

Atomic Layer Deposition (ALD) in Nanoelectronics and Plasma Enhanced Chemical Vapour Deposition (PECVD) in Photovoltaics

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Atomic layer deposition

Atomic layer deposition (ALD) is a thin film deposition technology which is used to fabricate ultrathin, highly uniform and conformal material layers on complex, three-dimensional objects with atomic precision. ALD uses alternating, self-limiting surface controlled chemical reactions between gaseous precursors and a surface to deposit material in an atomic layer-by-layer fashion. As shown in Fig. 1, the virtue of the ALD technique is that the deposition is controlled at the atomic level by self-limiting surface reactions by alternate exposure of the substrate surface to different gas-phase precursors. Each surface reaction occurs between a gas phase reactant (precursor) and a surface functional group creating a product molecule that desorbs from the surface, and a new surface functional group that is not reactive with the precursor. After pumping away the first precursor and the reaction products, a second precursor is introduced, which deposits a second element through reaction with the new surface functional group and then restores the initial surface functional group. This set of reactions form one ALD-cycle resulting in less than one atomic layer of film growth, typically $0.5\text{--}1.0\text{\AA}$ per cycle. The ALD cycle can be repeated until the desired film thickness is reached.

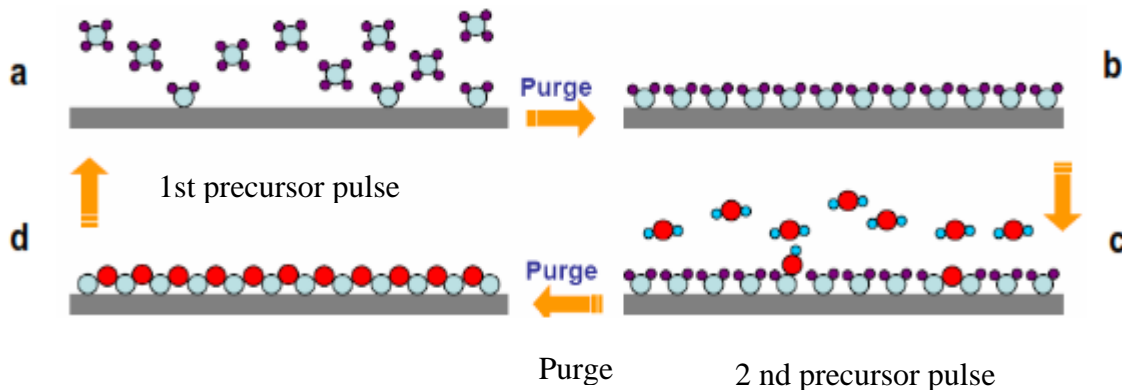


Figure 1. Schematic representation of one cycle of the atomic layer deposition (ALD). The cycle can be repeated until the film thickness projected is achieved [8].

Plasma Enhanced Chemical Vapour Deposition

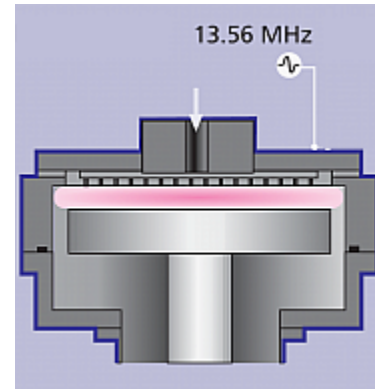
Plasma Enhanced Chemical Vapor Deposition (PECVD) is an excellent process for depositing a variety of thin films at lower temperatures. It is a process used to deposit thin films from a gaseous state to a solid state on a substrate. Chemical reactions occur

after creation of plasma of the reacting gases. Since the formation of the reactive and energetic species in the gas phase occurs by collision in the gas phase, the substrate can be maintained at a low temperature. Hence, film formation can occur on substrates at a lower temperature than is possible in the conventional CVD process. Some of the desirable properties of PECVD films are good adhesion, good step coverage and uniformity of deposition. Some of the popular applications of PECVD include deposition of passive and active waveguide layers, dielectric films such as silicon dioxide, low stress and low temperature silicon nitride, amorphous silicon and silicon carbide.

PECVD Reactor: Oxford instruments Plasma 100 system

The key features of the system are:

- Top electrode RF driven (13.56 MHz)
- Substrate sits directly on heated electrode
- Gas injected into process chamber via top “Showerhead”,
- 0.5-2.0 Torr operating pressure,
- 0.02-2.0 Wcm⁻² power density.



PECVD is utilized mainly for the following applications in thin film silicon photovoltaics:

- To deposit amorphous silicon films (doped and intrinsic) for fabrication of thin film solar cell on glass as well as on flexible materials.
- To deposit amorphous silicon layers on silicon substrates for fabrication of Heterojunction Intrinsic Thin Layer (HIT) solar cells.
- To deposit nanocrystalline silicon and silicon nanowires based solar cells.
