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# Development of Atomic Layer Etching (ALEt) for GaN-based materials

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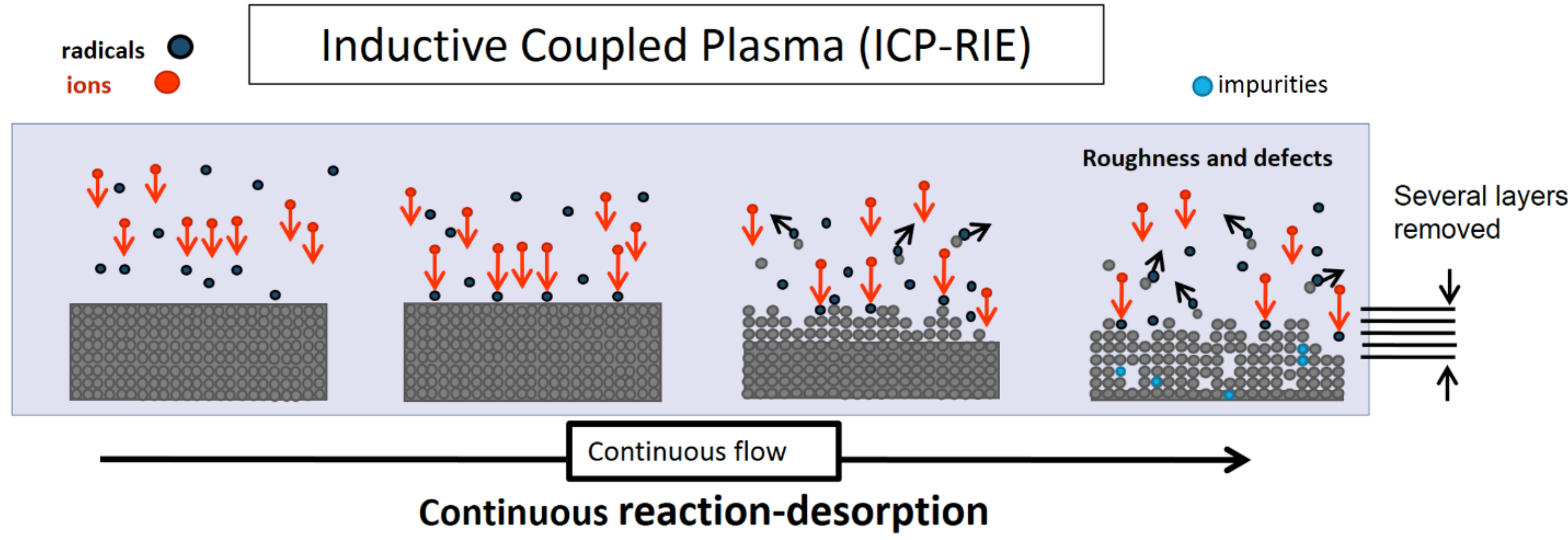
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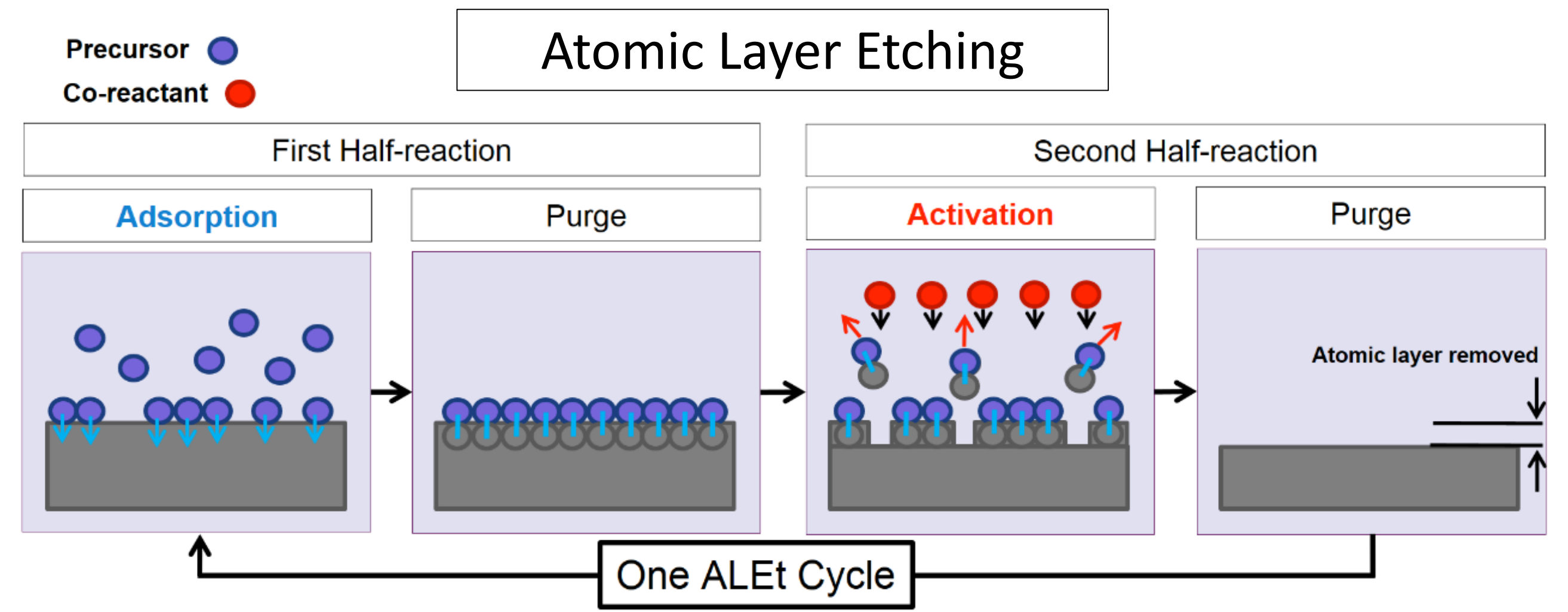


## 1. What is Atomic Layer Etching (ALEt)?

Conventional Dry Etching process for GaN-based materials



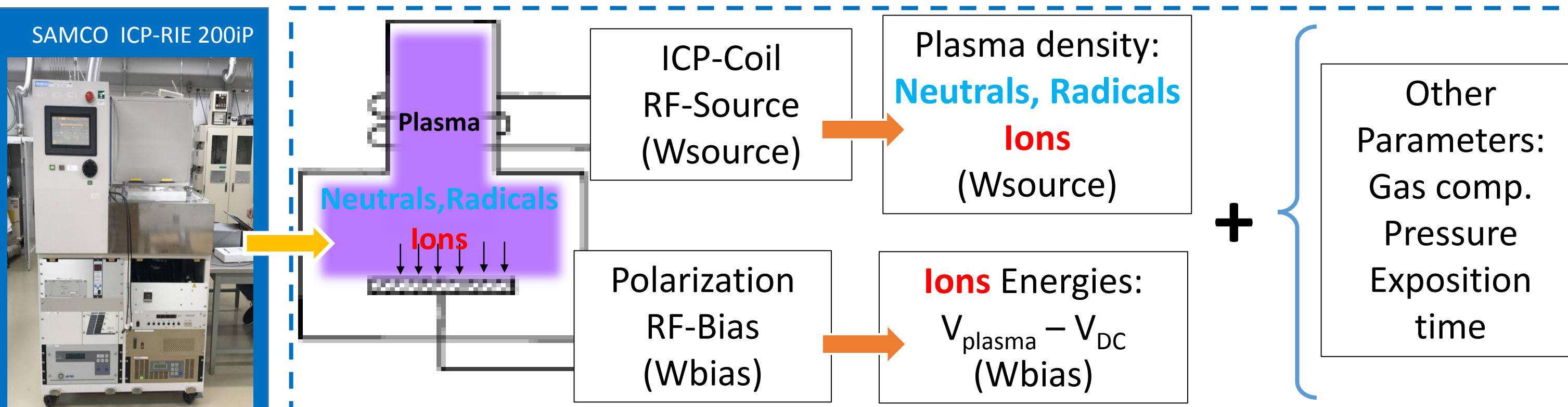
- Advantages:**
- Fast and deep etching
  - Separate controlled of Plasma density (neutrals, radicals, ions), Ionic Fluxes and Ions Energies
- Limitations:**
- Simultaneous effect of chemistry and ionic bombardment
  - Difficult to control Surface States (morphology and composition)



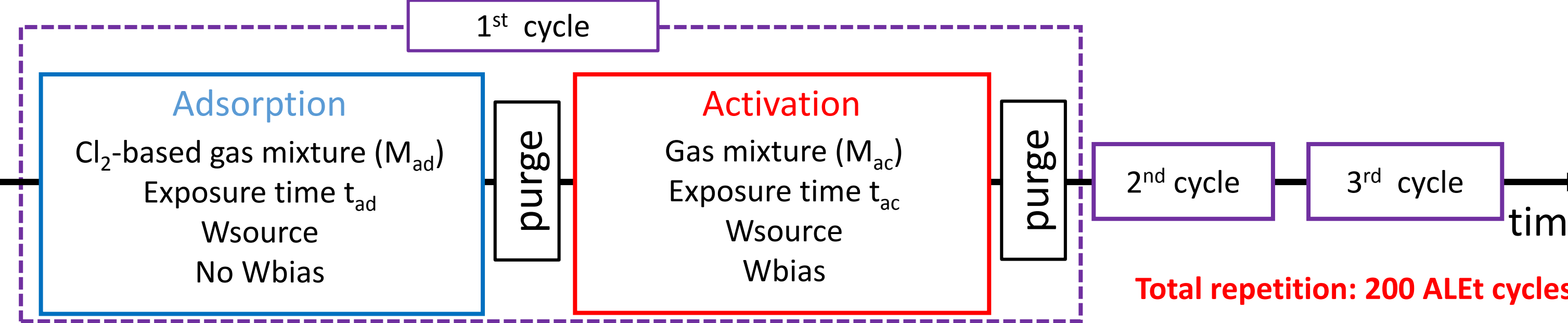
- Advantages:**
- Separation: **Chemistry (precursor)/ionic bombardment (co-reactant)**
  - Etch rate controlled by Numb. of cycles
  - Different plasma (or gases): for **chemistry** and **ionic bombardment**
- Challenges:**
- Keep the "self-limiting" feature
  - Slow: Etch profile defined by Numb. of cycles (< 1nm/cycle)
  - Monitoring of etched thickness

## 2. Experimental procedures

Development of ALEt on SAMCO ICP-RIE 200 iP



Our ALE process (to be patented):

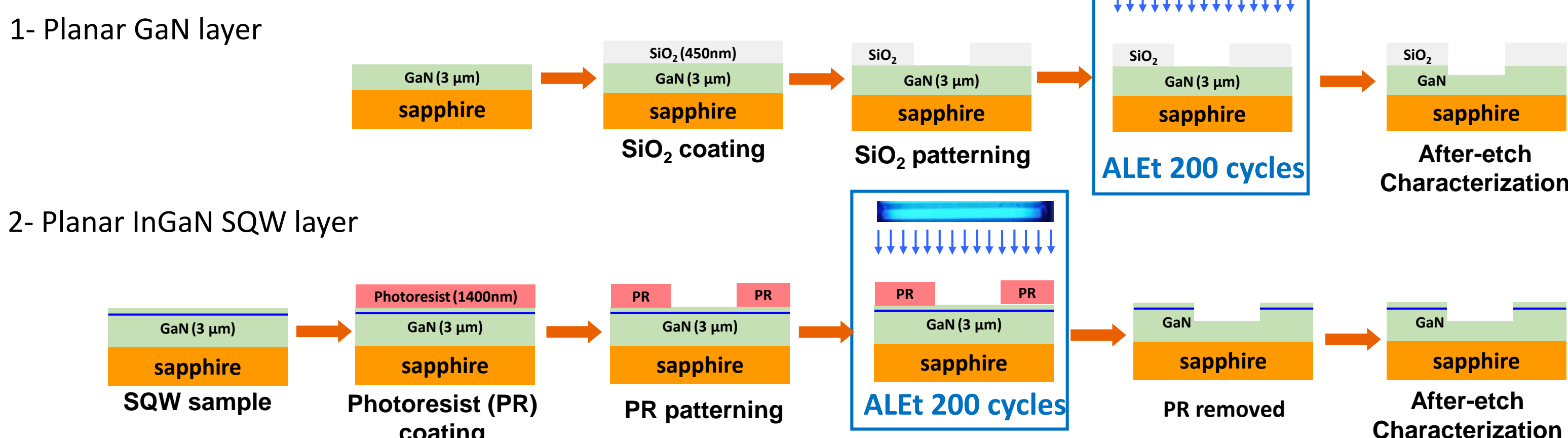


**Deposition:**  
GaN layers with embedded InGaN Single Quantum Well (SQW)

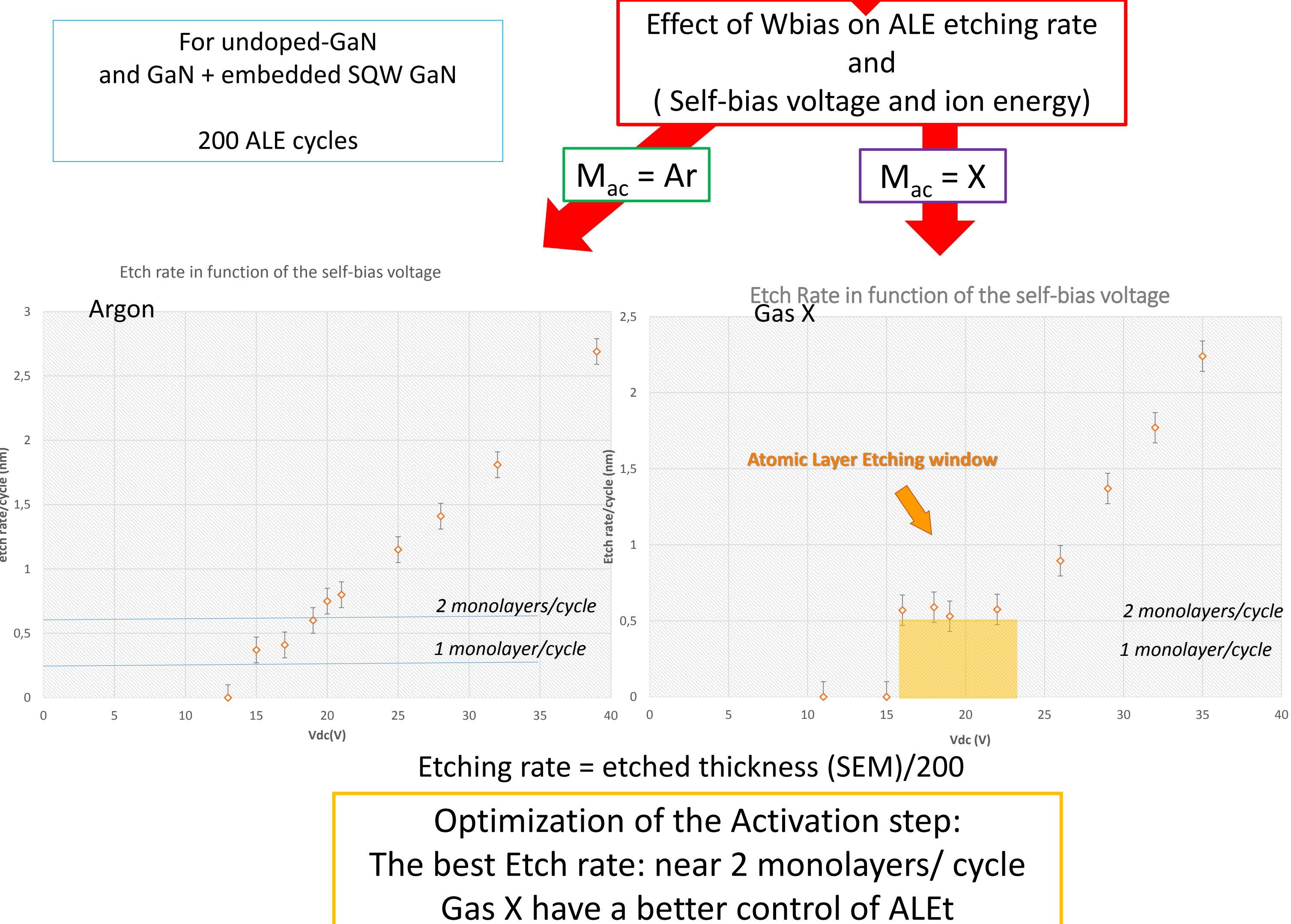
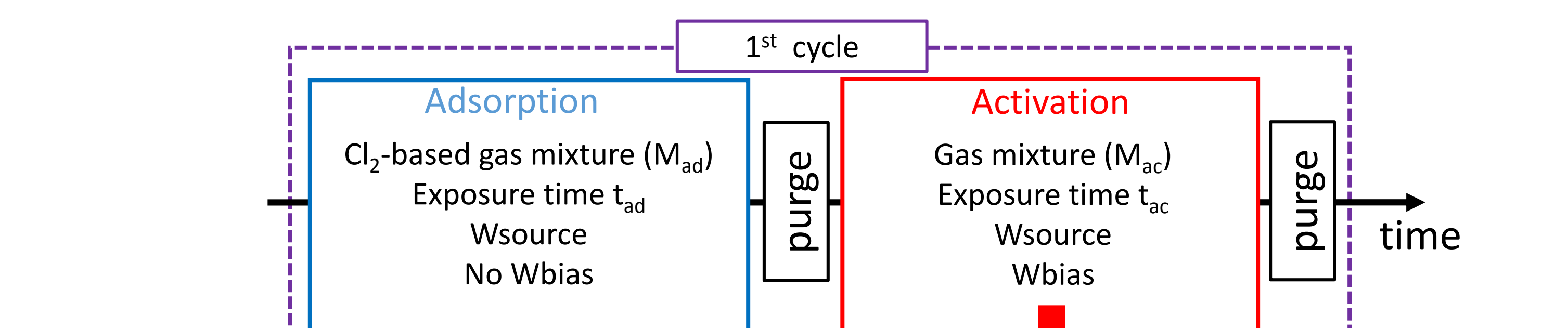


**Capping layer:** GaN (5 nm)  
**Single quantum well:** InGaN with 18% In (2.75 nm; 750°C)  
**GaN (3 μm)**  
**GaN (20 nm; 850°C)**  
**Underlayer:** InGaN with 3-5% In (50 nm; 750°C)

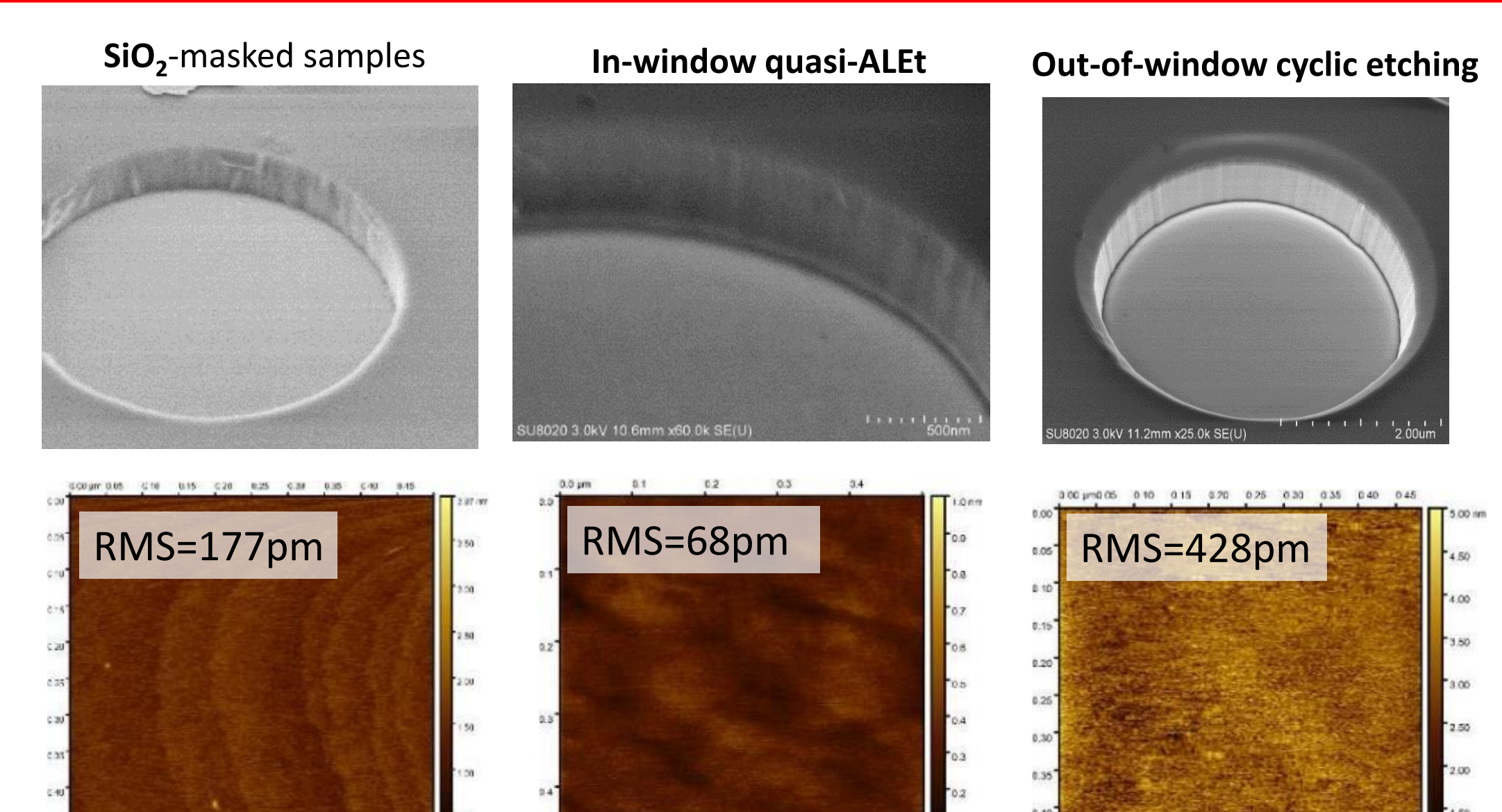
Holes fabrication process and Experimental procedures:



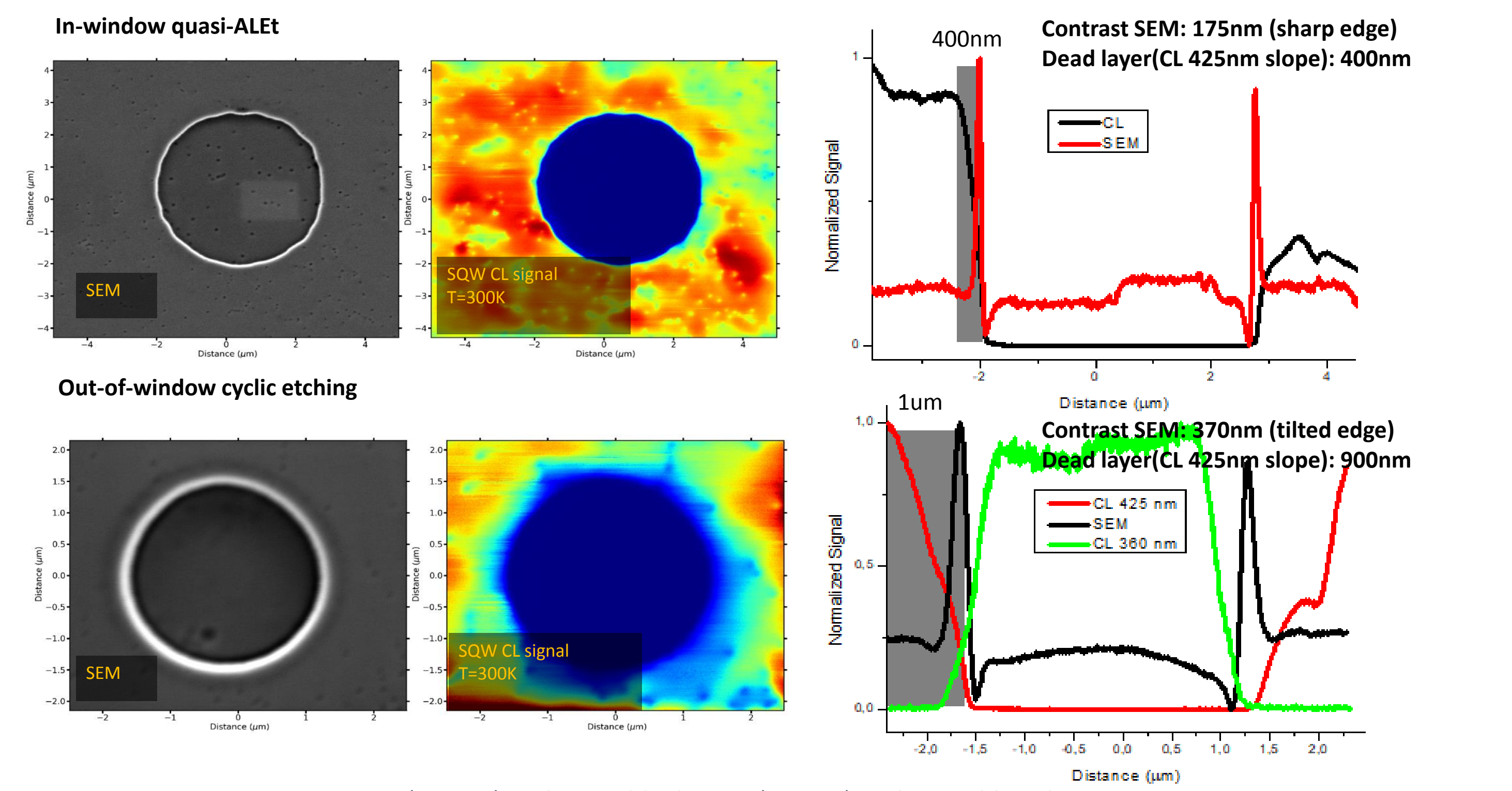
## 3. ALEt Etch rate as a function of Activation Bias



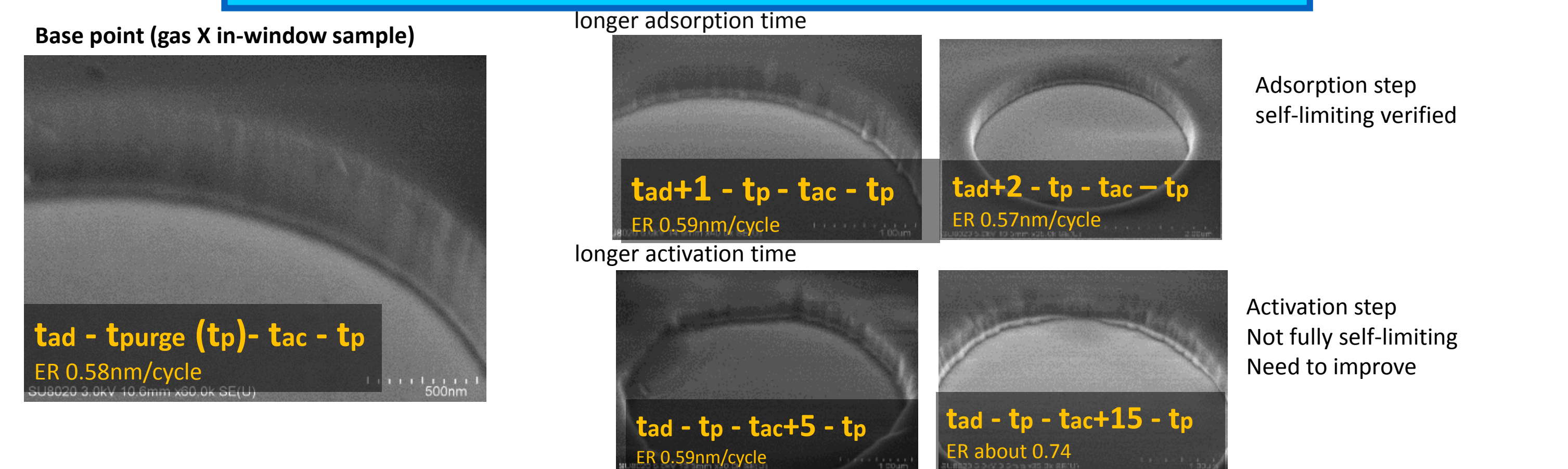
## 4. Comparison of in- and out-of ALEt window etched samples



Cathodo-Luminescence of SQW samples : Estimation of deadlayer thickness



## 5. Demonstration of the self-limiting



## 6. Conclusions and perspectives

- Gas X has a better etch control on the ALEt process
  - Quasi ALEt has a better etch quality: sharp border; thinner dead layer
- Optimizations → real ALEt + limiting the dead layer  
Improve the Activation step (take a Bias on the ALEt window → change the ICP power); change pressure in different steps, etc  
verify other advanced properties → Apply to Electronic/optoelectronic device