

新計測技術一Ⅱ

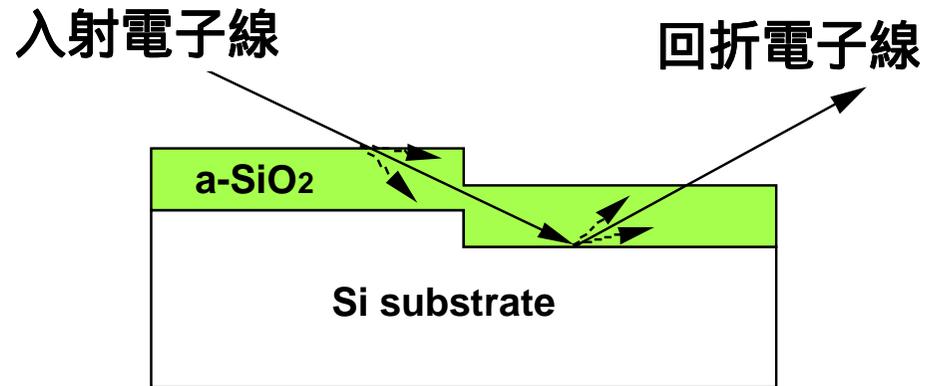
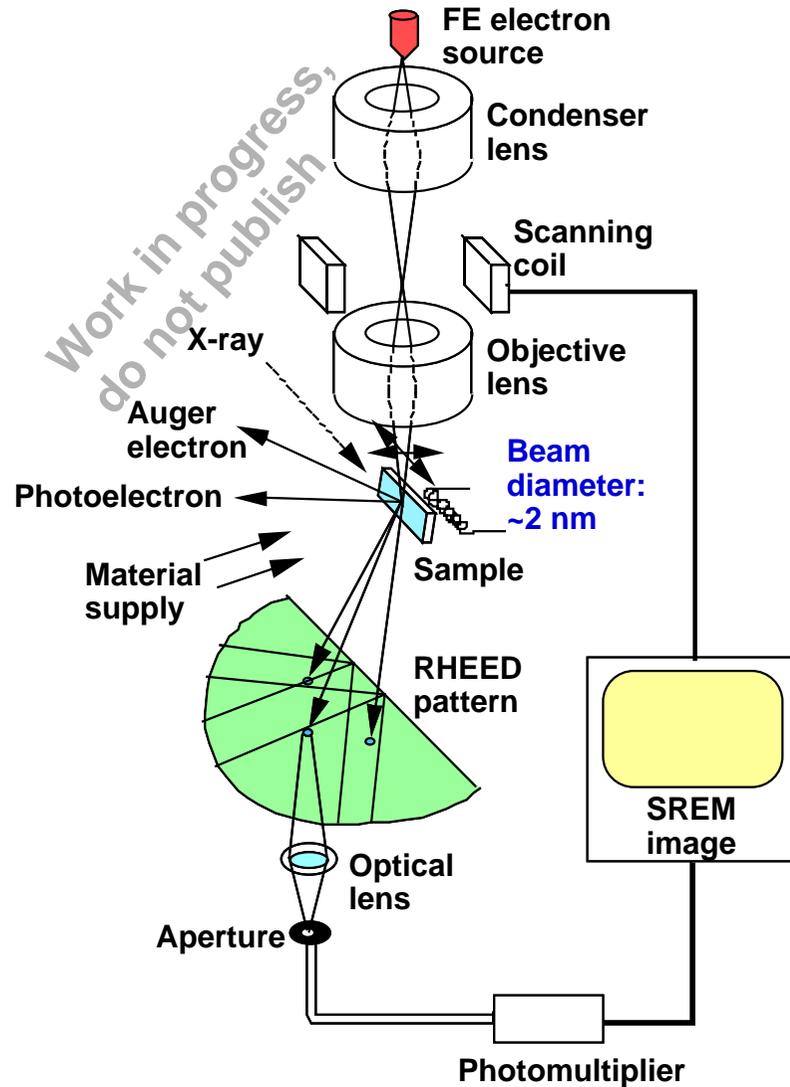
新原理計測技術

Work in progress,
do not publish

- 表面科学の測定法
 - 1) SREM, 2) RDS
- SPM(走査プローブ技術)の利用
 - 1) STM/STS: 絶縁膜欠陥、不純物分布
 - 2) Conductive AFM
- 原子・ナノレベルの材料解析技術
 - 1) ESR, 2)陽電子消滅

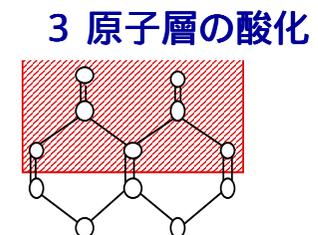
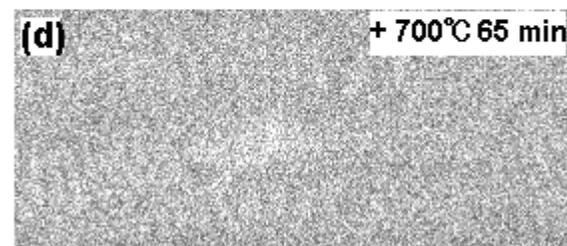
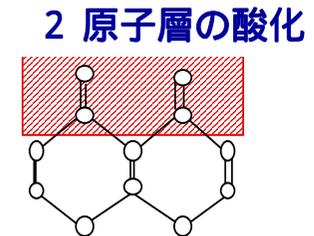
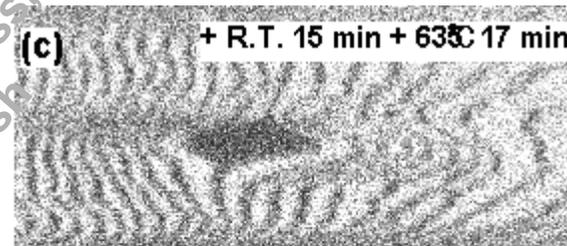
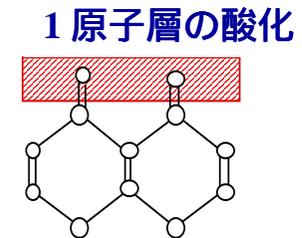
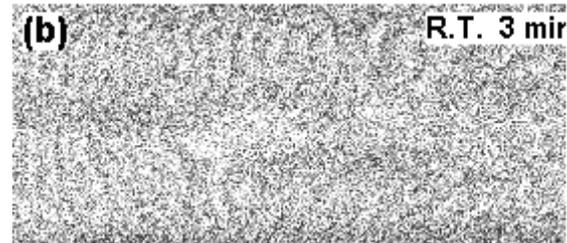
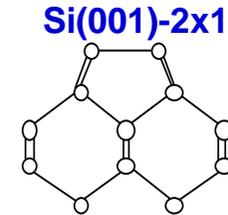
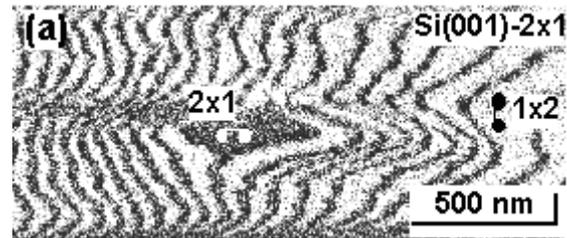
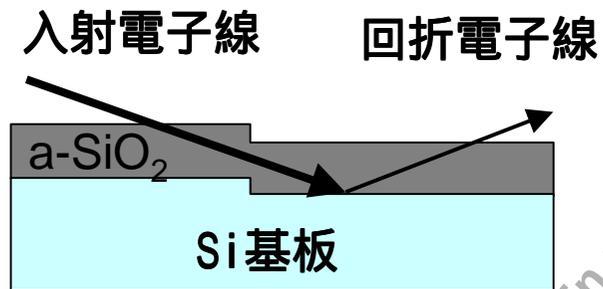
SREM

Scanning Reflection Electron Microscope, 走査反射電子顕微鏡 による界面の観察



SiO_2/Si 界面の観察

SREMによる酸化過程の観測

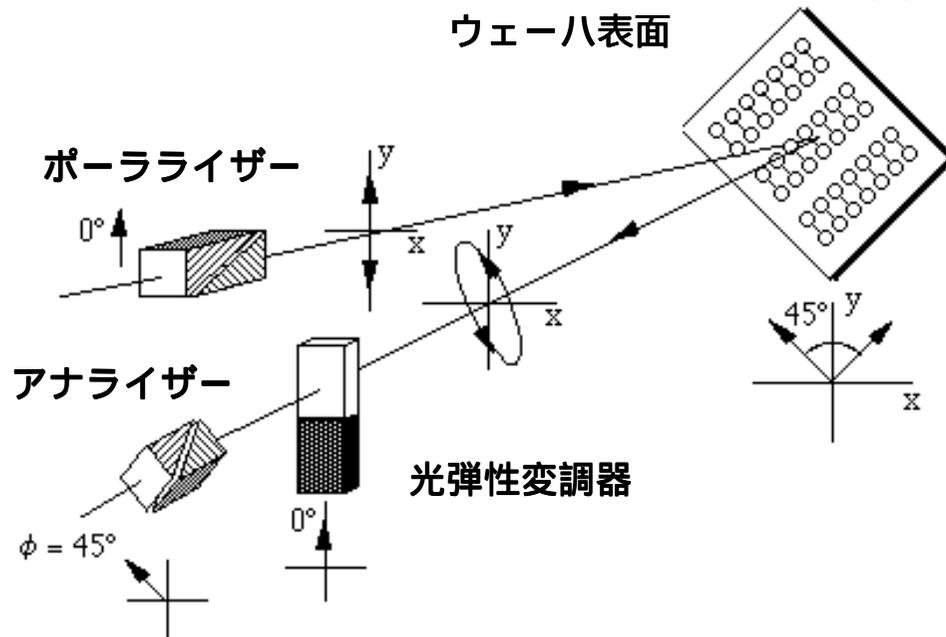


Siの酸化過程

渡辺、市川、他: *PR L* 80, 345 (1998)

RDS

Reflectance Difference Spectroscopy 反射率差分法 による原子層酸化観察

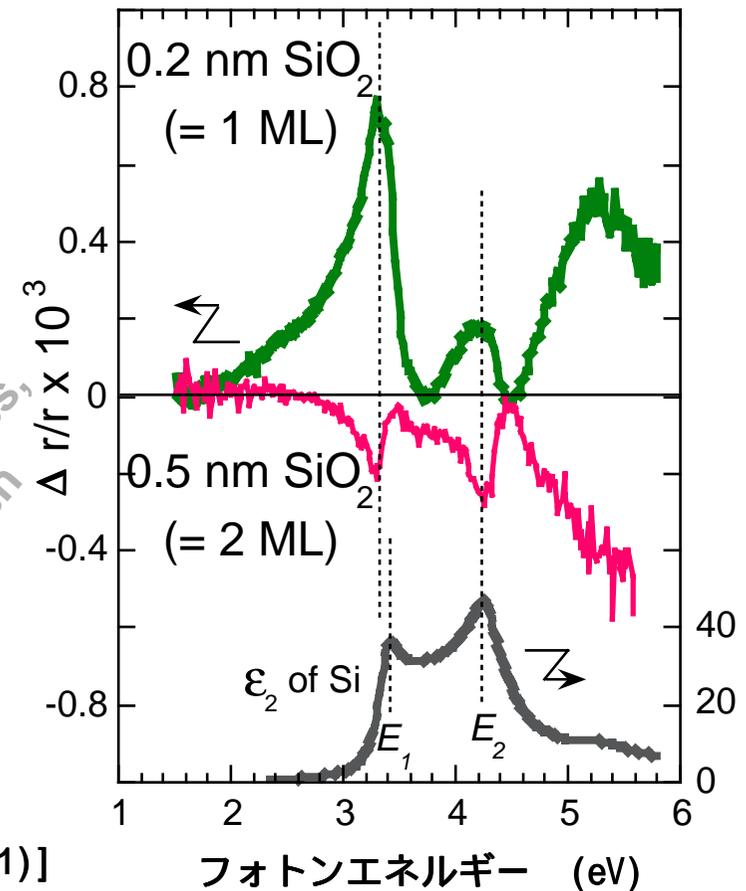


$$\frac{\Delta \tilde{r}}{\tilde{r}} = \frac{\tilde{r}_{-110} - \tilde{r}_{110}}{(\tilde{r}_{-110} + \tilde{r}_{110}) / 2}$$

光の反射率の偏光方向に依存する成分を測定

[Yasuda *et al.*, Phys. Rev. Lett. 87, 037403 (2001)]

原子層酸化に伴うRD信号の反転



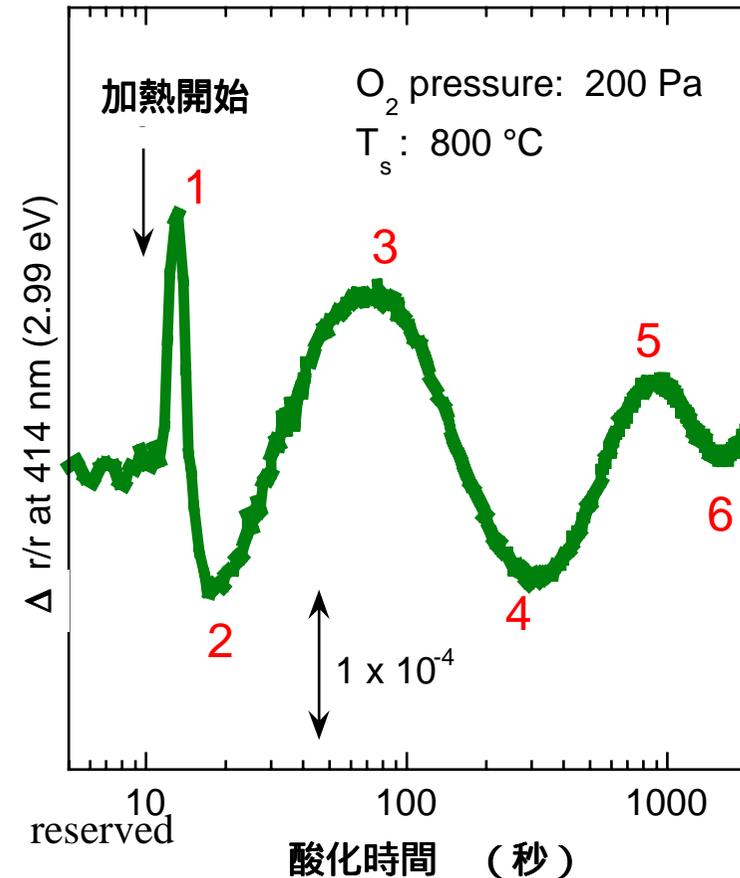
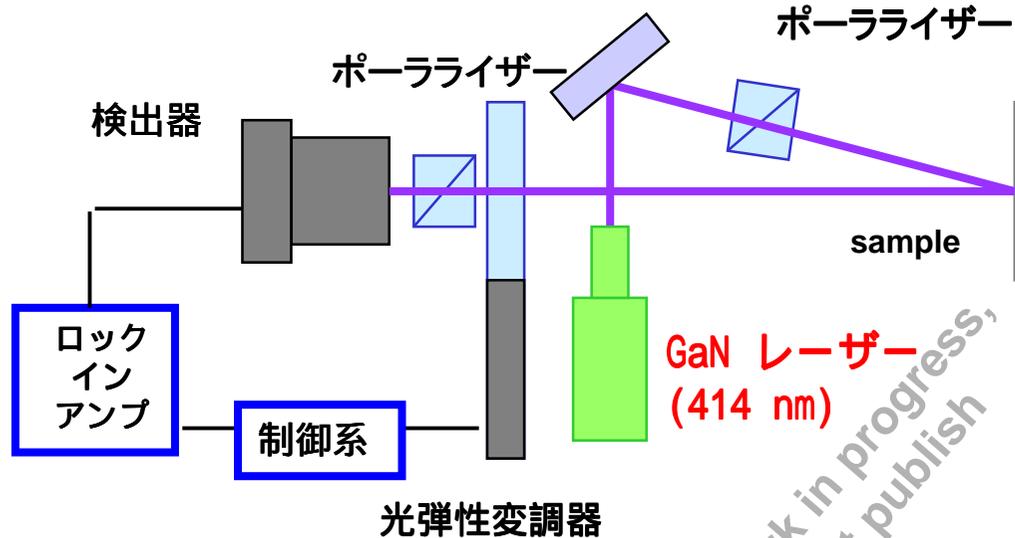
Work in progress,
do not publish

RDSによるSi(001)酸化速度の原子層精度測定

- GaN レーザーを光源とした、**シンプルかつ高S/Nの測定系**開発
- Si(001)酸化速度の層分解計測に初めて成功

例) 酸化反応の活性化エネルギー : 2層目は1.1 eV ; 3層目は2.0 eV

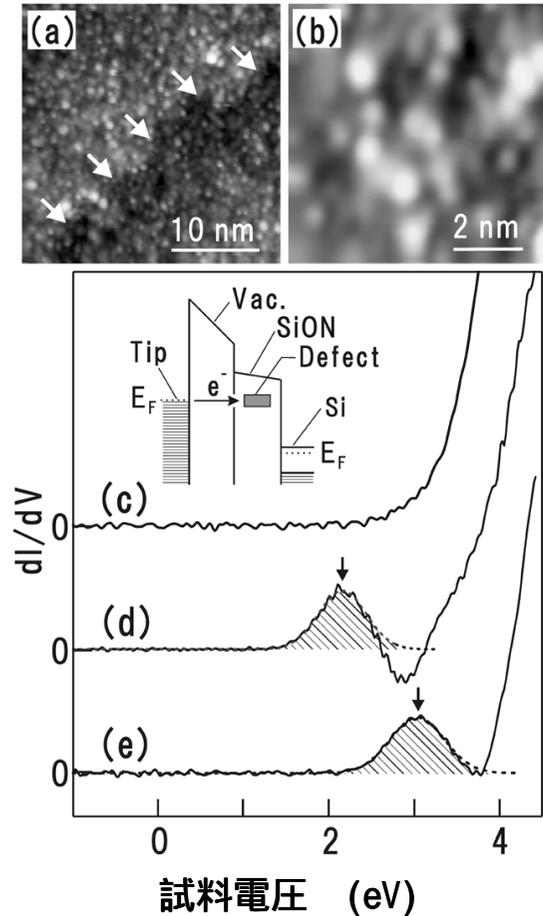
LSIプロセスで利用できる基礎データ



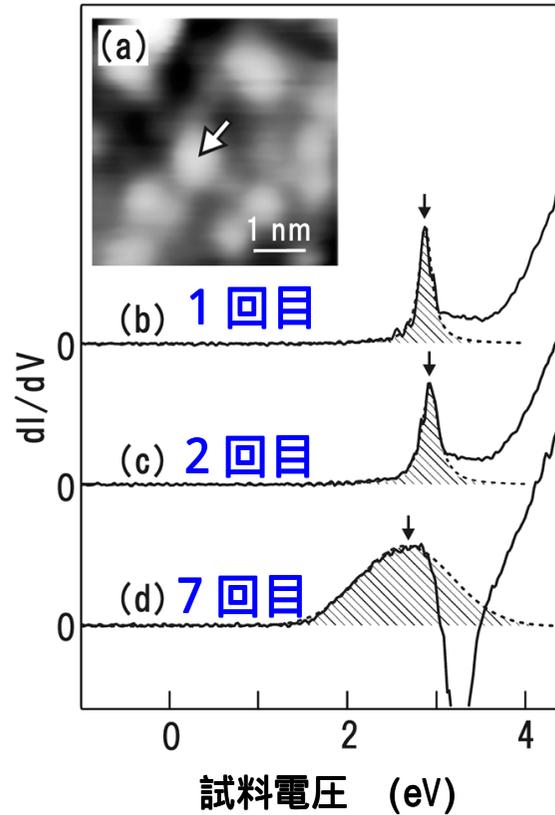
STM/STS

Scanning Tunneling Spectroscopy

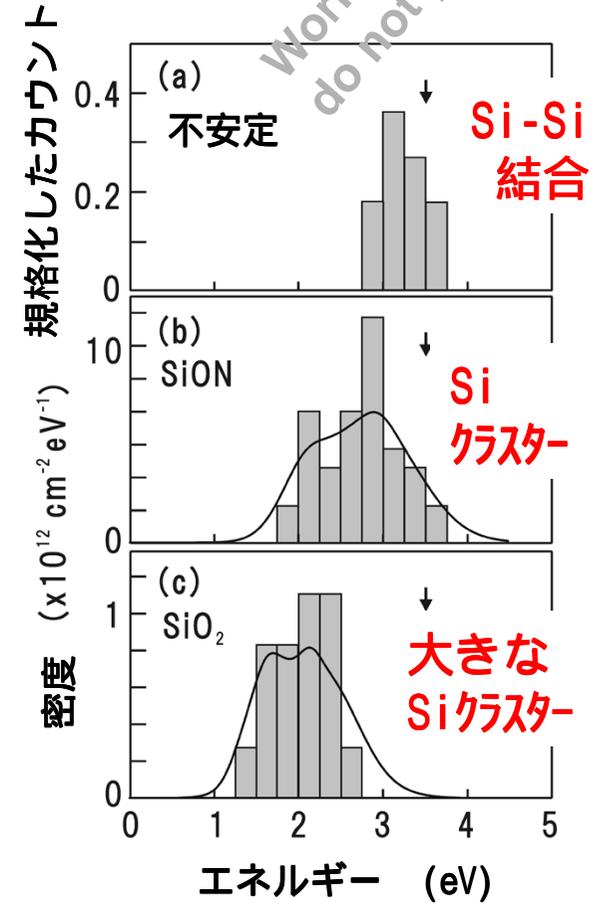
極薄Si酸窒化膜中の原子スケール欠陥の評価



SiON膜のSTM像と
STS(dI/dV)



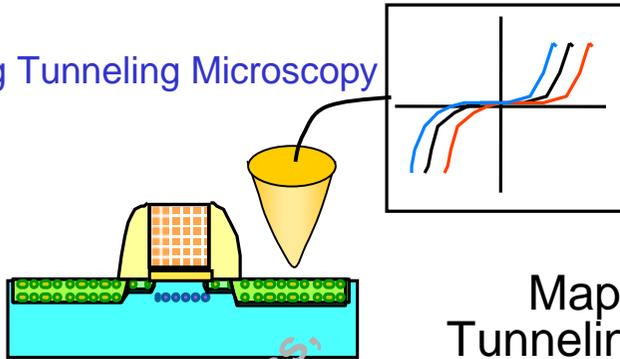
不安定な欠陥における
 dI/dV



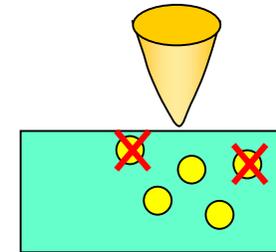
欠陥状態の
エネルギー分布

Impurity Profile Measurement by STM/STS

Scanning Tunneling Microscopy



Theoretical Model



Location of Active Impurity Atoms

Mapping of Tunneling Current-Voltage Characteristics

Work in progress,
do not publish

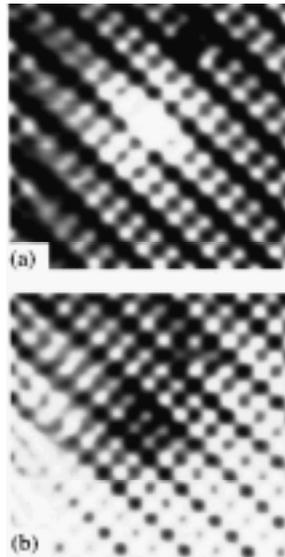


FIG. 1. (a) Filled state ($V_{\text{sample}} = -2$ V) and (b) empty state ($V_{\text{sample}} = +2$ V) topographic images of a boron-induced feature on the Si(100)2x1:H surface. The feature appears as a hill in (a) and a local depression in (b). Both images are 50 Å x 50 Å and were obtained at a tunneling current of 8.05 nA.

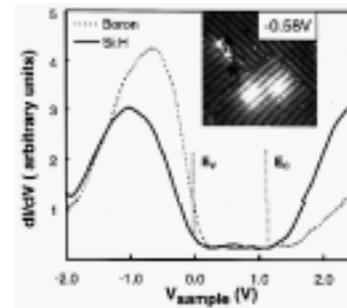


FIG. 3. CITS dI/dV spectra of a boron-induced feature and of the Si(100)2x1:H surface. The dotted line is measured at the corner of one of the boron-induced features, and the solid one is measured in the Si(100)2x1:H region with E_v and E_c indicated by vertical dashed lines. The inset shows the dI/dV spectroscopic image obtained at a sample bias of -0.58 V. Two boron-induced features appear as the two hillocks.

by Lequn Liu, Jixin Yu, and J. W. Lyding

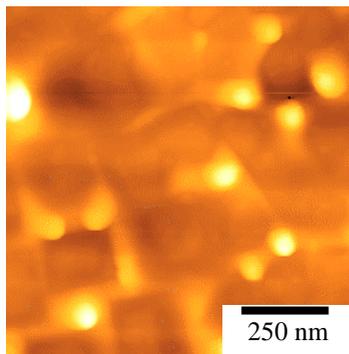
Appl. Phys. Lett. **78** (2001) 386

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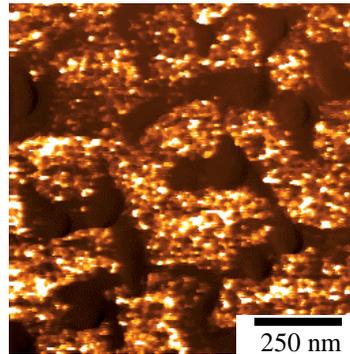
Conductive AFM

コンダクティブAFMを用いたリンドープ多結晶シリコン薄膜の形状・電気特性同時評価

Conductive AFM

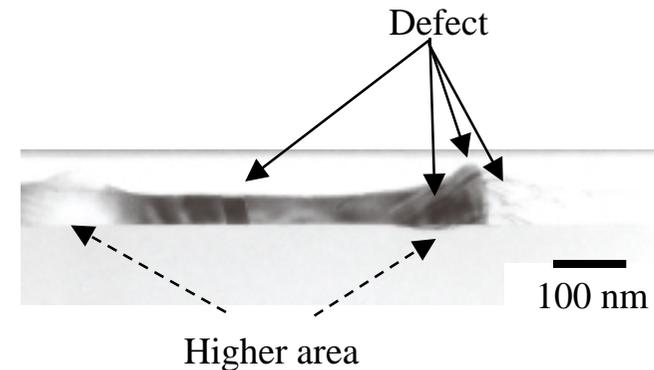


(a) Topography
(Black- White is 0-50nm)



(b) Current image
(Black- White is 0-36pA, sample bias 0.5V)

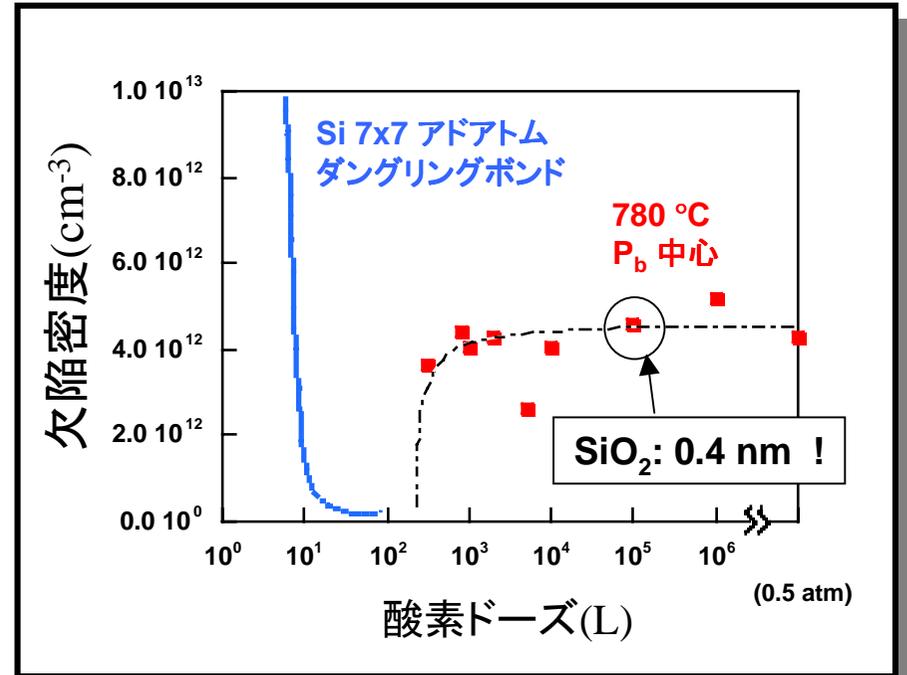
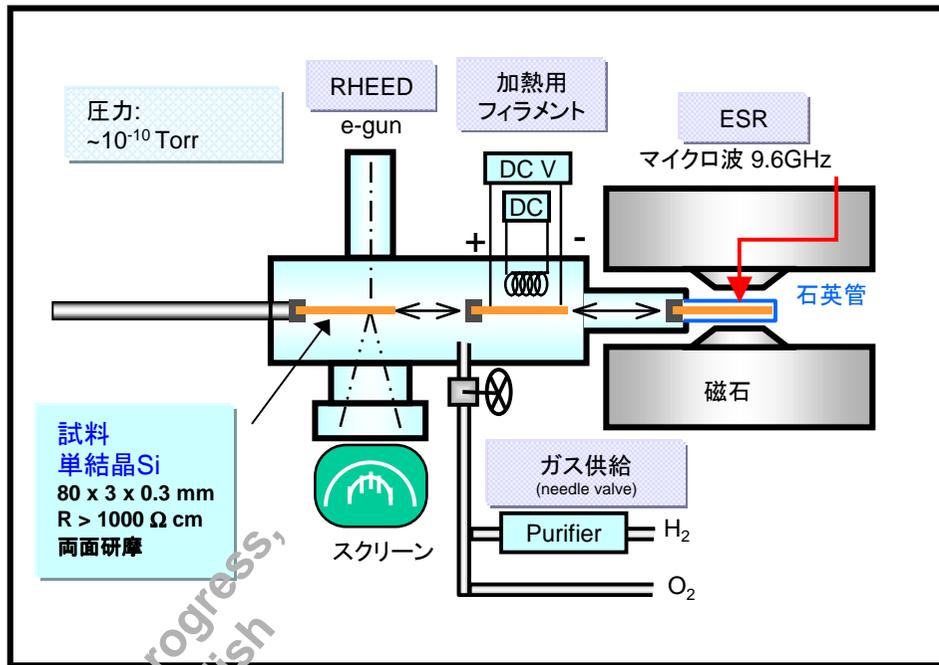
TEM image



Results

1. Higher areas in topography are less conductive than bottom areas.
2. Higher area contains a lot of structural defects.

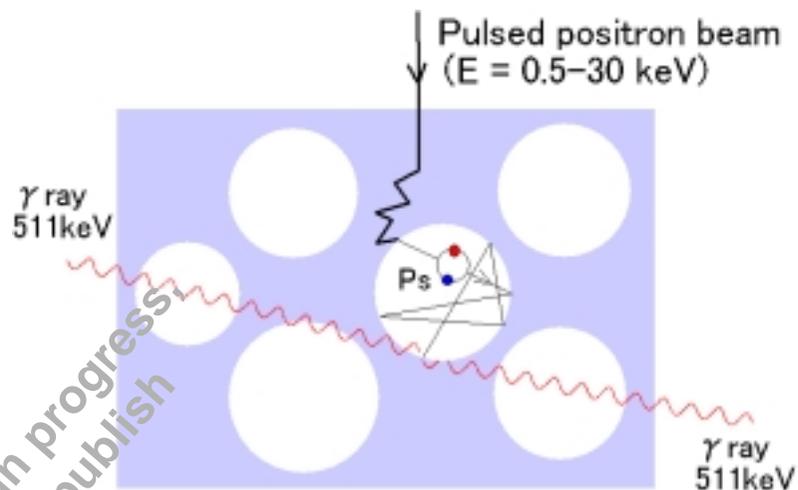
超高真空-ESR (Si 酸化過程のESRその場観察)



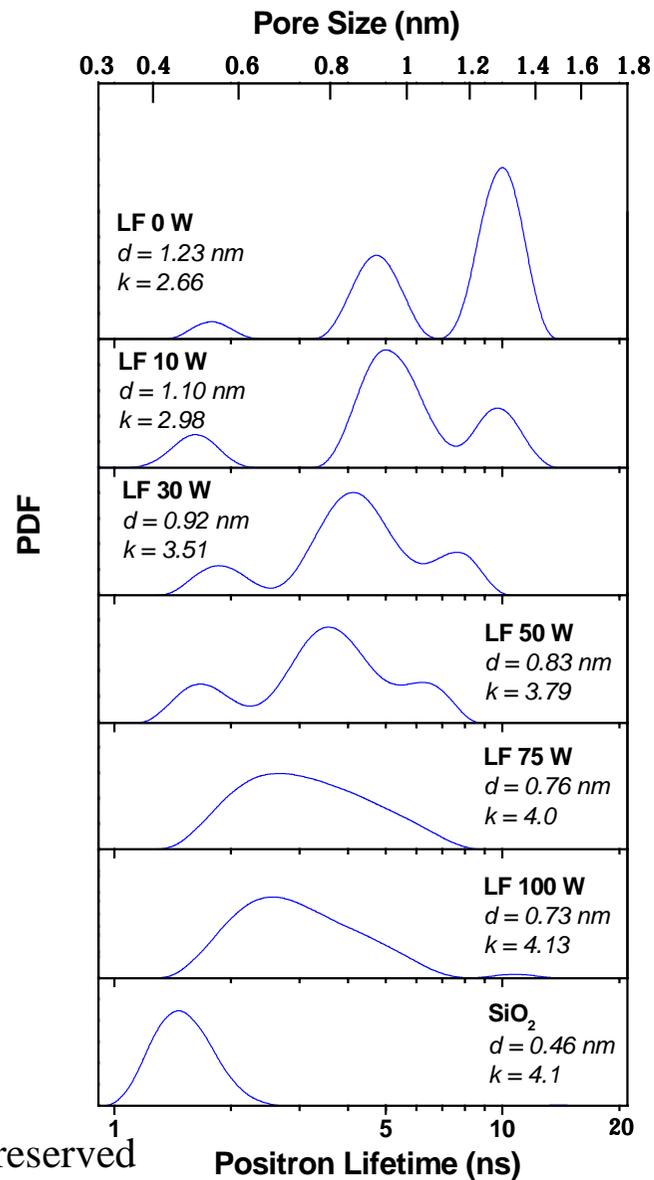
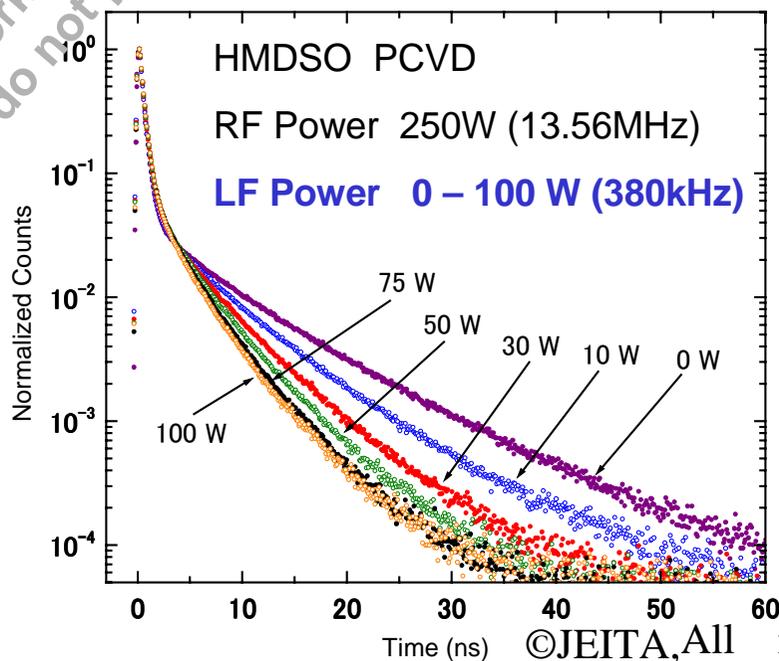
- Si酸化過程に発生する表面界面欠陥状態のその場観察に成功
- 界面欠陥発生の様子を見ながらのプロセス制御

Positron Annihilation

Determination of pore size from annihilation lifetime of positronium



Work in progress
do not publish



新計測技術一 II

新原理計測技術

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 - 1) 電子ビーム: SREM, 2) 光: RDS
- SPM(走査プローブ技術)の利用
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- 原子・ナノレベルの材料解析技術
 - 1) ESR, 2) 陽電子消滅

特長: 原子・ナノレベルの高分解能、特定の情報の抽出

課題: 実用性、信頼性、スループット、経済性