Atomic Layer Deposition In Microchannel Plates

HIGH ENERGY PHYSICS
Ph. D. IN EXPERIMENTAL PHYSICS - XXXVII CYCLE

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SUMMARY

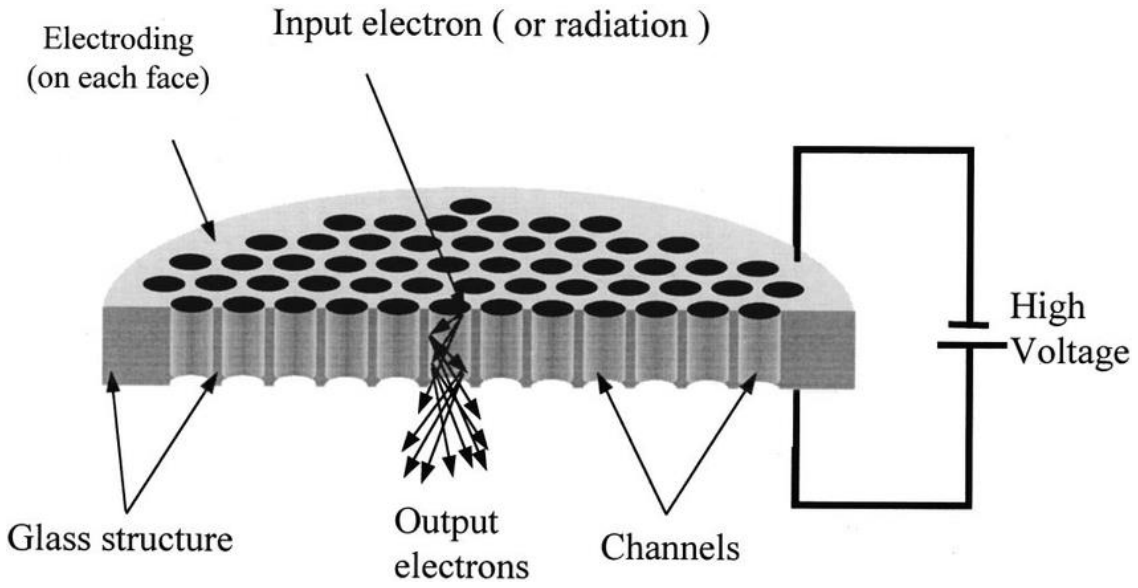
- **Introduction**
  - Multichannel plates (MCPs)
  - Atomic Layer Deposition (ALD)
- **Atomic layer deposition on MCPs**
  - Layer deposition techniques
  - Optimal layer thickness
  - Lifetime testing
  - Applications
- **Conclusions**

INTRODUCTION - MCP

Microchannel plate (MCP): array of micrometric electron multipliers etched within a glass plate.

Characteristics:

- Channel diameter: 4 – 25 μm
- Channel length: 0,2 – 1,2 mm
- Bias angle: ~ 8°
- Open area ratio: 60% – 80%
- Gain: 10^6 or greater



INTRODUCTION – MCP (2)

Advantages:

- Low darkcount rate
- Spatial resolution
- Magnetic field resistance
- Very high time resolution (<100 ps)
- Radiation hardness

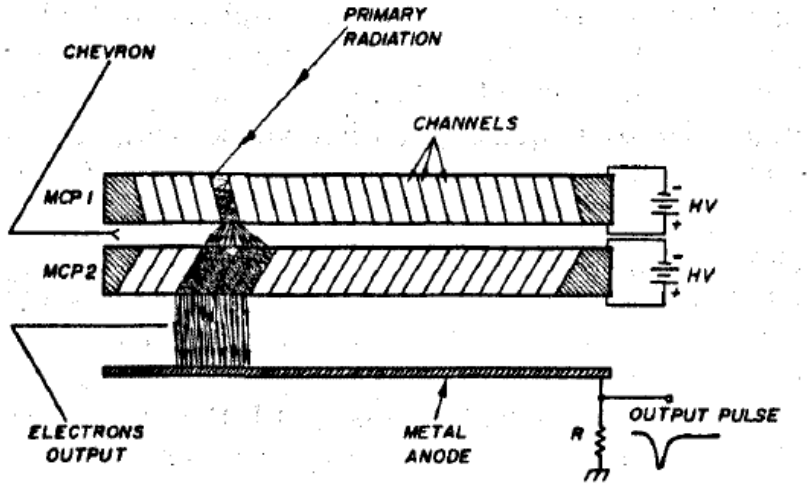
Applications:

- Image intensification (e.g: night vision devices)
- Photomultiplier tubes (MCP-PMT)
- Particle and photon detection (ions, electrons, neutrons, X-rays, UV rays)

INTRODUCTION – MCP (3)

Drawback: low lifetime due to heavy feedback ions, produced by ionizing low atmosphere gases or desorbed gas molecules from the channel walls.

Solution: coat the inner walls of the channels with a more suitable material, such as Al_2O_3 or MgO.



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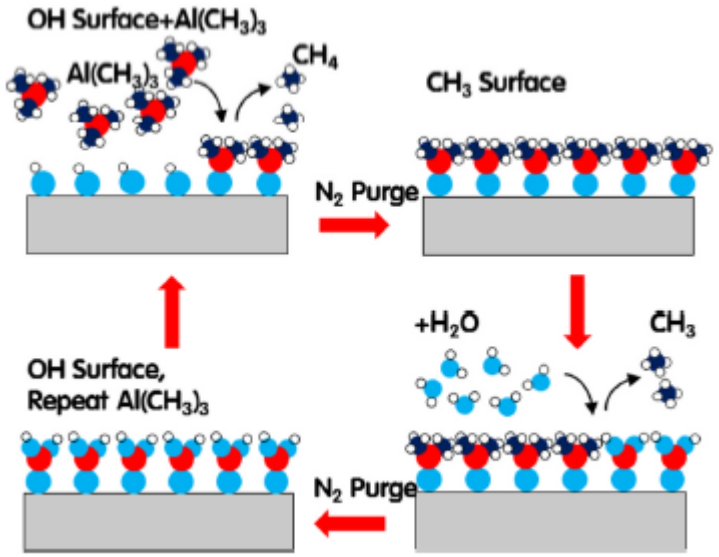
ATOMIC LAYER DEPOSITION

Atomic layer deposition (ALD): the substrate is exposed to pulses of alternated gas precursors. Its intrinsic surface reaction saturation mechanism ensures the uniformity of the layers.

For MCPs, greater uniformity was achieved by extending the gas pulse durations.



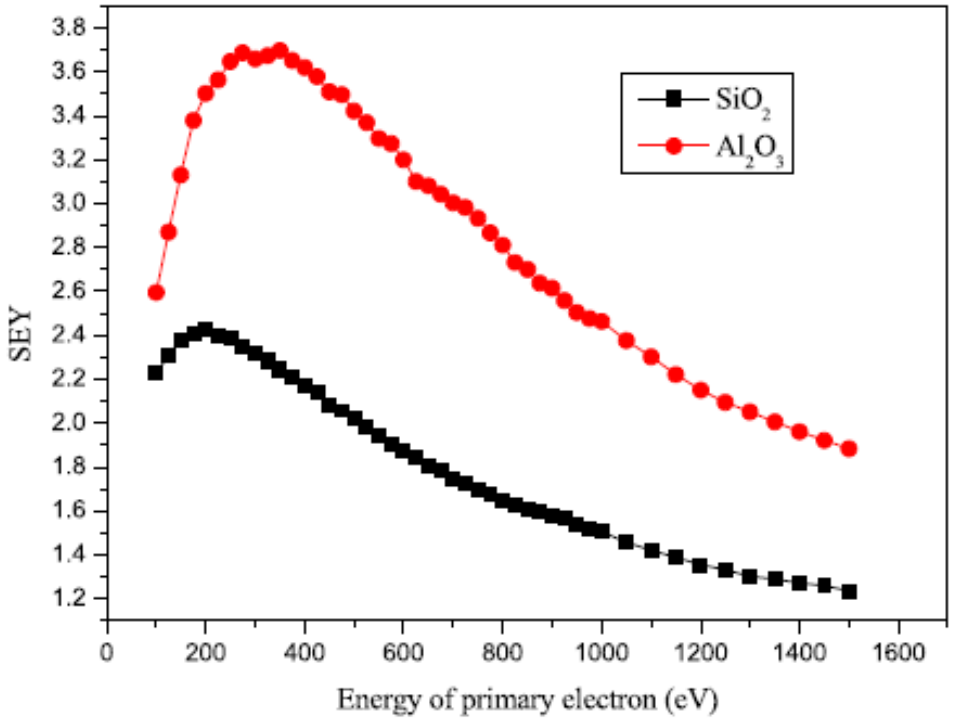
ALD ON MCPS

Cao et al. investigated which procedure creates the most uniform layer (extention of precursor gases or stop flow).

They also tested which Al_2O_3 thickness is ideal for MCPs.

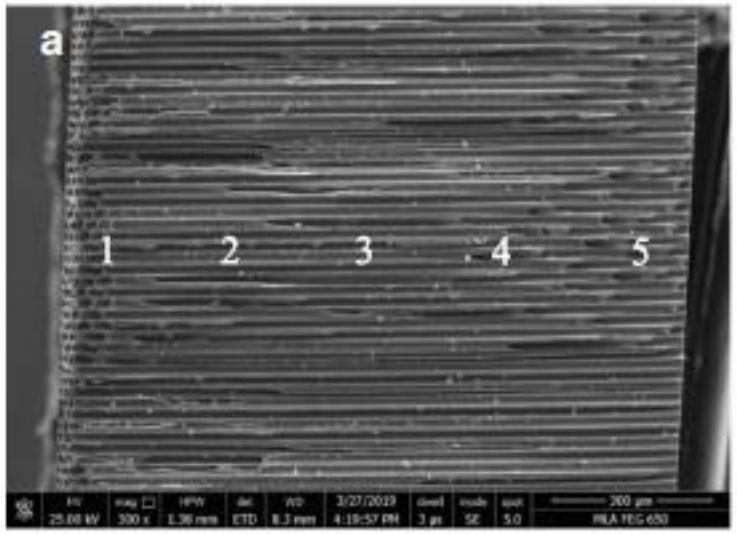
Table 1 Details of experimental samples for ALD

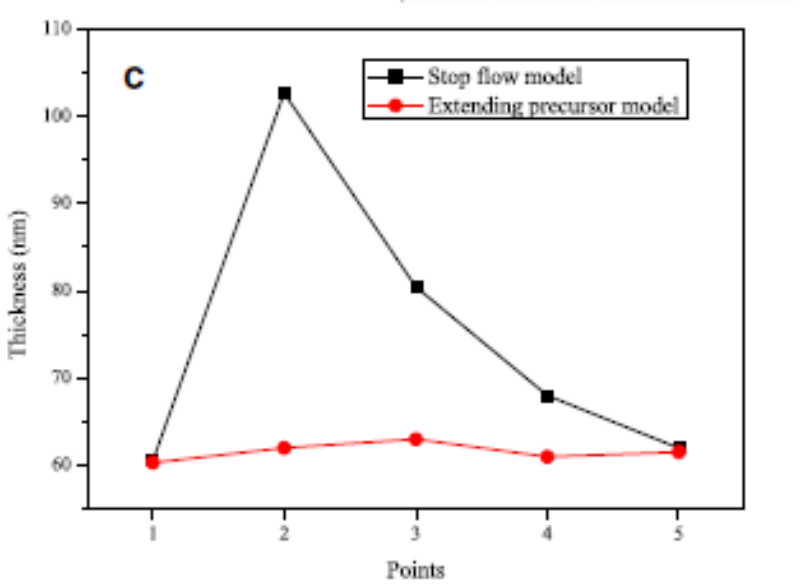
	Condition	Description
Sample A	Uncoated	Samples A, B, C, D, and E to confirm the best thickness of deposition layer
Sample B	Coated 4-nm ALD Al_2O_3	
Sample C	Coated 6-nm ALD Al_2O_3	
Sample D	Coated 8-nm ALD Al_2O_3	
Sample E	Coated 10-nm ALD Al_2O_3	
Sample F	Coated 60-nm ALD Al_2O_3 Extending precursors model	Samples F and G to confirm which deposition model is better
Sample G	Coated 60-nm ALD Al_2O_3 Stop flow model	
Sample H	Half coated 8-nm ALD Al_2O_3 Half no coated	



ALD ON MCPS (2)

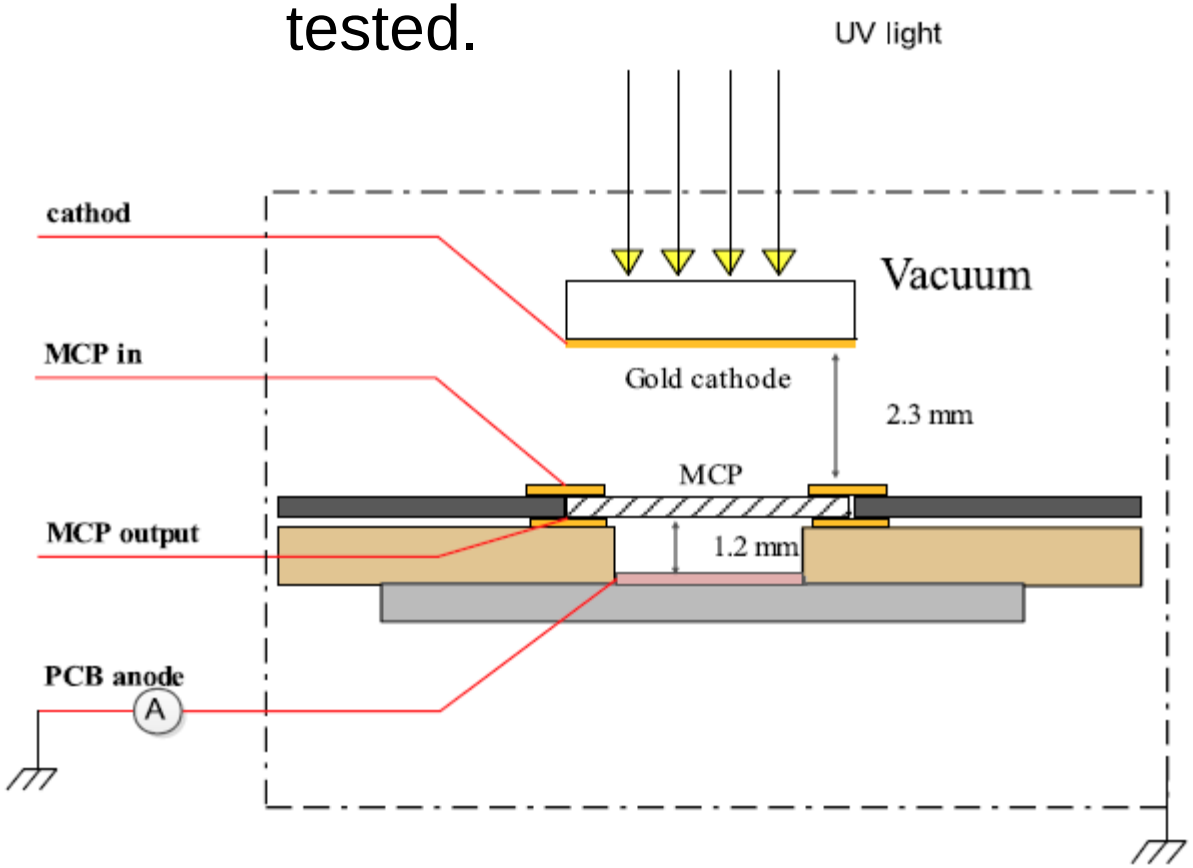
The thickness of the Al layer was measured by Scanning Electron Microscopy in 5 different positions within the pores. Precursor extension produced an uniform layer, while stop flow proved to be inadequate.

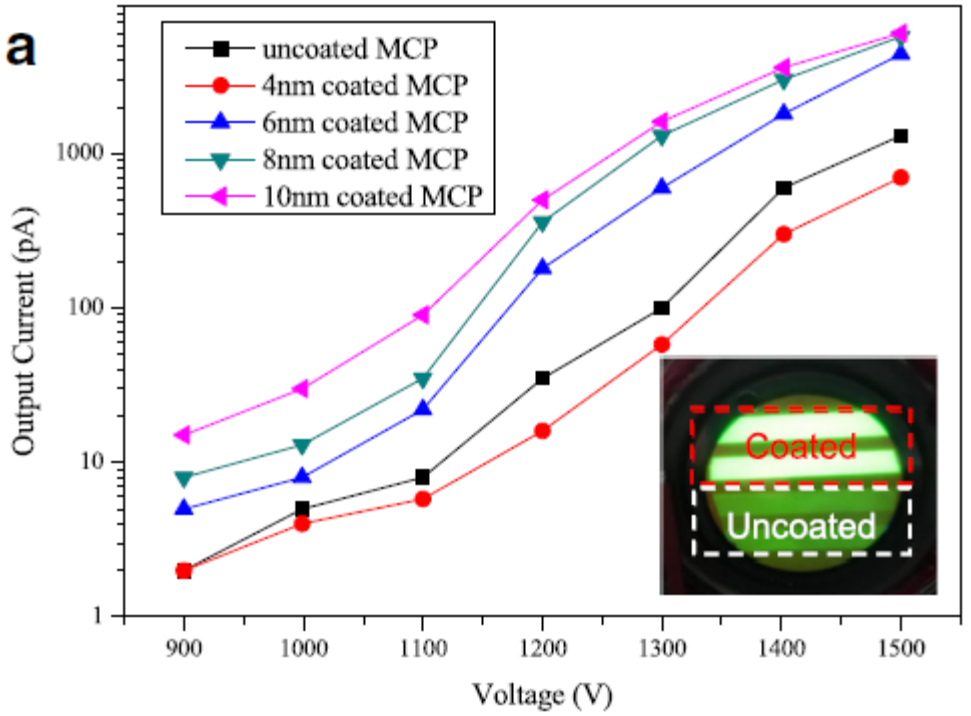




ALD ON MCPS (3)

The current output of MCPs with different Al layer thicknesses was tested.





ALD ON MCPS (4)

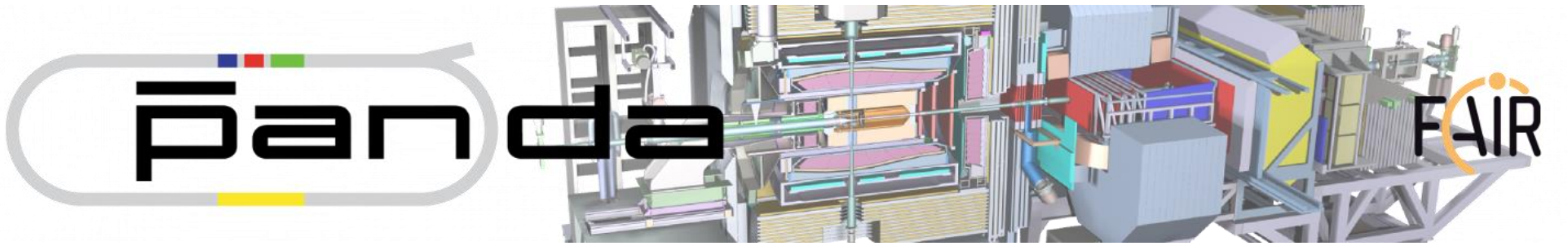
Lifetime testing: MCPs kept at saturation level under UV light for several days.

Table 2 Dark current and output current measured before and after lifetime testing

	Dark current before lifetime testing (pA)	Dark current after lifetime testing (pA)	Output current before lifetime testing (pA)	Output current after lifetime testing (pA)
Traditional MCP	1.0	6.5	1300	630
ALD-MCP	1.2	1.5	5700	6000

APPLICATIONS

- **Arradiance Inc:** first ALD-coated MCPs
- **Photonis, Hamamatsu, Photek**: commercial ALD-MCPs
- **PANDA experiment:** particle identification with DIRC detectors



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CONCLUSIONS

- **MCPs** have a large variety of applications, from image intensification (night vision devices) to particle detection.
- **Atomic Layer Deposition** can improve the electron yield of MCPs while also extending their operational lifetime.
- **ALD** and other nanostructure techniques opened up the possibility of creating MCPs in brand new ways and with different materials (borosilicate glasses, plastics…)

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