



Atomic Layer Etching

Innovative solutions for etching
to the atomic layer

What is Atomic Layer Etching?

Atomic Layer Etching (ALE) is a technique designed to allow the accurate removal of one atomic layer at a time; a level of control unachievable using conventional etching.

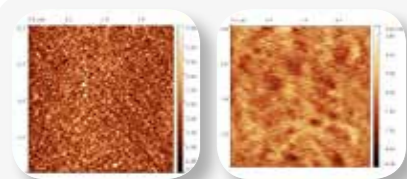
As layers become thinner to enable the next generation semiconductor devices there is a need for ever more precise process control to create and manipulate these layers. The PlasmaPro100 ALE delivers this through specialised hardware including:

- **Precise control** of gas dose
- **Excellent repeatability** of low power RF delivery
- **Rapid switching** enabled by fast PLC

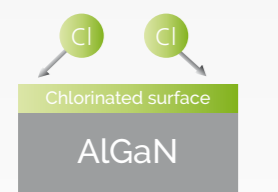
All these combine to enable etching with accuracy at the atomic scale.

Benefits of ALE

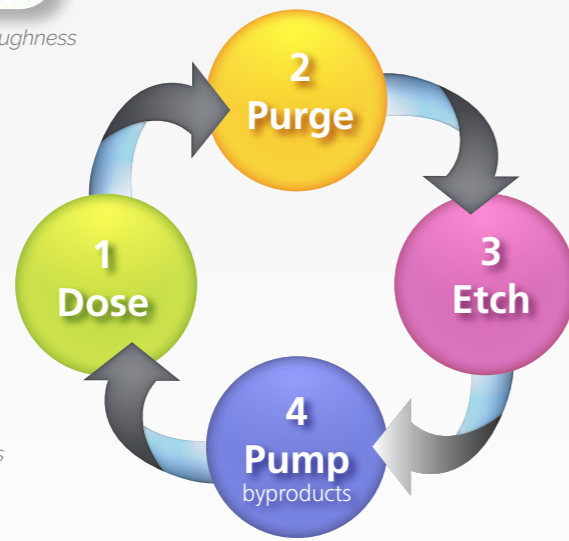
- **Smooth etch** surfaces
- **High selectivity** to layers including some materials not possible using a conventional plasma etch
- **Low damage**
- **Excellent uniformity**
- **Minimal aspect ratio** dependence
- **High accuracy** of etched depth
- Ideal for **nanoscale layer removal**
- Possibility of **single atomic layer etch** (e.g. for 2D materials)



AFM images show AlGaN surface roughness reduced by 0.3nm within 30 cycles

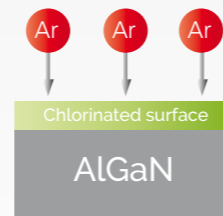


Step 1 | Dose Chamber is given a short dose with a chemically reactive species (Cl_2 for GaN, AlGaN or Si). This forms a layer on the substrate surface



Chlorinated surface
AlGaN

Step 2 | Purge Excess Cl_2 is pumped away to leave just a layer on the substrate surface

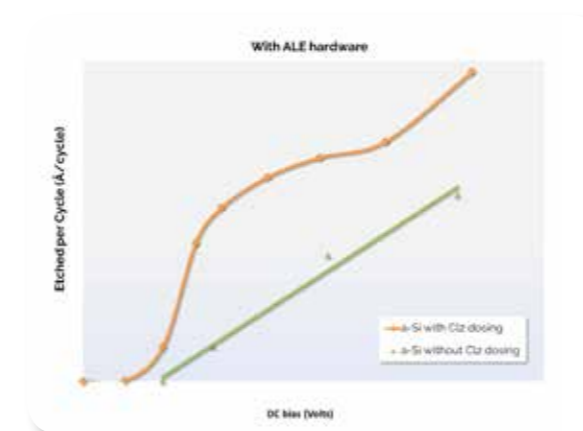


Step 3 | Etch A small amount of DC bias power is applied causing Ar ion bombardment to remove the top layer and leave a fresh substrate surface.

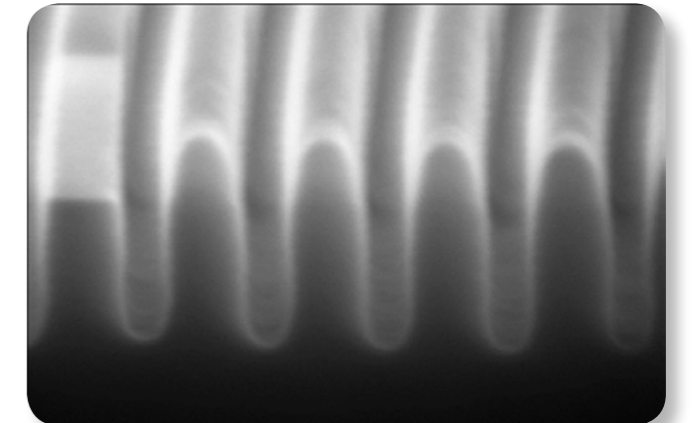
AlGaN

Step 4 | Pump Pump out step to remove all by-products from the chamber before a fresh dose of Cl_2 is introduced

ALE Process



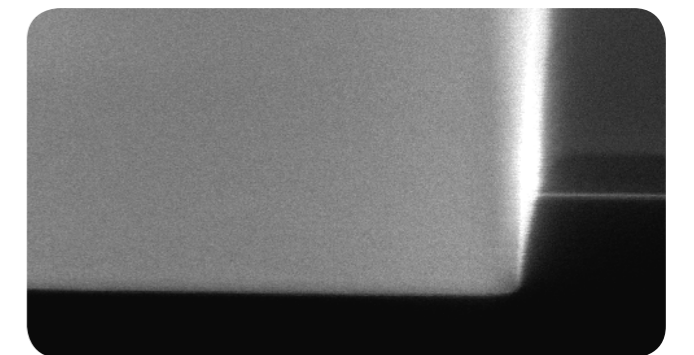
Graph showing true ALE plateau when etching a-Si, the precise control of the RF power is essential to achieve repeatable ALE.



25nm wide Si trenches etched to 110nm depth, 150cycles; HSO mask still in place

Wide range of materials

Material Etched	Dose Gas	Etch Gas
Si or a-Si	Cl_2	Ar
MoS_2	Cl_2	Ar
SiO_2	CHF_3 or C_4F_8	Ar or O_2
AlGaN/GaN	Cl_2 , BCl_3	Ar
AlGaN/GaN	N_2O	BCl_3



Smooth Si etch surface after 150 ALE cycles



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