



The Effect of Doping on the Digital Etching of Silicon-Selective Silicon–Germanium Using Nitric Acids

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1. *intrinsic Si selectivity with H₂O₂ or HNO₃ q-ALE*

Figure S1a and S1b show the SEM cross-section images of Sample II with the i-Si/i-SiGe/p⁺-Si laminated structure after etching with 30% H₂O₂ q-ALE and 31.5% HNO₃ q-ALE 50 cycles, respectively. The relative etch amount (REA) of SiGe/p⁺-Si with H₂O₂ and with HNO₃ is 24.8 nm (see Figure S1a) and 30.4 nm (see Figure S1b) respectively. The REPC with H₂O₂ is identical to the previous data. The REPC with HNO₃ is ~0.6 nm, higher than the previous value due to the increase of nitric acid concentration. It is shown in Figure S1a that the REA values of SiGe/i-Si with H₂O₂ and HNO₃ are identical, ~14 nm, smaller than that of SiGe/p⁺-Si, indicating poor selectivity to i-Si. This might be due to high reactivity of i-Si. It is illustrated that the selectivity of the digital etch SiGe to Si could be enhanced by doped Si.

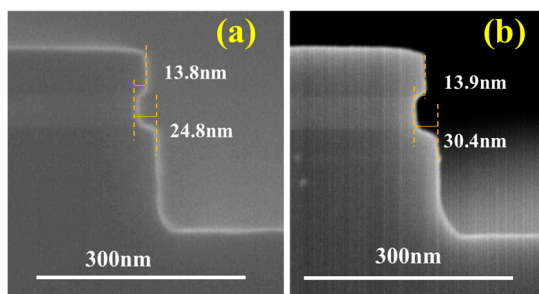


Figure S1. The SEM cross-section images of Sample II after digital etching at 50 cycles: (a) in 30% H₂O₂-dBOE q-ALE (b) 31.5% HNO₃-dBOE q-ALE.

2. *Dependence etch surface on HNO₃ concentration*

Figure S2 shows the SEM cross-section images of Sample I with the n^+ -Si/i-SiGe/ p^+ -Si laminated structure after HNO_3 q-ALE etching 50 cycles with varying HNO_3 concentrations. As shown, the relative etch amount (REA) of SiGe/ n^+ -Si increases first and then decreases with the increase of HNO_3 concentration. It is demonstrated that the selectivity of n^+ -Si is dependent on HNO_3 concentration.

It is shown in Figure S2a that the etched surface of SiGe is very rough at 25.5% HNO_3 concentration, indicating difficulty in etch reactivity. And, at 52% HNO_3 concentration, the rough surface might be due to etch damage. The significant etch damage could be observed in Figure S2d.

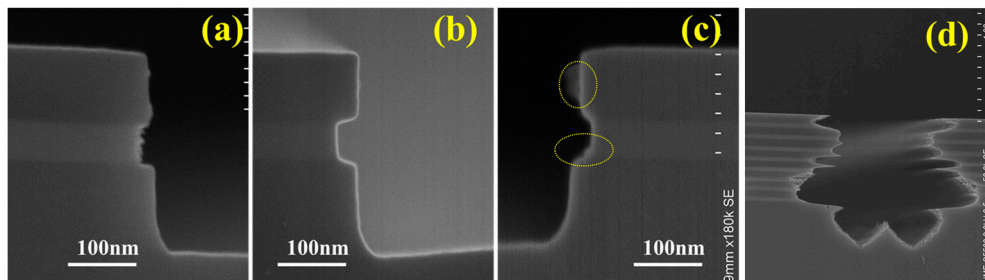


Figure S2. The SEM cross-section images of Sample I after HNO_3 digital etching at 50 cycles with varying HNO_3 concentrations: (a) 25.5% HNO_3 concentration (b) 36.5% HNO_3 concentration (c) 52% HNO_3 concentration, the etch damage is marked in the yellow dotted line. (d) significant etch damage at 52% HNO_3 concentration.