



Improvement of SPM Local Oxidation Nanolithography on Size Controllability of Si Oxide Wires

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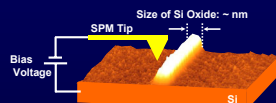


1. Introduction

◆ SPM Local Oxidation Lithography

→ Fabrication of Si Oxide Wire with Nano-Scales^[1]

[1] J. A. Dagata et al., Appl. Phys. Lett. 66, 2001 (1996).



Size of Si Oxide: ~ nm
Under SPM Tip: $H_2O \rightarrow H^+ + OH^-$ (Water Electrolysis)
Sample Surface: $Si + 2H^+ + 2OH^- \rightarrow SiO_2 + 2H^+$ (Anodic Oxidation)
[2] J. A. Dagata et al., Appl. Phys. Lett. 76, 2710 (2000).

◆ Previous Study

→ Size Dependence of Si Oxide Wires on Operation Mode with Different SPM Tips^[3]

[3] S. Nishimura, T. Toyofuku and J. Shirakashi, J. Phys. Conf. Ser. 61, 1066 (2007).

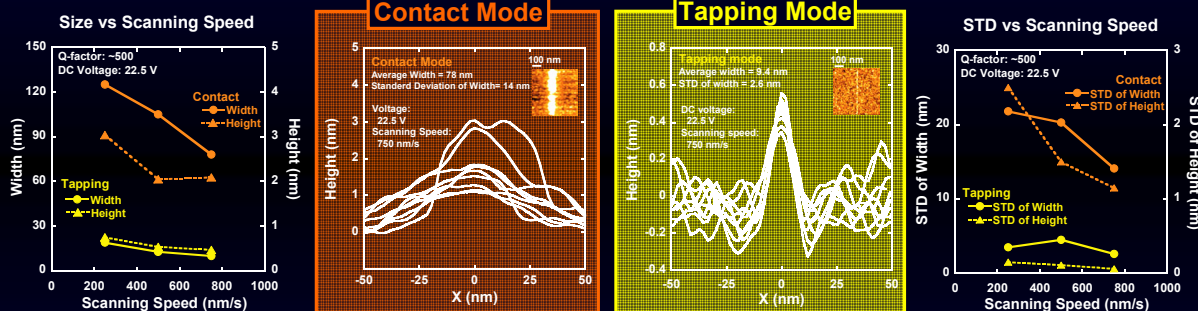
In this study

→ Contact and Tapping Mode Experiments
→ Same SPM Tip & Same Oxidation Condition
→ Analytical Model of Tapping Mode SPM Local Oxidation

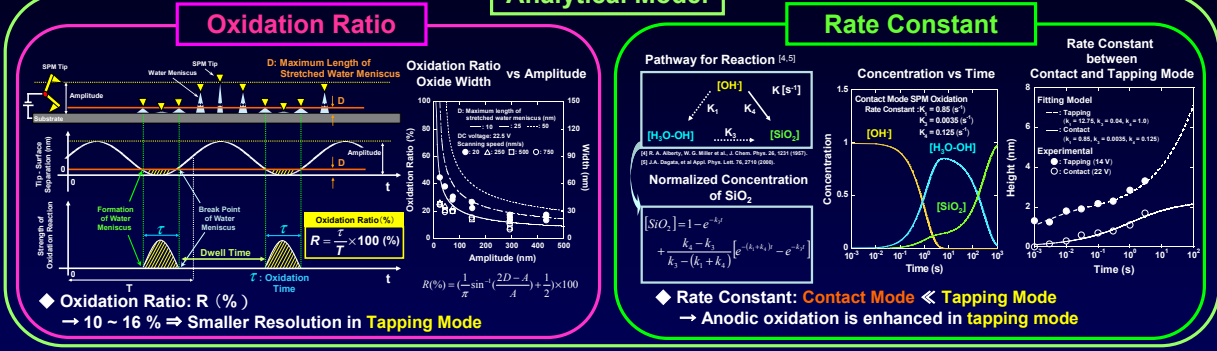
2. Experimental

Sample	p-Si(100), ~1kΩ·cm, HF-dipped, Surface Roughness: ~ 0.6 nm	
SPM Tip	Spring Constant: 42 N/m	Tip Radius: 7 nm 500 nm Tip Material: n ⁺ -doped Silicon
Operation Mode	Contact	Tapping
Applied Bias	DC	
Voltage	22.5 V	
Scanning Speed	250 ~ 750 nm/s	
Humidity	21 ~ 22 %	
Q-factor	—	~ 500
Amplitude	—	292 nm (Initial: 146 nm)

3. Size Dependence of Si Oxide Wires on Operation Mode



Analytical Model



4. Conclusion

1. Size Controllability and Uniformity

◆ Size Dependence of Si Oxide Wires on Operation Mode → Contact (Width = 78 nm, STD of Width = 14 nm)
Tapping (Width = 9.4 nm, STD of Width = 2.6 nm)

2. Analytical Model of SPM Local Oxidation

◆ Oxidation Ratio → Tapping: 10 % ⇒ Smaller Resolution
◆ Rate Constant for SPM Local Oxidation → Contact Mode < Tapping Mode ⇒ Stable Oxidation

3. Tapping Mode SPM Local Oxidation

◆ Experimental → V = 22.5 V, SS = 750 nm/s, A = 292 nm ⇒ 9.4 nm Width, 2.6 nm STD of Width
◆ Fitting Model → R = 10 %, K₁ = 12.75 (s⁻¹), K₃ = 0.042 (s⁻¹), K₄ = 1.0 (s⁻¹) ⇒ Smaller Resolution, Stable Oxidation