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ATOMIC LAYER DEPOSITION IN FLUID SYSTEMS

Uniform inner coatings in fluidic systems with nanometer-thick layers poses a special challenge. Often the diffusion limits uniform deposition of layers extending into the rearmost corners of the extremely long and narrow channels. The objective of the work at the Fraunhofer IST is to homogeneously precipitate compact layers in complex fluidic systems even at low temperatures by atomic layer deposition at atmospheric pressure.

Atomic layer deposition (ALD)

Atomic layer deposition is a chemical gas phase process. The characteristics of the process are two self-limiting successive surface reactions, so that extremely thin and low-defect layers can be deposited. Usually, two gases are used, which are separately routed over the surface through an alternating inert gas flushing.

For the investigations at the Fraunhofer IST trimethyl aluminum (TMA) was used as the layer former, which is deposited as an atomic layer when gases flow over the surfaces. Excess TMA is removed in a subsequent flushing step. Via inert gas that contains water vapor the TMA layer can then be oxidized, so that aluminum oxide Al_2O_3 is formed. The excess water vapor is removed in a subsequent flushing step. Optionally the process then starts over again and an additional monolayer TMA can be deposited on the surface. In this manner compact, homogeneous layers are deposited through cyclic film and subsequent oxidizing with

water vapor. For standard processes the gas exchange is supported through evacuation of the process chamber and temperatures of more than 100 °C.

ALD at atmospheric pressure

With conventional ALD processes at vacuum, the diffusion limits layer deposition through the channel openings and fluidic systems. Moreover, for the coating of plastic sufficiently low process temperatures of less than 100 °C are required. Consequently, at the Fraunhofer IST ALD processes have been developed that are suitable for fluidic systems with long channels of plastic.

For the investigations of the Fraunhofer IST the reactive gases cited above flow directly through PVC tubes with a 4 mm diameter and are flushed with inert gas. The high flow speed in the channels permits a fast exchange between the reactive gas mixtures so that the cycle time could be reduced to 120 s. Even at a process temperature of 50 °C closed layers

could be deposited in the tubes (see Fig. 1). Tests with a small reactor showed that at the same parameters compact layers can even be deposited on silicon (see Fig. 2).

Outlook

The homogeneous, nanometer-thick inner film of fluidic plastic systems is also interesting for the deposition of diffusion barriers, because the surface contour remains intact at minimal layer thicknesses. Moreover, through the virtually unlimited lengths of the channel systems to be coated additional varied application possibilities arise, such as the inner coating of heat exchangers or cooling systems.

1 Compact Al_2O_3 coating in a PVC tube after 250 cycles.

2 Fracture edge of a 50 nm thick Al_2O_3 coating on silicon, produced after 500 cycles.

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