***Inherently Selective Atomic Layer Deposition for Optical and Sensor Applications: Microreactor Direct Atomic Layer Processing (DALP™)***

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The integration of additive manufacturing principles with thin film deposition technologies presents significant opportunities for advancing material processing capabilities. While conventional lithography and vapor-phase methods have demonstrated reliable performance, they face fundamental limitations in process flexibility and step reduction. This work explores a novel approach to spatial atomic layer deposition that addresses these constraints. The miniaturization of Spatial Atomic Layer Deposition (SALD) technology introduces specific challenges in gas flow control and precursor delivery. ATLANT 3D presents a micro-nozzle system enabling Direct Atomic Layer Processing (DALP), which achieves localized deposition through precise gas flow confinement within micrometer-scale regions. The system maintains conventional ALD surface chemistry while enabling selective area processing. Initial characterization demonstrates that this approach achieves crystalline thin film formation with quality comparable to conventional ALD methods. The localized nature of the process enables rapid prototyping of materials and processes as well as novel device architectures by reducing the number of required lithography steps. The system demonstrates compatibility with standard ALD precursor chemistries while providing enhanced spatial selectivity.

Experimental validation of this technique has been conducted across several application domains. Temperature sensor fabrication demonstrates sensitivity comparable to conventional methods, while optical applications such as Bragg mirrors exhibit expected reflectivity profiles. The ability to create overlapping depositions enables complex multilayer structures, as evidenced by the formation of ultrathin optical elements. Additional applications in catalysis and microelectronics highlight the versatility of the approach. This work demonstrates the feasibility of miniaturized spatial ALD for selective area processing. The results suggest potential applications in rapid prototyping and novel device architectures, particularly where traditional lithography poses limitations.

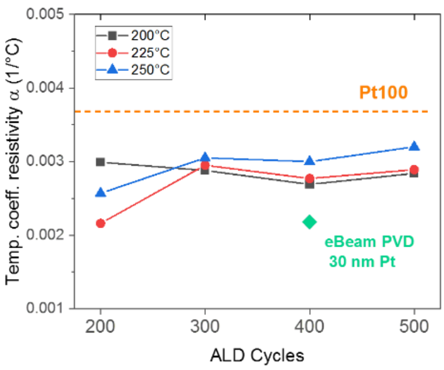


**Fig.1** – Temperature coefficient of resistivity of DALP devices fabricated at different temperatures. Performance approaches that of a standard macroscopic Pt100 sensor and is superior to a lithography-processed reference.

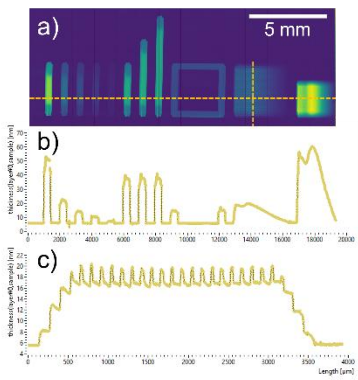


**Fig.2** – a) imaging ellipsometry thickness map of a sample TiO2 deposition. b) thickness map cross-section in the horizontal direction of the entire sample. c) thickness map cross-section in the vertical direction of one rastered section.

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