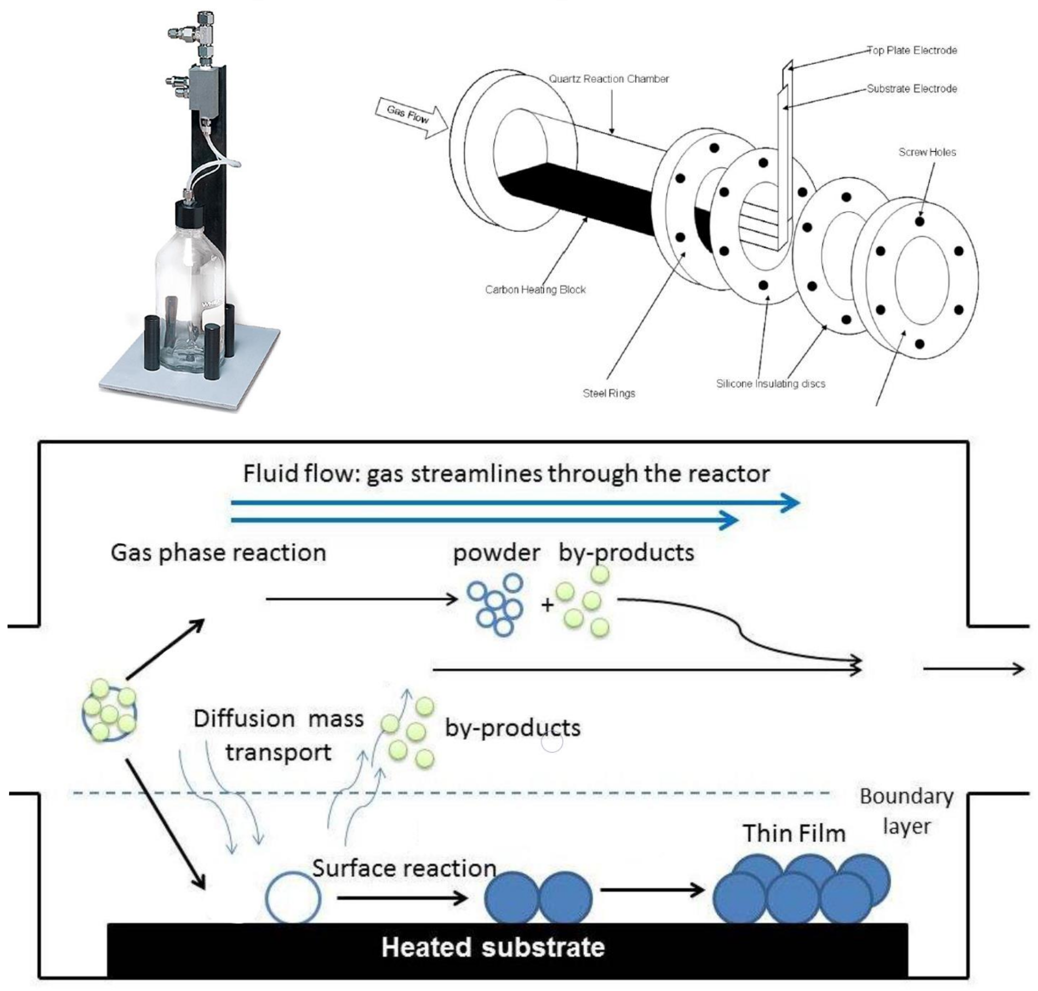


Figure 1: Scanning electron microscope images of various thin films with different crystalline morphologies. [3]

2) Aerosol Assisted Chemical Vapour Deposition

- ❖ Precursor solutions are aerosolised and transported to the reaction chamber
- ❖ Precursor aerosols deposit on the hot substrate and react
- ❖ Decomposition and evaporation of side groups generates a thin crystalline film of inorganic materials



Figures 2, 3 and 4: A TSI 3076 aerosol generator, and schematics of an AACVD reaction chamber. [4]

3) Chemical Precursors

- ❖ Need the correct elements to make the target thin film. No need for volatility but solubility is important
- ❖ Single source precursors are used to guarantee stoichiometric ratios

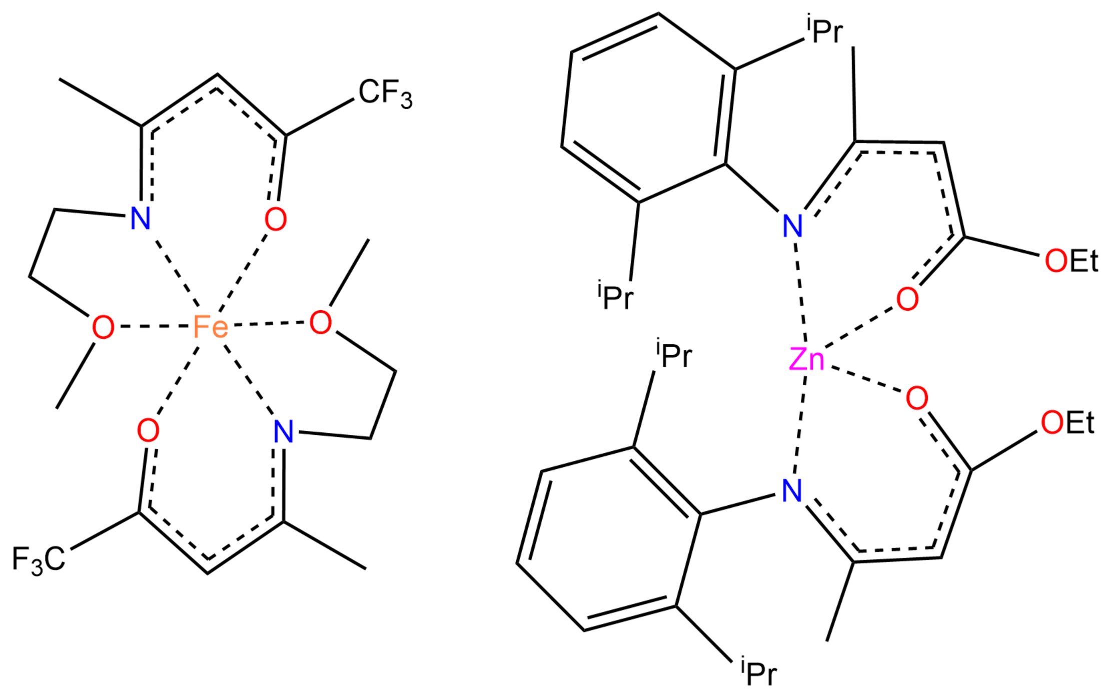
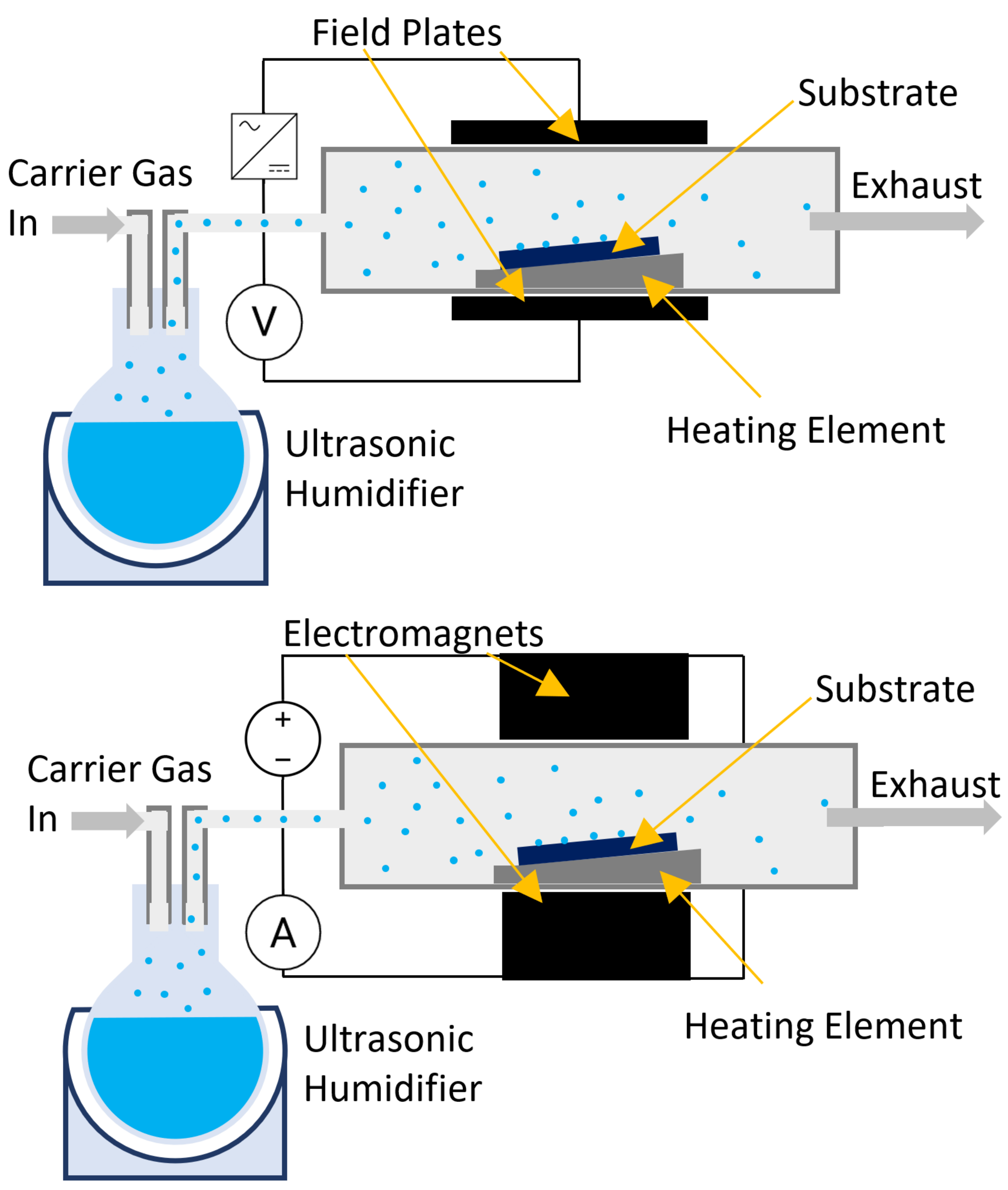


Figure 5: Examples of single source AACVD precursors possessing synergy with applied fields. [5]

4) Directing Effects of Electric and Magnetic Fields

- ❖ Aerosols are affected by fields during transport and thin film synthesis
- ❖ Electric fields can direct charges and align dipoles on deposition
- ❖ Magnetic fields can direct paramagnetic species on deposition
- ❖ In depth investigation into nature of aerosols during transport planned



Figures 6 and 7: Example AACVD schematics configured to use electric field direction and magnetic field direction respectively.

5) Challenges and Responsible Innovation

The work is among the first studies of electric field AACVD, and there is no literature precedent for magnetic field AACVD. The quality of the precursor syntheses will be critical in establishing repeatable benchmarks.

The work will be focused on abundant elements not at risk of depletion, starting with iron magnetite / hematite films, to minimise societal impacts. Environmental impacts of the syntheses and depositions involved will hopefully be offset by enabling production of higher efficiency batteries, capacitors, and solar cells.

[1] Canadian Solar Inc., 2023. [2] TSMC Ltd press release, 2020. [3] A. J. T. Naik, C. Bowman, N. Panjwani, M. E. A. Warwick and R. Binions, *Thin Solid Films*, 2013, **544**, 452–456.
[4] L. Romero, PhD thesis, Queen Mary University of London, 2013. [5] M. A. Bhide, C. J. Carmalt and C. E. Knapp, *ChemPlusChem*, 2022, **87**, 4. Iron precursor known to the Johnson Group.