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Reactive ion etching of 100 and 113 diamond for development of power devices

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General background

- **113 diamond** is a good candidate for power devices development such as PIN diodes due to better electronics properties of n-type layers (high electrons mobility and better doping incorporation) compared to 100
- Need to develop an etching process for power devices manufacturing with:
 - ➔ Low etched surface roughness
 - ➔ No micro-masking
 - ➔ Anisotropic sidewalls
 - ➔ High etching mask selectivity

Etch process previously optimised on 100 diamond :

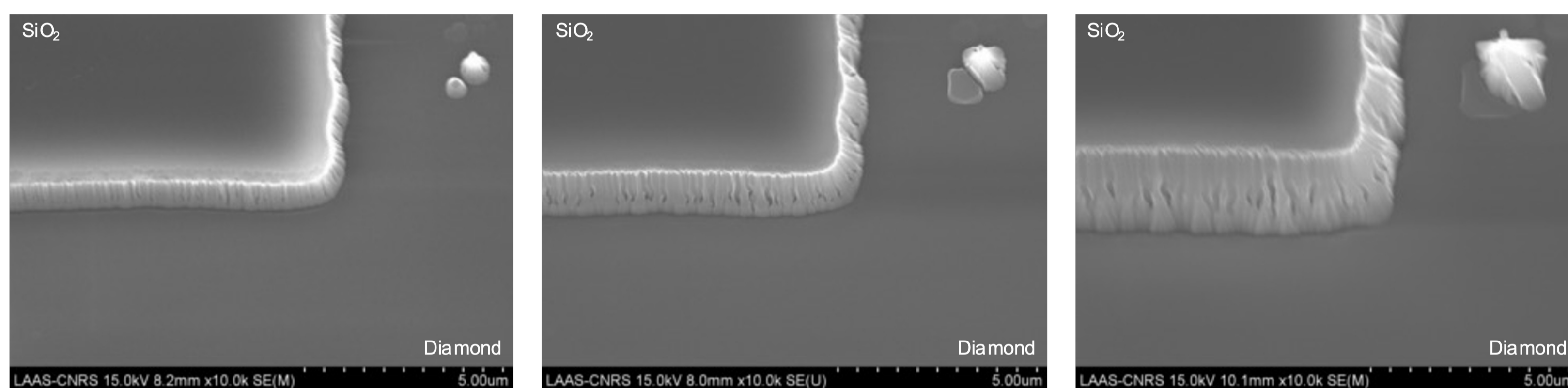
- a) CCPECVD SiO₂ layer as etching mask
- b) SiO₂ patterning by laser lithography and CHF₃ ICP-RIE etching
- c) **O₂ plasma etching :**
O₂ 25 sccm, 6 mT, ICP: 500 W, Bias: 35 W, 15 °C

This work :

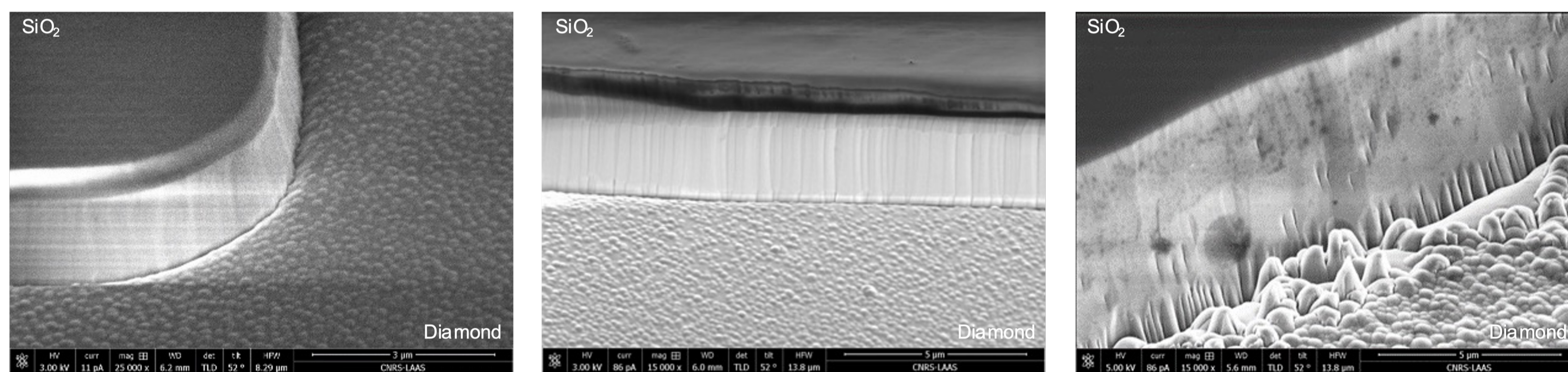
Transfer of this optimized process to 113 layers

O₂ etching for low [B] doped 100 & NID 113 diamond layers

100 diamond [B] doped at 3x10¹⁷ cm⁻³



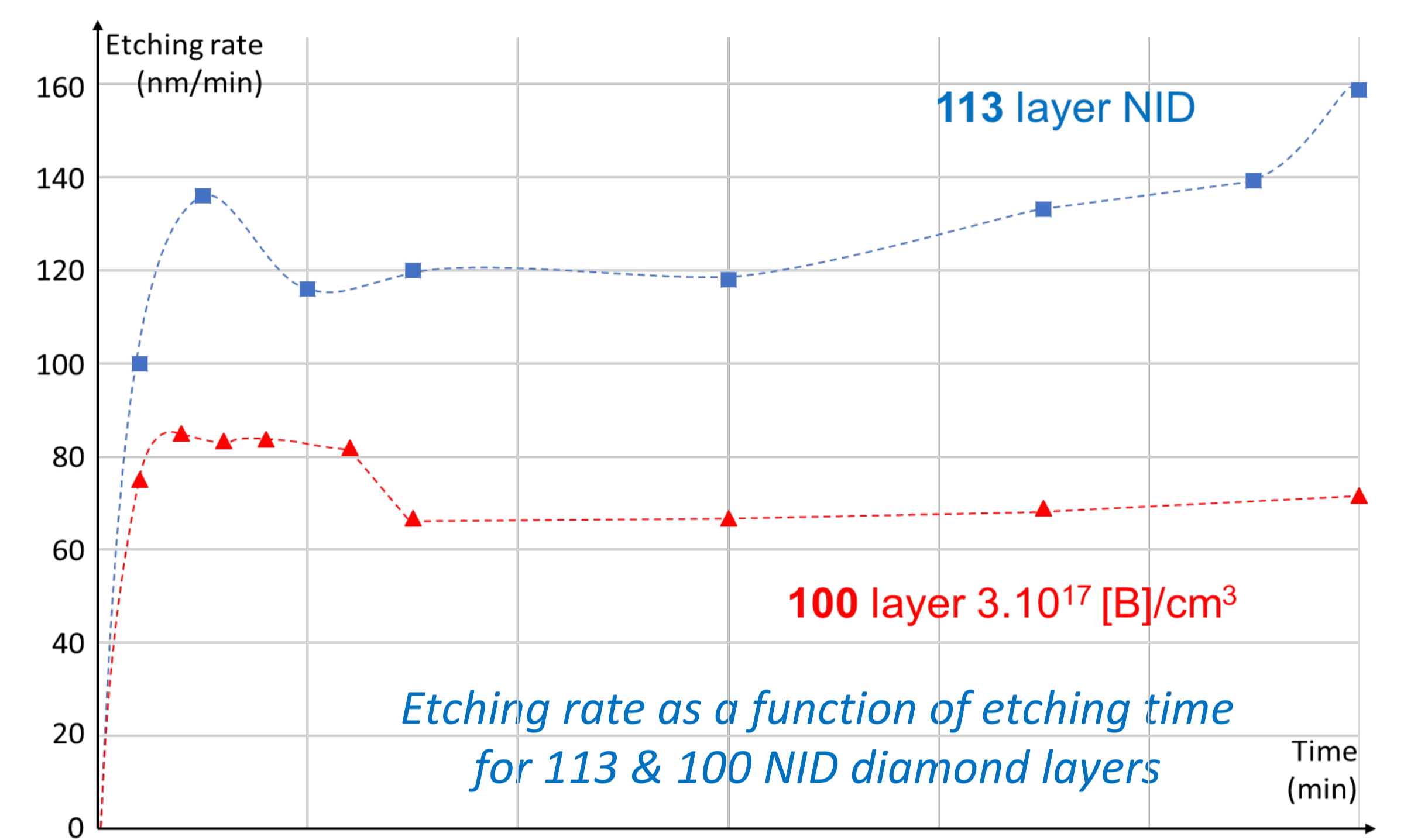
113 NID diamond



Etch time : 15 min

Etch time : 30 min

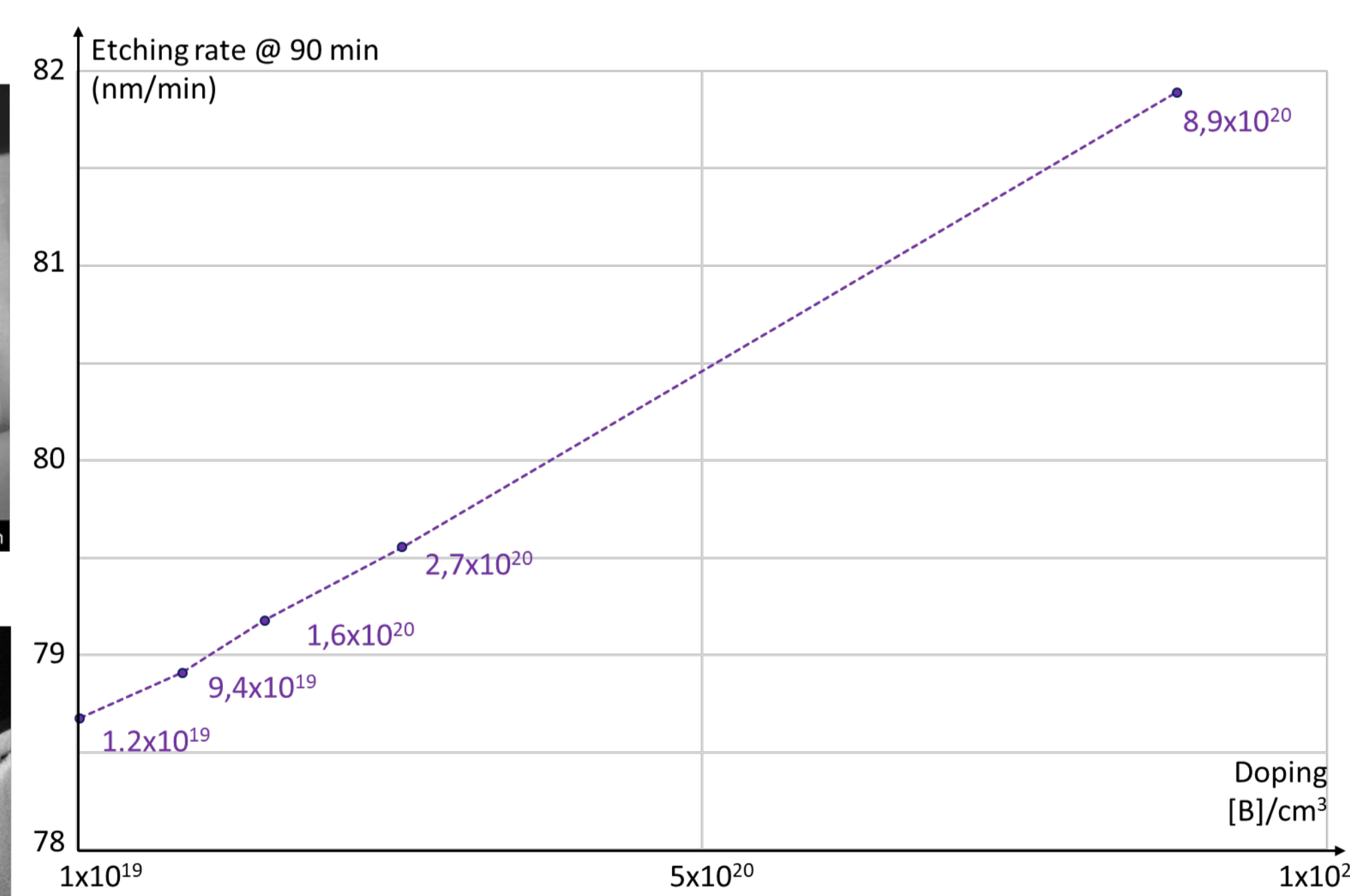
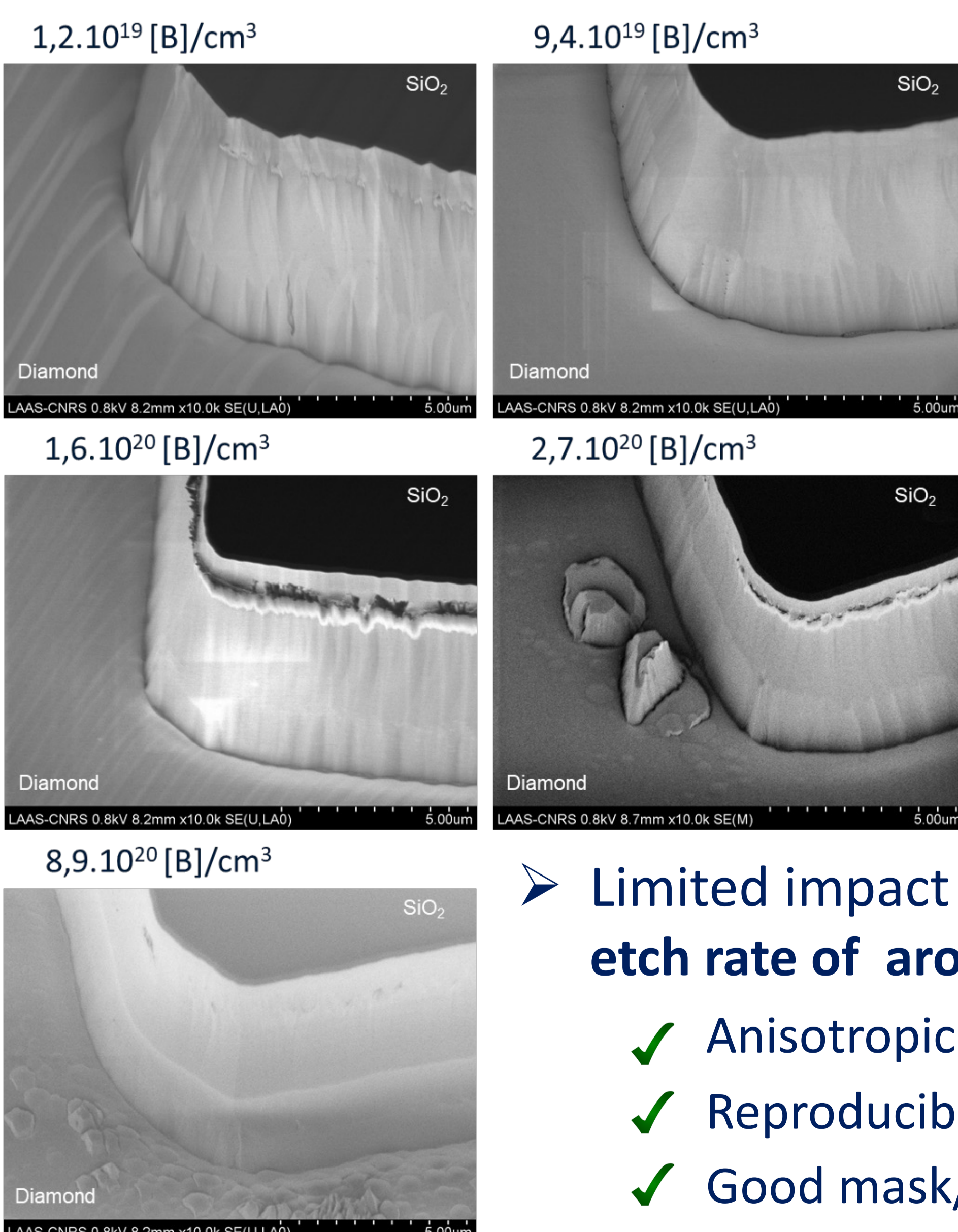
Etch time : 60 min



- Etch rate stabilization after 15 min etching on both 100 & 113 layers
- Higher etch rate for 113 NID layers due to a lower crystal quality and a higher roughness

O₂ etching of 113 layers for various [B] doping

(Etch time of 90 min in successive 15 min steps : etch depth around 7 μm)



Etching rate @ 90 min as a function of doping for 113 [B] doped diamond layers

- Limited impact of the doping :
 etch rate of around **80 ± 2 nm/min** from **10¹⁹ to 9 x 10²⁰ cm⁻³**
 - ✓ Anisotropic sidewalls
 - ✓ Reproducibility
 - ✓ Good mask/diamond selectivity
 - ✓ No surface roughness induced by etching
 - ✓ Low trenching
 - ✓ No micro masking

Conclusion

Influence of diamond crystallinity on plasma O₂ etching rate for 113 NID layers

Similar etching rates on 113 & 100 [B] doped layers:
80 nm/min (113) vs 70 nm/min (100)

Advantage of the SiO₂ inorganic mask for O₂ plasma etching

- Very high selectivity
- No micromasking effect
- Easily removable mask

Etching process suitable for deep etched layers and the manufacturing of bipolar devices on 113 diamond

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