# A Comparative Study of Atomic Layer and Reactive Ion Etching

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One of the recent popular topics regarding future electronics is how to improve the existing fabrication methods or discover a new one in order to achieve high-resolution patterns and a low degree of damage. Thanks to research efforts in the electronics manufacturing industry, we started using electronic devices which have the size of a palm or smaller. Manufacturing of nano-scale devices such as transistors or quantum dots includes several steps based on three main processes: lithography, etching, and deposition. Repeating these processes will lead us to the final product. However, the fact that nano-scale devices have larger surfaces compared to the bulk material makes the control of manufacturing procedures more important due to the possibility to introduce defects that can negatively affect the optical and electrical properties of the devices.

Dry etching, particularly reactive ion etching (RIE), plays a crucial role in pattern transfer during nano-fabrication. RIE bombards the surface of the target material with high-energy ions, offering accuracy and high-resolution etching capabilities below 10 nm laterally. Nevertheless, as the demand for increased lateral and vertical patterning resolution grows, the continuous etching approach of RIE may no longer meet the new requirements. To address this, alternative methods of material removal are urgently sought, particularly those capable of providing shallow etching depths down to one atomic layer (Monolayer, ML) of etched material.

One promising approach for achieving precise ML etching control is atomic layer etching (ALE), a cyclic process that serves as an alternative to RIE. ALE removes one ML of material at a time and shares similar chemistry with RIE, but the key distinction lies in its cyclic nature, where modification and etching processes are separated.

In this project we performed a comparative study of radiation damage in Si etched using a conventional RIE with $Cl_2/Ar^+$ process and a newly developed ALE with the same etch chemistry. After that, the etched surface is characterized by a combination between atomic force and Kelvin probe microscopy.

By investigating the impact of different etching techniques on radiation damage and employing advanced microscopy techniques for surface characterization, this project contributes to the ongoing efforts to enhance fabrication methods for future electronics. The findings shed light on the potential of ALE as a promising approach for achieving high-resolution patterns with minimal damage, paving the way for advancements in nano-scale device manufacturing.