Atomic Layer Deposition for Microchannel Plate Applications

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Abstract: Microchannel plates (MCPs) are a continuous 2d array of 104- to 107-micron-sized pores (typically 10 mm in diameter and 400 mm in length), which act as electron amplifiers. These channels display high sensitivity to electron signals (from the cathode input face) for secondary electron generation and multiplication as they propel towards the anode output face of the plate. MCP based detectors can have a unique combination of properties such as high secondary electron emission, high gain, high spatial and timing resolution, and very low background rate. MCPs can be used in a various applications like low-level signal detection, photo-detection, secondary electron microscopy, time-of-flight detection, particle collision studies, fluorescence imaging applications in biotechnology, and field emission displays.
Conventional MCP fabrication involves multi-fiber glass drawing, assembly, and etch of solid core glass tubing resulting in channels in a wafer of lead silicate glass. Additional thermo-chemical hydrogen firing is used to activate the channel walls for electron multiplication. The electrical resistance and the secondary electron emission properties cannot be adjusted independently because both of these properties are imparted during the thermal activation step. Also it is extremely difficult to build large- area MCPs with small delicate pores as they warp after hydrogen-firing. (continue on next page …)

Atomic layer deposition (ALD) is a robust thin film deposition method involving alternation of precursor and purge gas exposures with the unique capability to deposit conformal, stoichiometric films inside of porous substrates. The use of ALD thin films in the fabrication of MCPs affords tailorable independent control of the resistivity and electron emissivity of the resulting MCP. ALD can be used to functionalize MCPs wherein a nanocomposite resistive layer is deposited followed by a highly electron emissive layer that generates secondary electrons within the pores of the MCP. W:Al2O3 and Mo:Al2O3 are ALD nanocomposite materials with tunable resistivity in the range of 1e6 to 1e10 ohm.cm suitable for resistive coatings to functionalize borosilicate glass MCPs. At Argonne National Laboratory, we have developed ALD processes where the resistivity of the film can be tailored by adjusting the content of W and Mo in the composite W:Al2O3 and Mo:Al2O3 films which is further dialed in by the number of ALD cycles involving WF6 and MoF6 precursors, respectively. Next, the secondary electron emissive layer in the form of a thin layer of Al-2O3 or MgO is deposited by ALD on to the MCP. These materials with high emissivity of secondary electrons are responsible for the high gain of the MCP. A final thermal anneal step in nitrogen atmosphere affords desirable properties of MCP. These ALD MCPs exhibit significant resistance to high processing temperatures and show low outgassing unlike conventional MCPs. This technology can be used to coat large area MCP substrates with very conformal pinhole free resistive and emissive films. These processes have been transferred to industry and are used to manufacture large area microchannel plates.