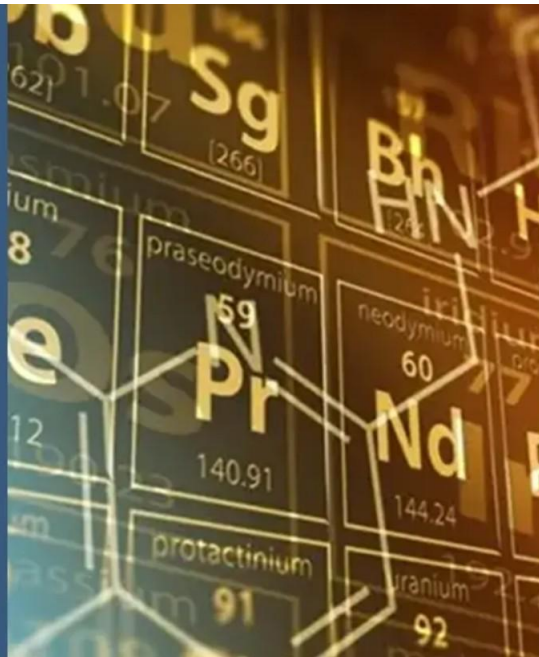# Atomic Layer Deposition

What Is ALD ?

Subset of *Chemical Vapor Deposition (CVD)*

Atomic Layer Deposition

CVD
Precursor gases injected simultaneously
These react in gas phase to produce film growth

ALD
Precursors gas injected sequentially producing **surface only film growth**

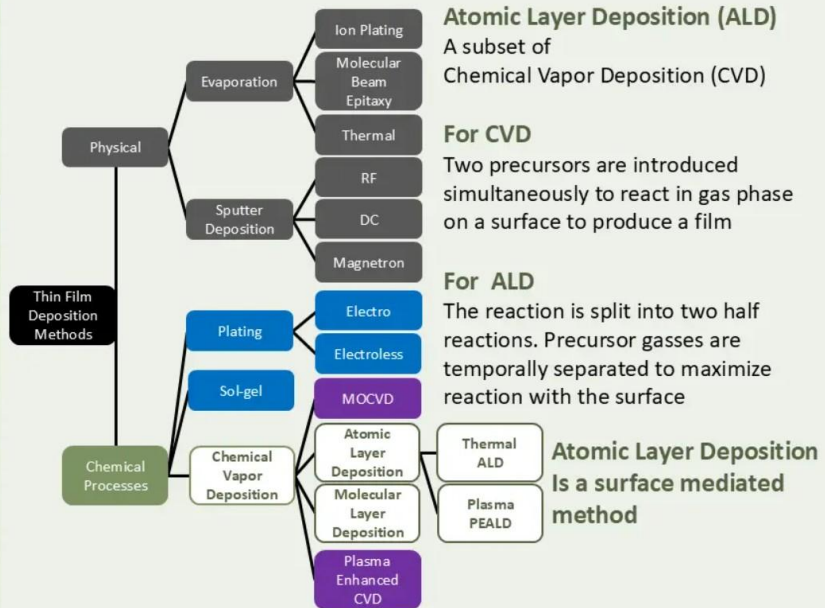*ALD exposes surfaces with pulsed chemical vapours called precursors*

ALD exposes a surface sequentially with pulsed chemical vapours separated by a nitrogen purge. A first precursor forms one monolayer of coating by reacting with the substrate surface (usually with OH groups terminating a surface). The next precursor reacts with the surface of the previously formed monolayer and forms another monolayer. Usually two different precursors are used, resulting in binary coating materials (like Al2O3), although elemental coatings (pure metals etc.) and much more complex compositions are also possible

The number of monolayers of the coating (thickness) can be determined simply by setting the number of sequential pulses. The vapours do not condense on the surface, because the excess vapour is evacuated between the precursor pulses using a nitrogen purge. This means that the coating after each pulse is self-limiting to one monolayer. This allows complex shapes to be coated with atomic precision (the coating thickness inside a porous material will be the same as on its surface!). Due to this and many more remarkable features, ALD is becoming increasingly popular for more and more applications

What is ALD?
Thin film deposition methods

Thin film deposition methods

Atomic Layer Deposition (ALD)
A subset of
Chemical Vapor Deposition (CVD)

For CVD
Two precursors are introduced simultaneously to react in gas phase on a surface to produce a film

For ALD
The reaction is split into two half reactions. Precursor gasses are temporally separated to maximize reaction with the surface

Atomic Layer Deposition
Is a surface mediated method

The ALD advantage
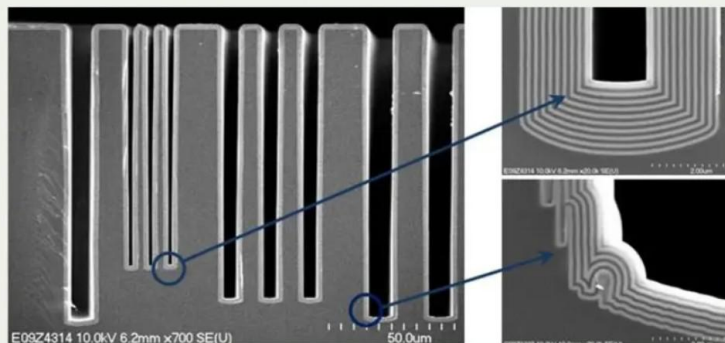*Conformal deposition for complex geometry*

ALD is a reaction-controlled method

Diffusion-controlled (CVD)
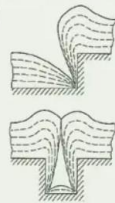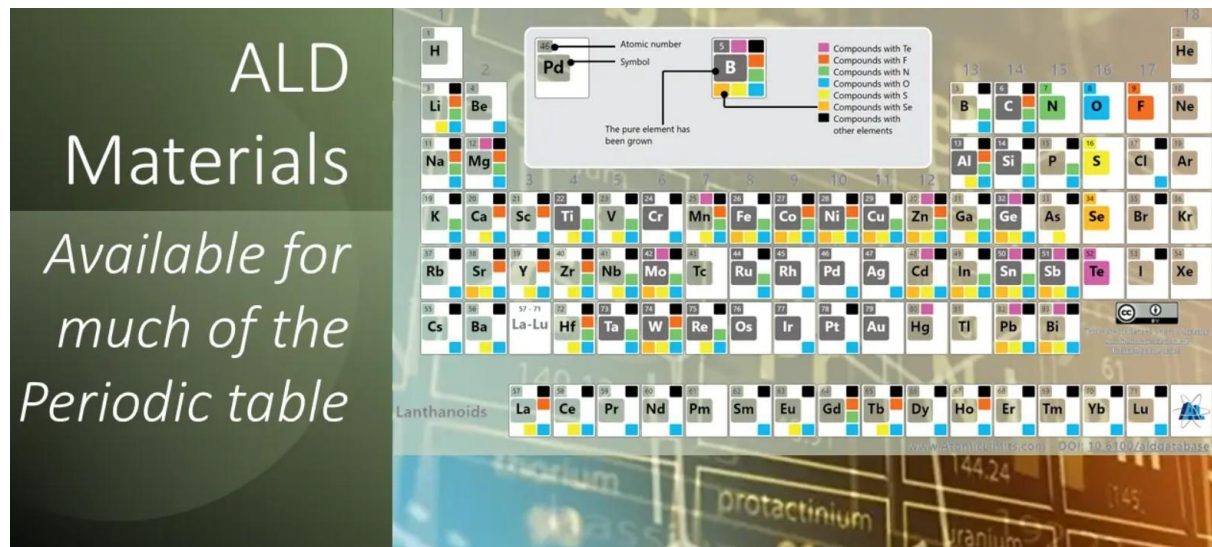
Reaction-controlled (ALD)
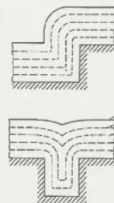
Produces conformal Pin-hole free deposition on complex geometry with large L/D ratio

E09Z4314 10.0kV 6.2mm ×700 SE(U)   50.0um

Alternating layers of Ta_2O_5 and Al_2O_3 for deep trenches in silicon

***The inherent strength of ALD technology***

Is the ability to utilize much of the materials available on the periodic table as shown above. In addition, conformity and the ability to adapt to various substrates, shapes and high aspect ratio structures producing uniform, pinhole free single material and Nano-laminate coatings has created broad interest in many fields.

Molecular Layer Deposition (MLD)

MLD is a gas phase deposition technology

Extending the Toolbox of Gas Phase Deposited Materials with GEMStar XT-D

Molecular Layer (MLD) is a gas phase deposition technique. It can be used to deposit thin conformal organic polymers such as polyamides, polyimides, and polyesters to name a few. Similar to ALD, MLD separates the reaction of co-reacting chemicals into two surface- mediated half reactions separated by a purge step.
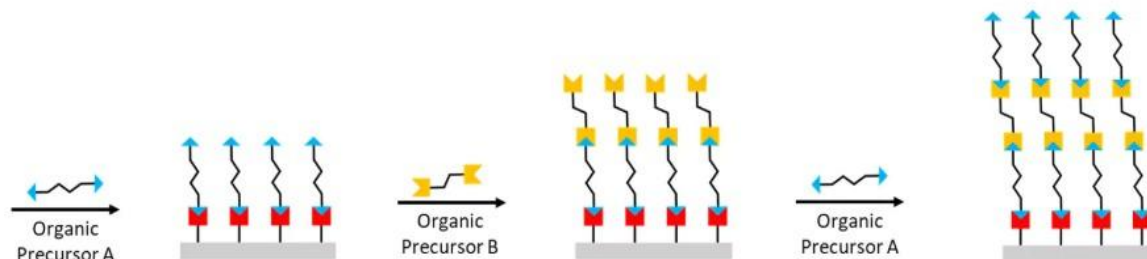
With a unique dual manifold design
Patent pending gas distribution

Arradiance's GEMStar XT-D is the ideal tool for depositing MLD and ALD films. By separating co-reacting precursors within two individually heated manifolds, deposition and film grown only occur within the chamber and not within the manifold lines. This key feature separates the GEMStar- XT-D from other commercially available ALD tools and is the only Benchtop tool capable of safely depositing ALD and MLD films. Furthermore, the compact and small footprint of the GEMStar XT-D takes up minimal lab space and can easily be integrated to any Glovebox making it an ideal tool for air sensitive research.
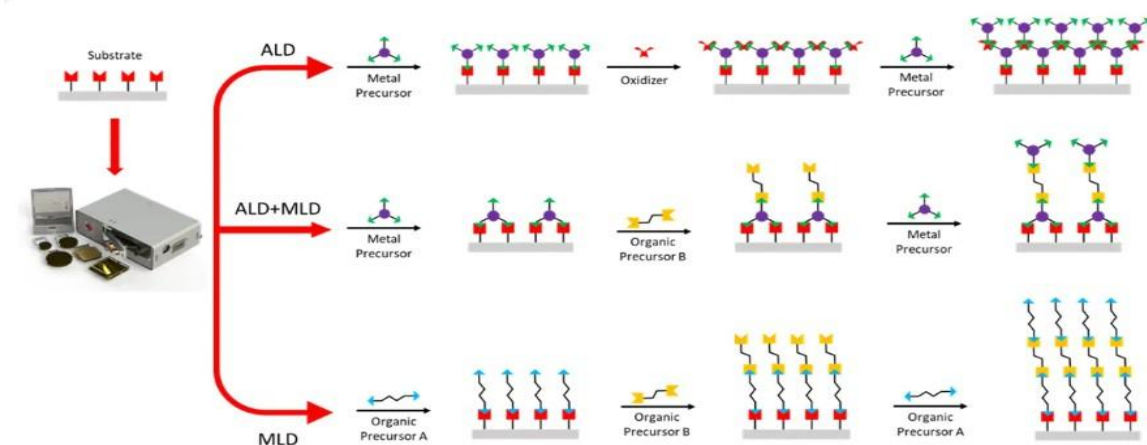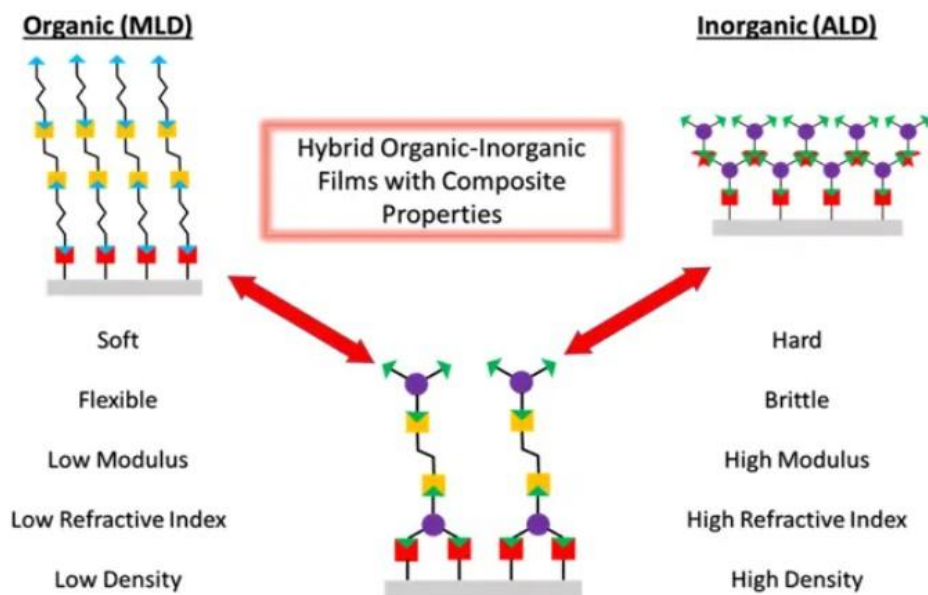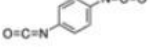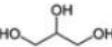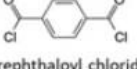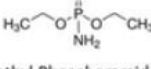
Some organic precursors can react with inorganic precursors

Defining a new class of hybrid organic-inorganic thin films. These hybrid materials have properties that range between pure organic and inorganic films, allowing for control over density, refractive index, elastic modulus, and hardness

This enables developing films with precisely tuned mechanical, optical, chemical bio-chemical, and electrical properties, further extending the range of materials that can be deposited. Given these unique tuneable properties, ALD and MLD have found application in a number of difference fields including energy storage, fuel cells, photovoltaics, biotechnology and semiconductors to name a few.

Organic (MLD)   Hybrid Organic-Inorganic Films with Composite Properties   **Inorganic (ALD)**

Soft	Hard
Flexible	Brittle
Low Modulus	High Modulus
Low Refractive Index	High Refractive Index
Low Density	High Density

MLD	Organic Precursor A	Organic Precursor B
Polyimide	Pyromellitic dianhydride	Ethylene Diamine
Polyurea	P-Phenylene diisocyanate	Ethylene Diamine
Polyester	Terephthaloyl chloride	Ethylene Glycol

ALD+ MLD	Metal Precursor	Organic Precursor B
Alucone	Trimethylaluminum	Ethylene Glycol
Titanicone	Titanium Chloride	Glycerol
LiPON	Lithium Tert-Butoxide	Diethyl Phosphoramidate