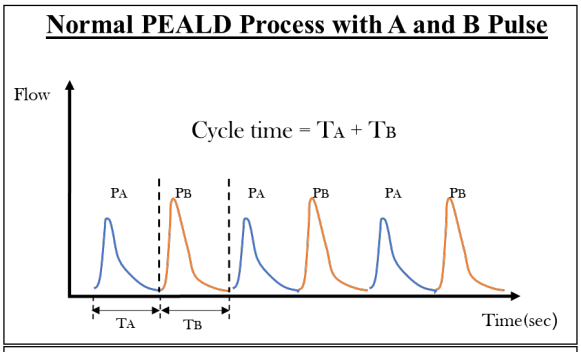
NANO-MASTER, Inc

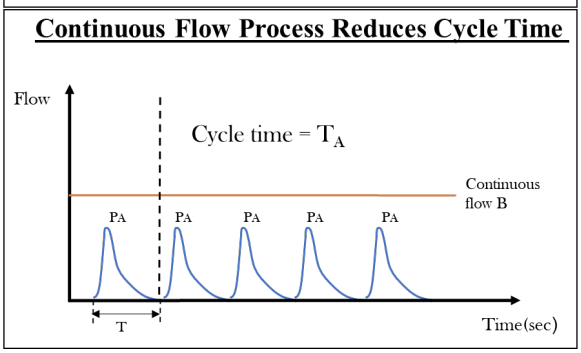
Continuous-Flow Plasma Enhanced Atomic Layer Deposition (PEALD)

Atomic Layer Deposition (ALD) is a thin film deposition technique based on sequential, self-limiting surface reactions that enable atomic-scale control over film thickness and composition. In each ALD cycle, gaseous precursors are introduced one at a time, reacting only with the surface and not in the gas phase, which ensures excellent conformality and uniformity even on high-aspect-ratio and complex 3D structures.

Plasma-Enhanced ALD (PEALD) is a variation that replaces one or more thermal steps with a plasma-excited species, allowing deposition at lower temperatures and improving film properties such as density, purity, and adhesion. PEALD is particularly valuable for depositing high-quality dielectric, barrier, and conductive films on temperature-sensitive substrates.

In semiconductor manufacturing, ALD and PEALD are essential for advanced node integration, enabling the fabrication of ultra-thin gate oxides, high-κ dielectrics, encapsulation layers, and metal contacts with sub-nanometer precision—supporting the continued scaling of devices and the production of highly reliable and high-performance electronic components.





Nano-master patented continuous-flow plasma enhanced atomic layer deposition (PEALD) is aiming to produce ultra-uniform, high-quality thin films on substrates in a shorter cycle time. The innovation lies in the integration of continuous plasma flow with precise control mechanisms to enhance film uniformity while minimizing potential damage to sensitive substrate surfaces.

Key components and functionality

- **Planar inductively coupled plasma (ICP) source**: Generates a continuous plasma flow, facilitating the deposition process.
- **Substrate chamber design**: Features a configuration that separates the plasma generation zone from the substrate processing area, preventing direct exposure of the substrate to high-energy plasma species.
- **Gas flow management**: Employs a system that allows for the continuous introduction and removal of process gases, ensuring a stable and controlled deposition environment. The first precursor enters through horizontal flow while the second precursor comes from showerhead gas distribution plate.
- **Material deposition control**: Utilizes self-limiting surface reactions characteristic of ALD, enhanced by plasma activation to improve film quality and conformity. For example, making nitrides with N2 rather than NH3

Advantages

- **Enhanced film uniformity**: The continuous-flow design ensures consistent plasma conditions, leading to uniform film thickness across the substrate.
- **Reduced substrate damage**: By isolating the substrate from direct plasma exposure, the system minimizes potential damage to delicate structures. This is unlike down stream plasma systems that try to protect the substrate from plasma ions and electrons by filtering them and only allowing activated precursor to enter the ALD volume through shower head separator.
- **Increased throughput**: The continuous operation mode allows for higher processing speeds compared to traditional ALD methods. By making the second precursor flow continuously cycle time is reduced by a factor of two and throughput is doubled.
- **Scalability**: The apparatus is adaptable to various substrate sizes and can be integrated into existing semiconductor fabrication lines.

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