DRESDEN THIN FILM TECHNOLOGY

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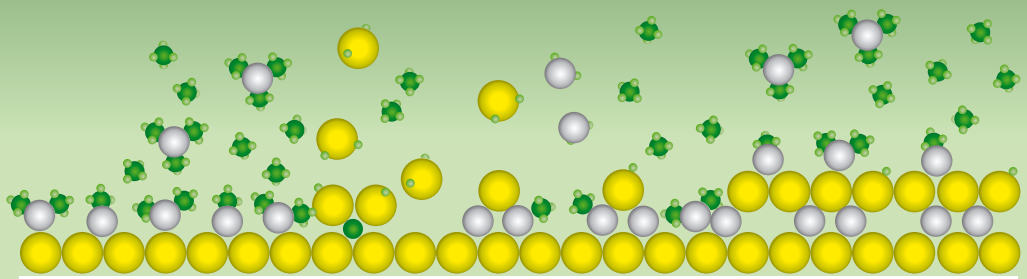

ALD - ATOMIC LAYER DEPOSITION

A New Age of Controlled Deposition by Ultrathin Multi-Layers

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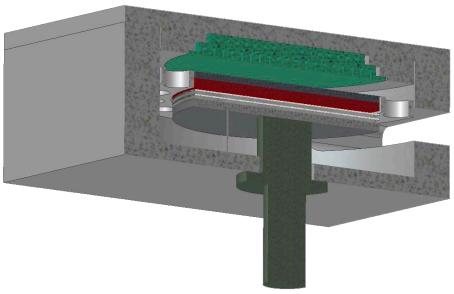
High layer conformity at high aspect ratios as well as an exact control of the layer thickness itself require a special coating process which is very different to standard CVD or PVD processes. The process of **A**tomic **L**ayer **D**eposition (**ALD**) as a special CVD process fulfils the above mentioned requirements.

The basic principle of ALD is a chemical reaction of two or more reactants on the substrate to obtain the desired layer material. To control of the growth of the desired layer the precursors (which form reactants) are injected sequentially and homogeneously over the substrate separated by an Argon-flush. The appropriate time of the precursor-inlet as well as the time of the Argon-flushing guarantee a layer growth of the material for each process cycle. Because of the fact that chemisorption is taking place homogeneously over the complete substrate-surface an excellent homogeneous layer thickness distribution without pinholes is being achieved even at 3D-surfaces.

For the advanced processing of your substrates DTF offers tailor-made reactor-tools with high performance gas-inlet or DLI (Direct Liquid Injection) systems in combination with high speed gas-valves and highly adaptable software to develop your processes. DTF's ALD coating-tools are designed for R&D-processes as well as for processes in an industrial scale.



> Cross-section of an ALD-process chamber.

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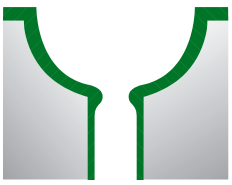
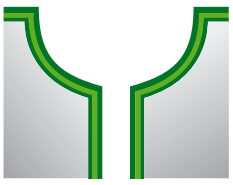
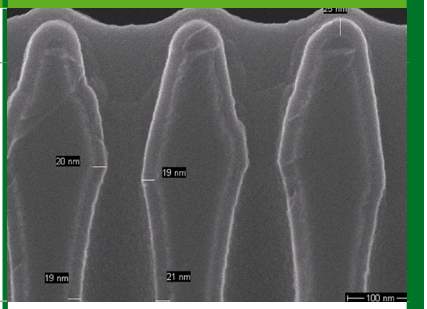
Advantages of DTF´s ALD Coating-Tools at a Glance:

- excellent layer conformity of 3D-geometries (high aspect ratios)
- overall layer thicknesses of about 1 nm to more than some hundred nanometers according to the number of coating cycles
- usability of a wide range of different precursors
- DLI systems for precursor development
- adjustable process temperature below 400 °C for ALD-processing
- possibility of process temperatures above 400 °C for (standard) CVD processing
- highly adaptable and easy-to-use control-software

Example of Layer Properties : Layer Conformity

PROPERTIES	CVC	PECVD	PVD	ALD
desposition rate	high 1-10 µm/h	high 1-5 µm/h	medium 0.1 – 1 µm/h	low 1-5 nm/min
homogeneity	high	medium / high	high for planar substrates	very high
deposition of complex 3D-geometries	very good	good	limited	excellent
temperature budget to substrate	high	low	low	low
adhesion of layers	very high	medium / high	medium / high	medium
variety of materials	high (depending on precursors, limited of metals)	high (depending on precursors, limited for metals)	high all metals, not possible for a-C:H, a-Si:H	high (depending on precursors, limited of metals)

NOZZLE-COATING			TRENCH-COATING
PVD (e.g. sputtering)	**CVD**	**ALD**	
			
coatings on sidewalls too thin	bulging on edges	perfect conformity of the layer	trench-coating with a homogeneous alumina-layer (source: FhG IKTS)

Typical Layer Materials for ALD processes (depending on the available precursors)

- Metals: Cu, Ta, W, Mo, Ru,…
- Oxides: Al_2O_3, SiO_2, HfO_2, ZnO, La_2O_3,…
- Nitrides: TaN, TiN, Si_xN_y, AlN,…
- Sulfides: ZnS, CdS,…

ALD process development is carried out in a collaboration between DTF and Fraunhofer IKTS Dresden.