ALUMINIUM OXIDE PREPARED BY ATOMIC LAYER DEPOSITION IN ORGANIC THIN-FILM TRANSISTORS OPERATING AT 2 V: COMPARISON WITH UV-OZONE OXIDATION

Stuart Hannah, Helena Gleskova

Department of Electronic and Electrical Engineering, University of Strathclyde, Glasgow, United Kingdom
(stuart.hannah.2013@uni.strath.ac.uk)

➢ INTRODUCTION

Large-area, roll-to-roll fabrication of thin-film circuits demands layer thickness uniformity over large areas. Previously, a 10-nm-thick dry bi-layer dielectric based on aluminium oxide (AlO_x) prepared by UV-ozone oxidation and n-octylphosphonic acid (C_8PA) monolayer prepared by vacuum evaporation has been developed for organic thin-film transistors (OTFTs). Here we compare such OTFTs to similar transistors that incorporate ALD-AlO_x/C_8PA bi-layer.

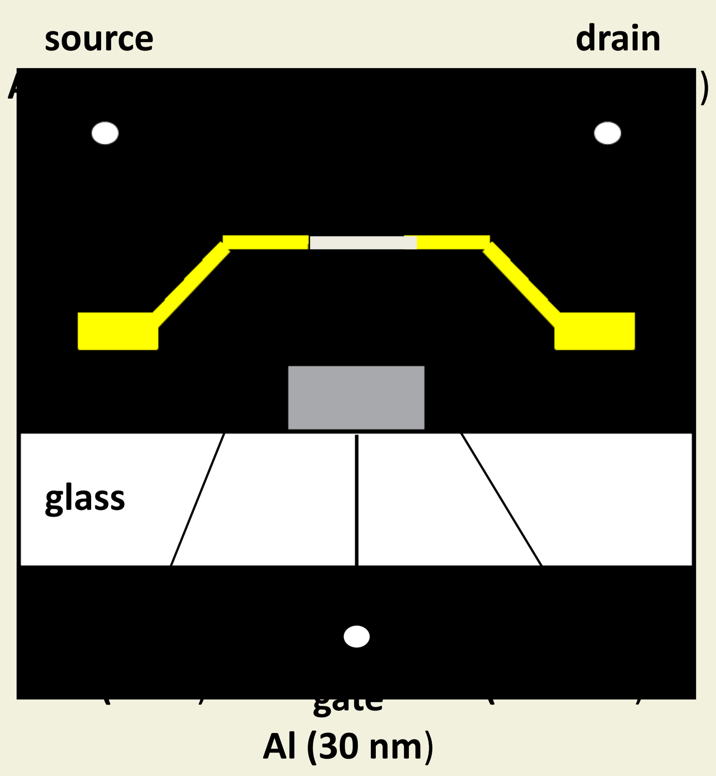
➢ AIMS

- Use atomic layer deposition (ALD) to grow thin layers of AlO_x for low-voltage OTFTs.
- Compare Al/ALD-AlO_x/C_8PA/pentacene/Au and Al/UV-ozone-AlO_x/C_8PA/pentacene/Au transistors and metal-insulator-metal (MIM) structures.

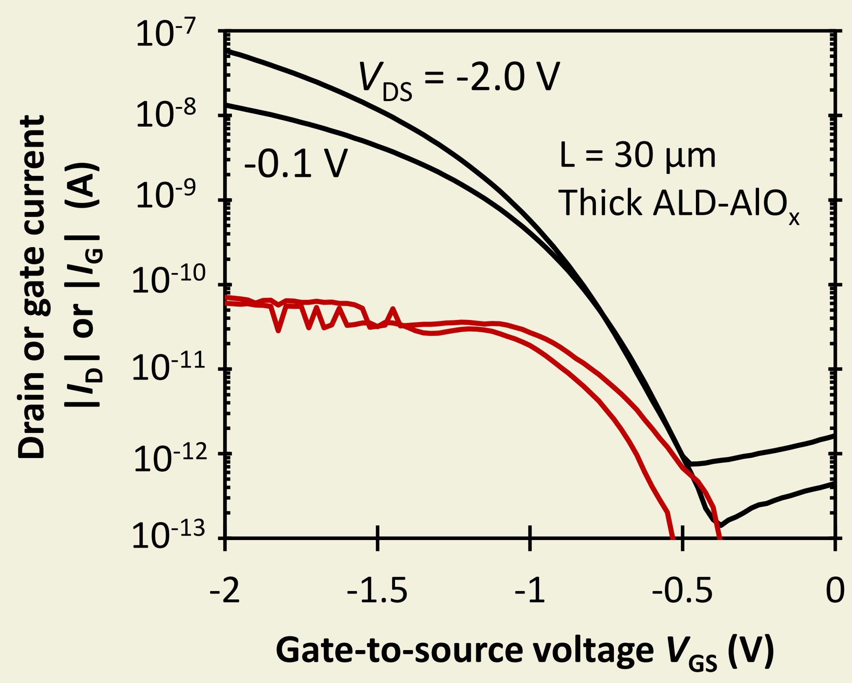
➢ EXPERIMENT

- Two samples incorporated thin ALD-AlO_x (12.9 nm) and two samples used thicker (36.8 nm) ALD-AlO_x.
- Within each pairing, one sample underwent a 2-minute UV-ozone clean prior to C_8PA assembly.
- All other transistor layers were identical to UV-ozone-AlO_x (9 nm) OTFTs.
- ALD performed from water and trimethylaluminium (TMA) at 160°C.

➢ TRANSISTOR MEASUREMENTS



W = 1000 µm
L = 30, 50, 70 and 90 µm



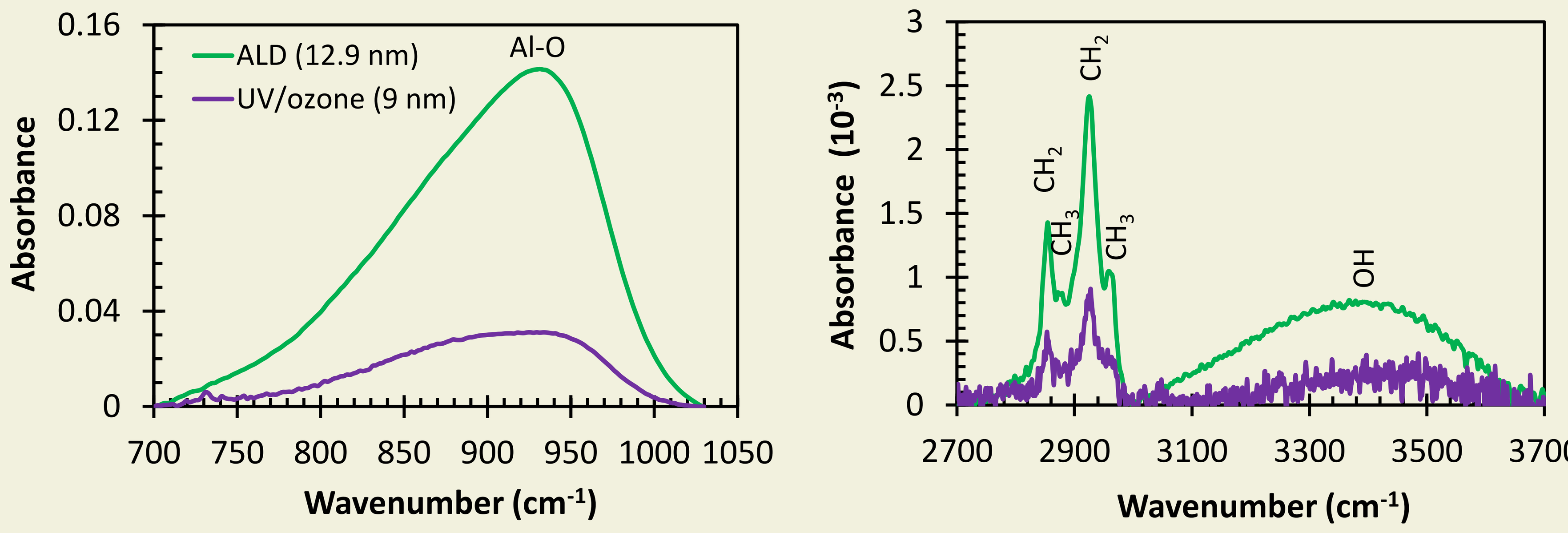
Linear regime ($|V_{DS}|<|V_{GS}-V_t|$):

$$I_D = \mu C \frac{W}{L}(V_{GS}-V_t)V_{DS} \qquad \mu_{lin} = \frac{\partial I_D}{\partial V_{GS}} \cdot \frac{1}{C V_{DS}\frac{W}{L}}$$

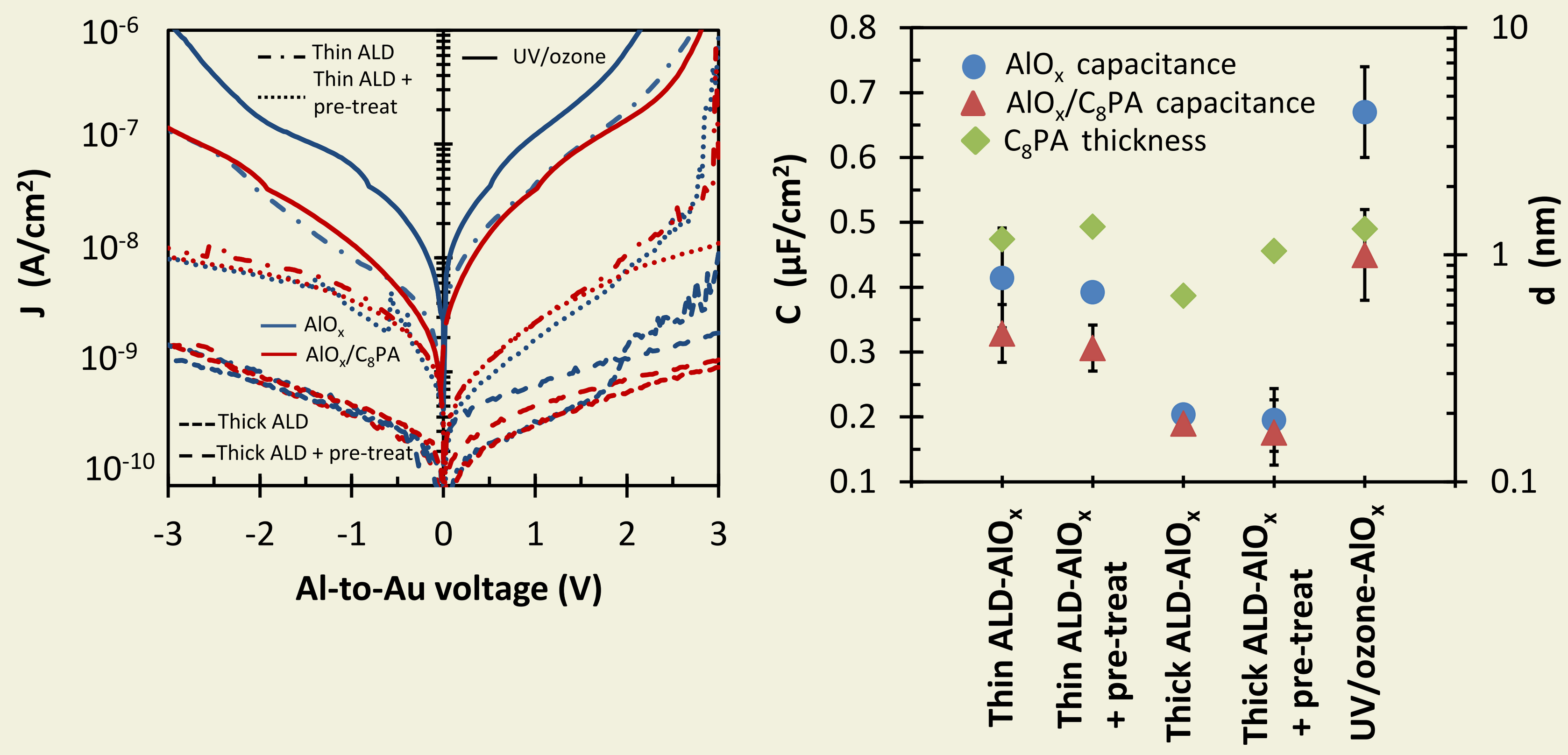
Saturation regime ($|V_{DS}| > |V_{GS}-V_t|$):

$$I_D = \mu C \frac{W}{2L}(V_{GS}-V_t)^2 \qquad \mu_{sat} = \left(\frac{\partial \sqrt{I_D}}{\partial V_{GS}}\right)^2 \cdot \frac{1}{C\frac{W}{2L}}$$

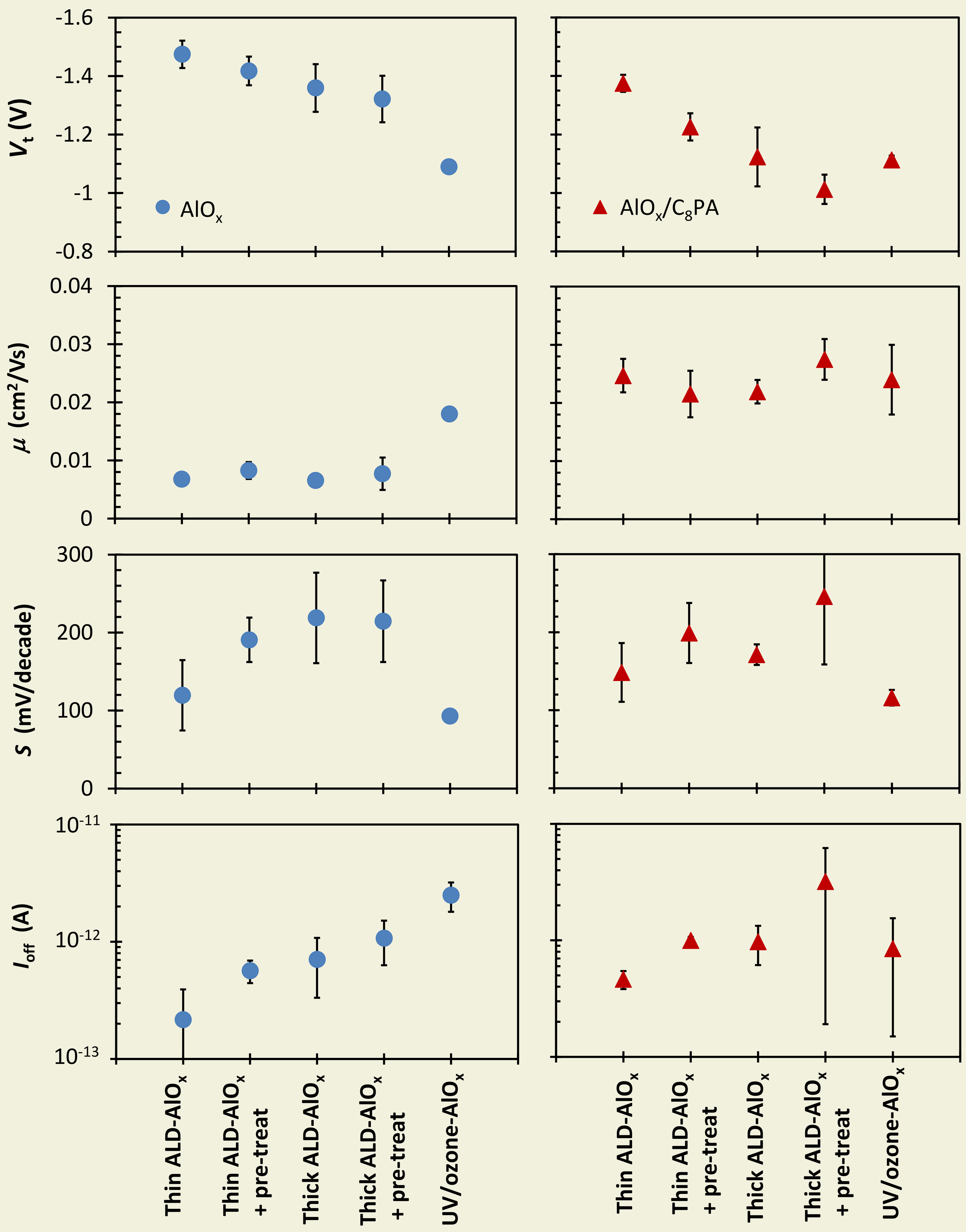
➢ FTIR



➢ RESULTS: MIM STRUCTURES



➢ RESULTS: TRANSISTORS



➢ CONCLUSIONS

- Leakage current density and capacitance are lower for ALD-AlO_x; primarily as a result of the thicker layers.
- C_8PA self-assembly is not affected by the AlO_x layer or by its treatment.
- UV-ozone-AlO_x leads to the lowest threshold voltage. Other parameters are comparable to OTFTs with ALD-AlO_x.

Stuart Hannah is a recipient of a DTG PhD Scholarship funded by Engineering and Physical Sciences Research Council (EPSRC).
He would like to thank the School of Engineering of University of Glasgow for transistor fabrication support, the Micro/Nano Fabrication Laboratory of Princeton University for access to ALD system, New Technology Research Centre of University of West Bohemia for FTIR measurements, and C. Watson from School of Electronic Engineering of Bangor University for ellipsometry measurements.