Coupling of STM with Hard X-ray μ-Beam from 27m Long Undulator at SPring-8

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Collaborators

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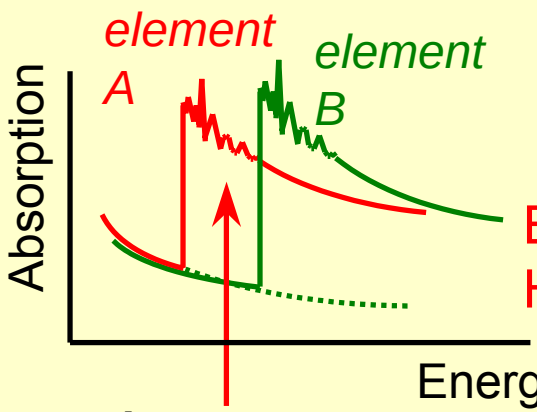
2005. Nov. 17 @ X-tip Workshop, Grenoble

Concept of SR (Synchrotron Radiation)-STM

STM + Inner-Shell Excitation by SR → STM + analysis of chemical species

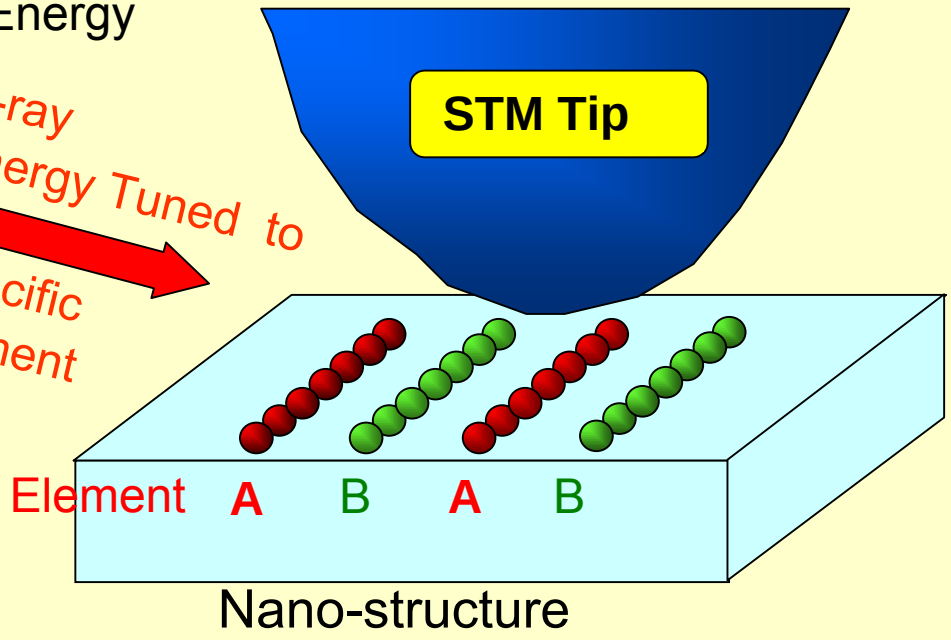


Energy Tunability
High Brilliance

Monochromator

White Beam

X-ray Energy Tuned to Specific Element



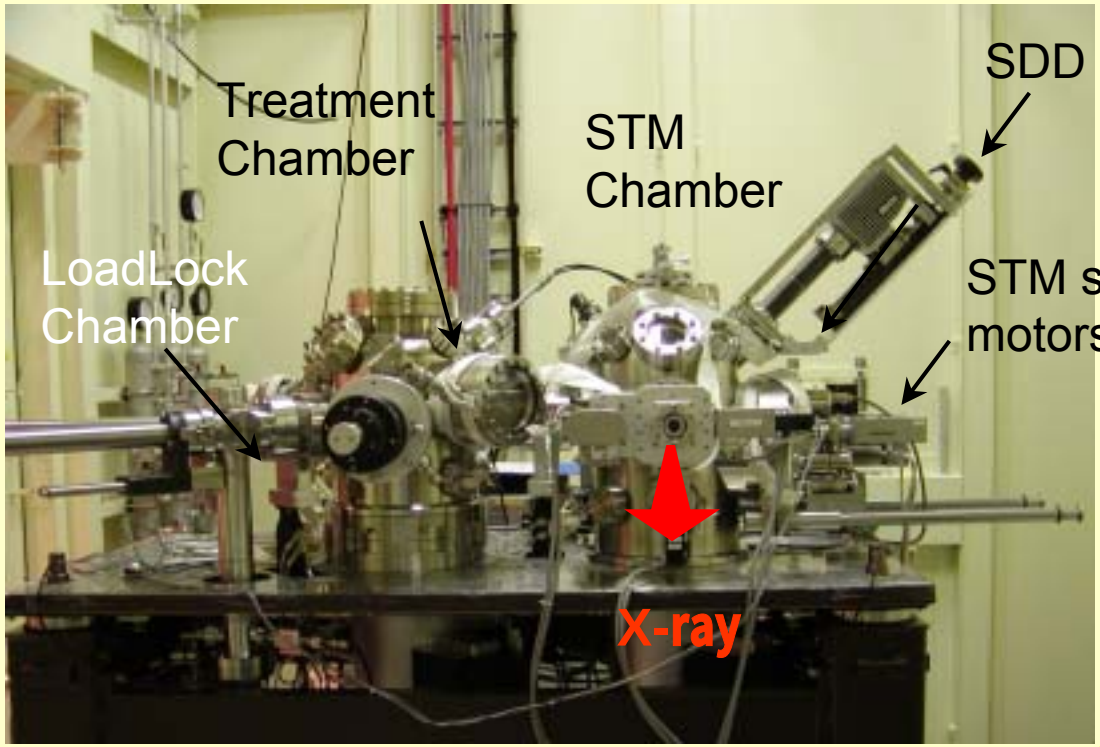
Key: high S/N ratio

High Brilliance
Small Beam
@ STM observation point
fast alignment, in UHV

A.Saito et al. : JJAP(2006), in press

UHV Chamber @BL19LXU, SPring-8

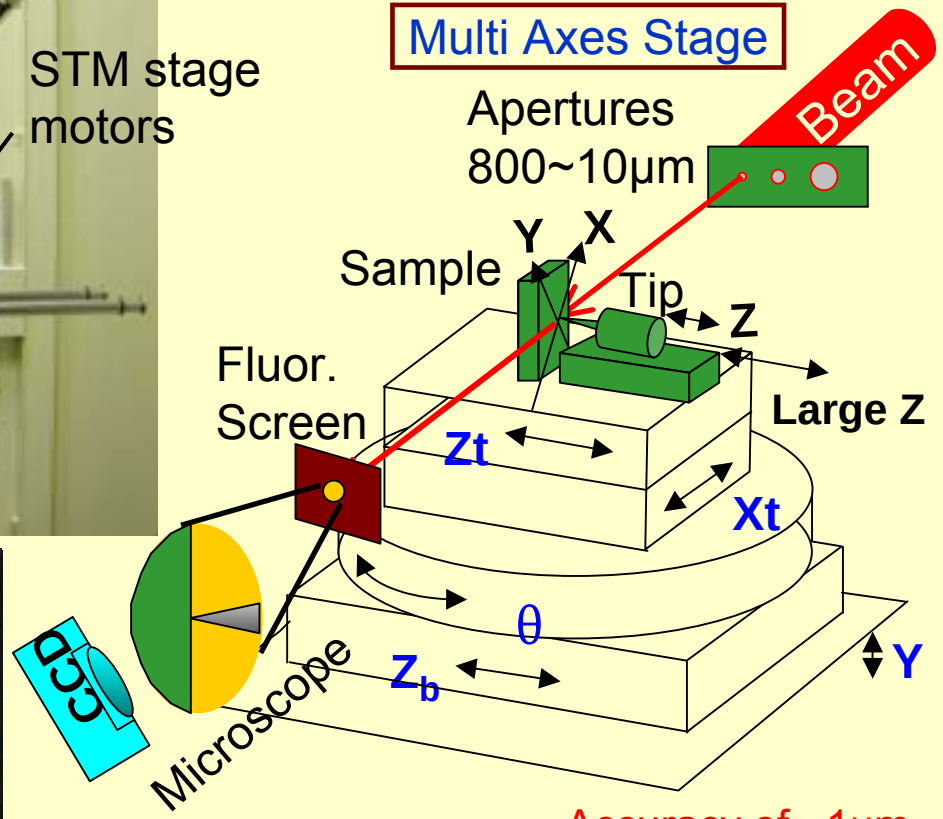
A.Saito et al. : J.of Synchrotron Rad. (2006), in press.



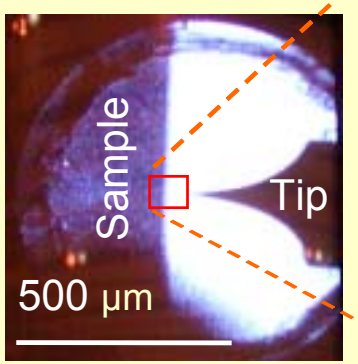
Fluorescence Monitor

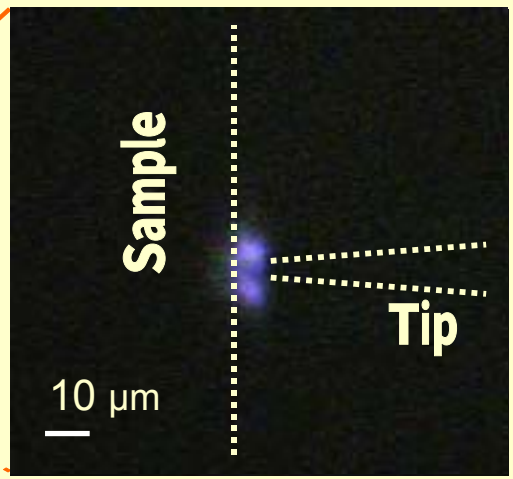
Adsorbate, Tip Align] check

Multi Axes Stage



Coarse align





Position Monitor

Silhouette

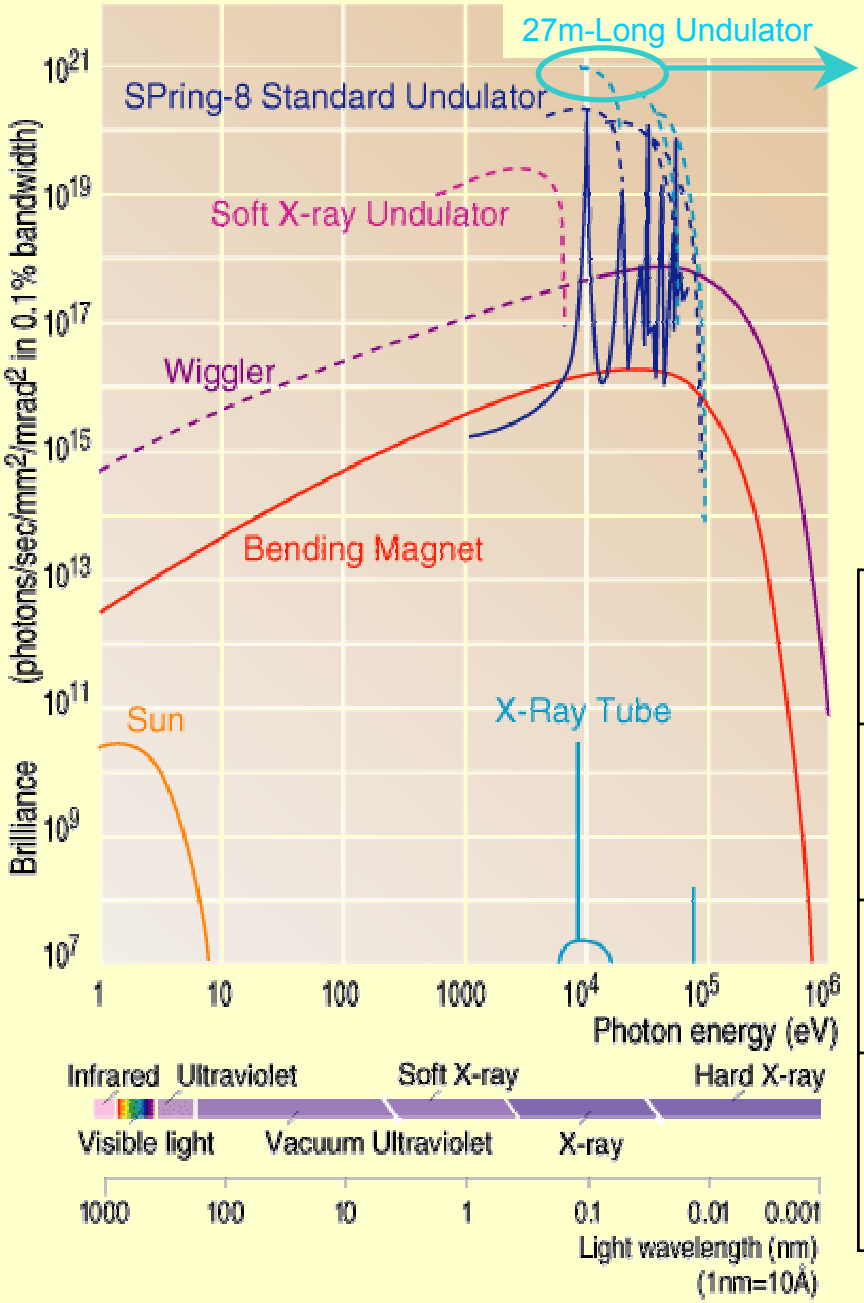
→ Real-time monitor

Accuracy of ~1μm

Fast Align

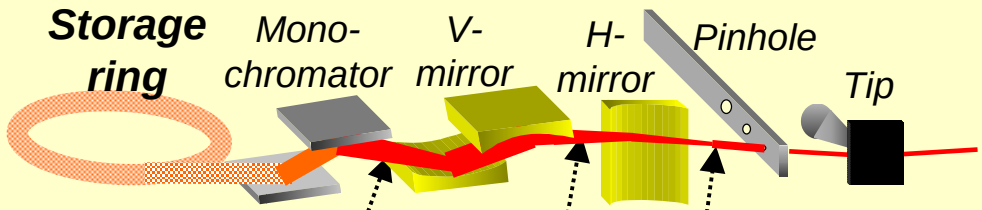
(as diffraction exp.)

Light Source

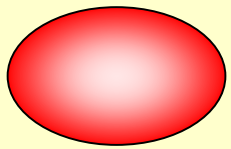
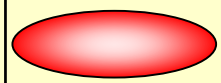


Brilliance: ~1×10^{21} (photons/s /mrad^2/mm^2/0.1% b.w./100mA)

Energy range: 7.2~18(keV)



Photon Density @ each step

From Upstream	Only wtih Mono	Vertical Focus	Horizontal Focus	After Pin-hole
Beam Shape				
Beam Size (@ sample)	1000 x 500 (H x V μm)	1000 x 200	50 x 200	10 x 10
Photon density (@ sample)	4 x 10^{14}	1 x 10^{15}	1 x 10^{16}	1 x 10^{16}

(photons/s/mm^2/0.1% b.w./100mA)

How the irradiation affects to STM observation ?

In-situ observation w/atomic resolution is possible @ BL19

Beam On/Off ➔ Bright & Dark Contrast

Vs=-2V, It=0.3nA (Const. Current mode＝ contrast is based on Tip motion)

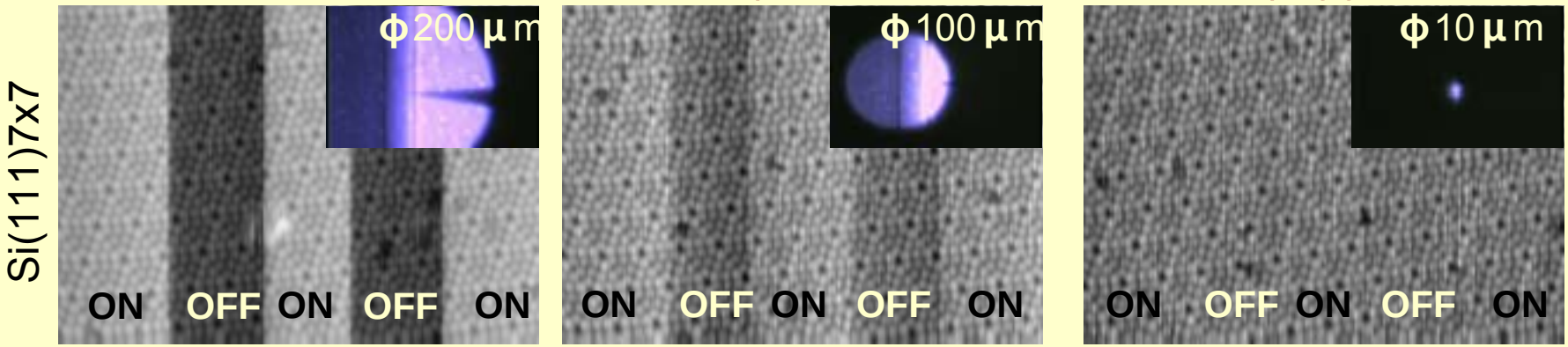
Reduction of the contrast (noise)

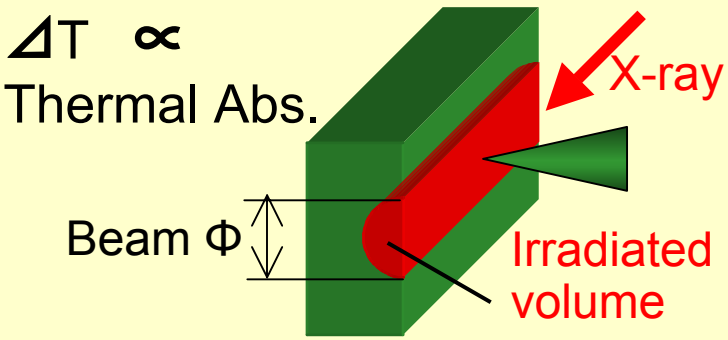
(Incident Energy 16.5 keV, angle 1.5 °)

Beam Size Φ200μ m → Φ 100μ m → Φ 10μ m

Emission Yield 1/2 1/20

Thermal Abs. 1/4 1/400





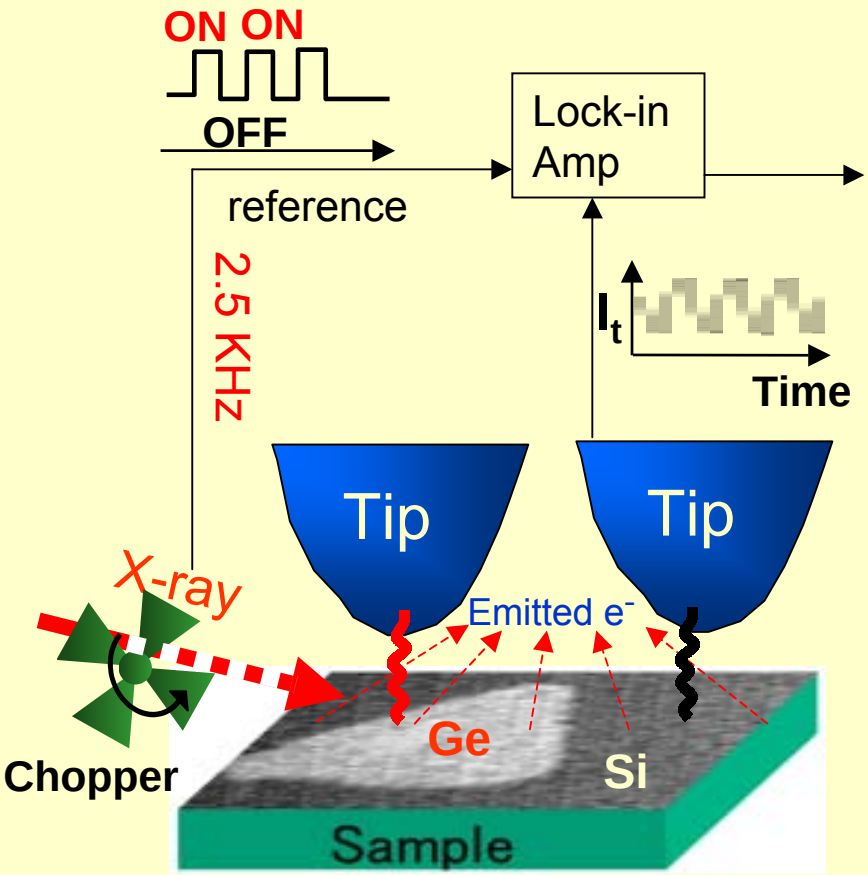
Contrast is dominated by Thermal Expansion

- Reduction of the Beam size to Φ 10 μ m,
  ➔ the contrast was removed effectively.
- For higher S/N ratio with Focus Beam,
  ➔ total reflection condition is important.

Elemental Analysis - Mode 1. Point spectra

Tip=fixed, Energy=scanned

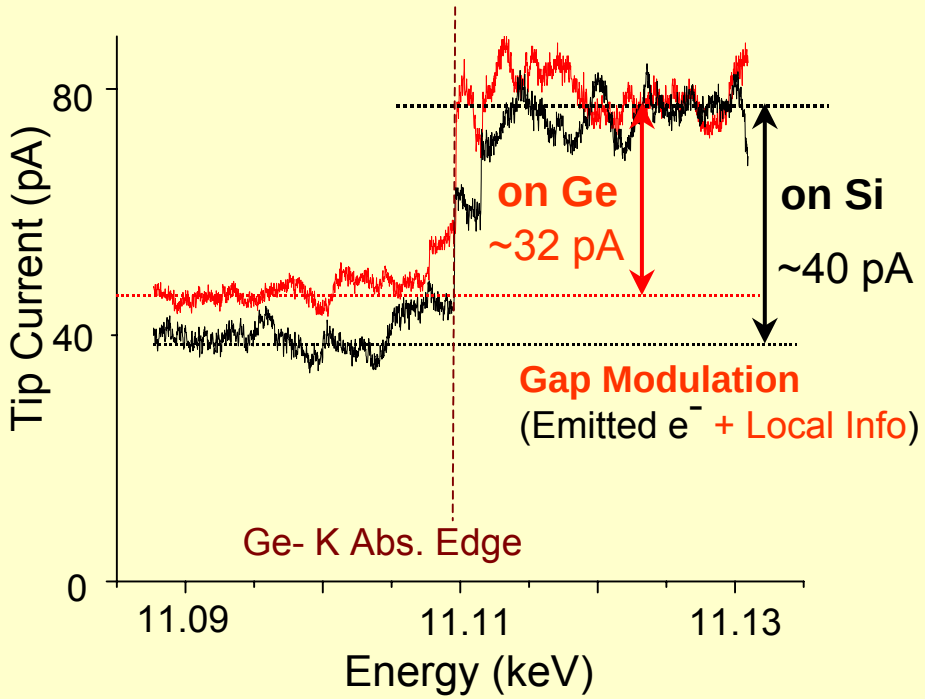
A.Saito et al. : JJAP(2006), in press

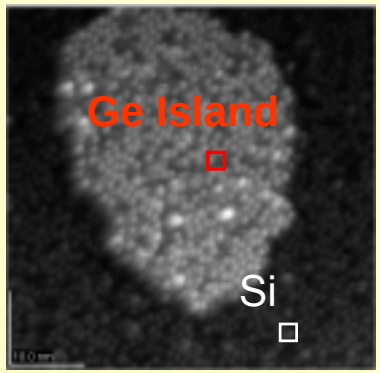


Tunneling Condition

(Tip Current =
Emitted e⁻ + **Tunneling Current**)

A.Saito et al. : J.of Synchrotron Rad. (2006), in press.





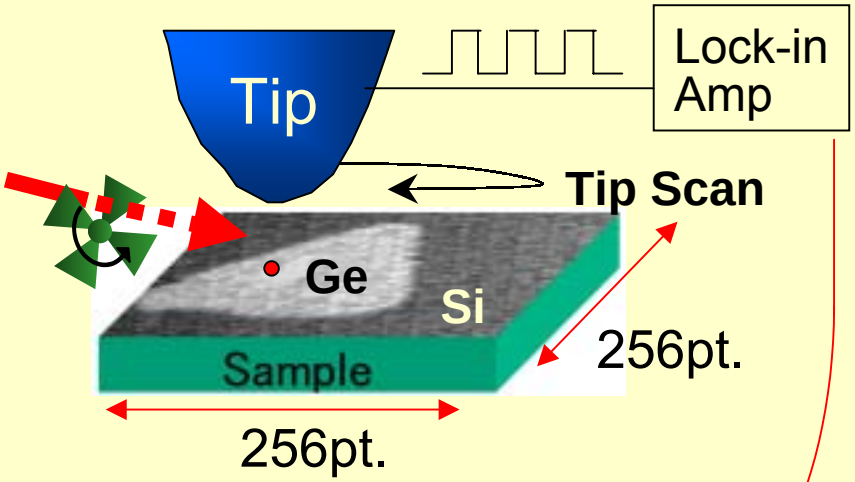
35x35nm,
Vs=-2.0V, It=0.3nA

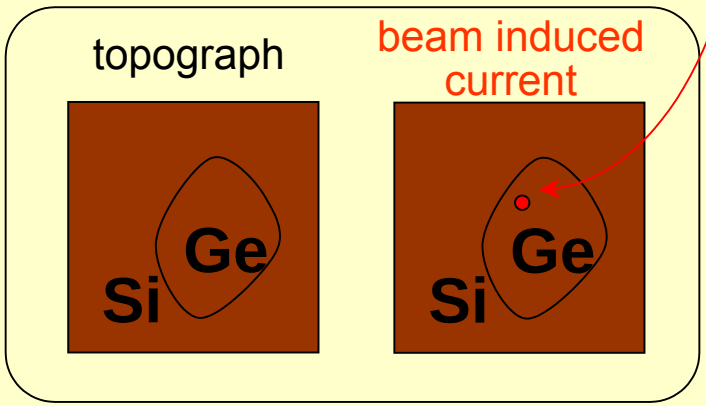
Ge nanoisland on Si(111)

Elemental Analysis - Mode 2. imaging

Tip= scanned, Energy= fixed

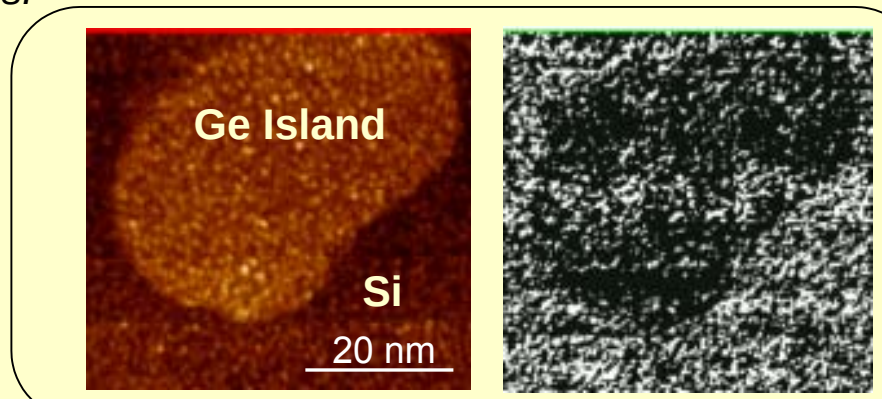
A.Saito et al. : J.of Synchrotron Rad. (2006), in press.



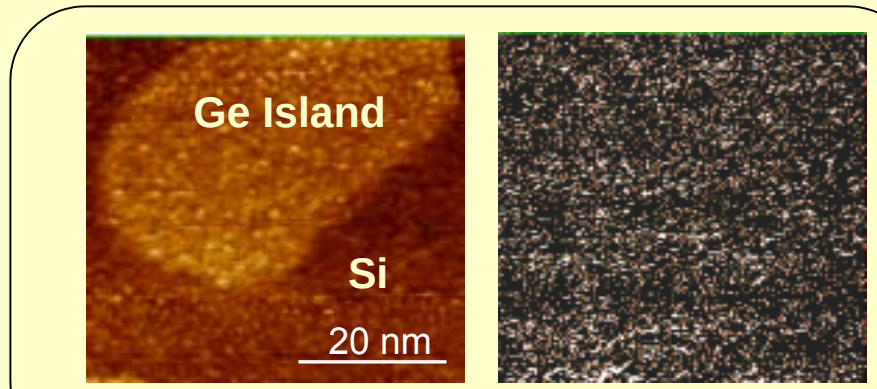


Topograph Beam Induced Image

11.114keV



11.090keV



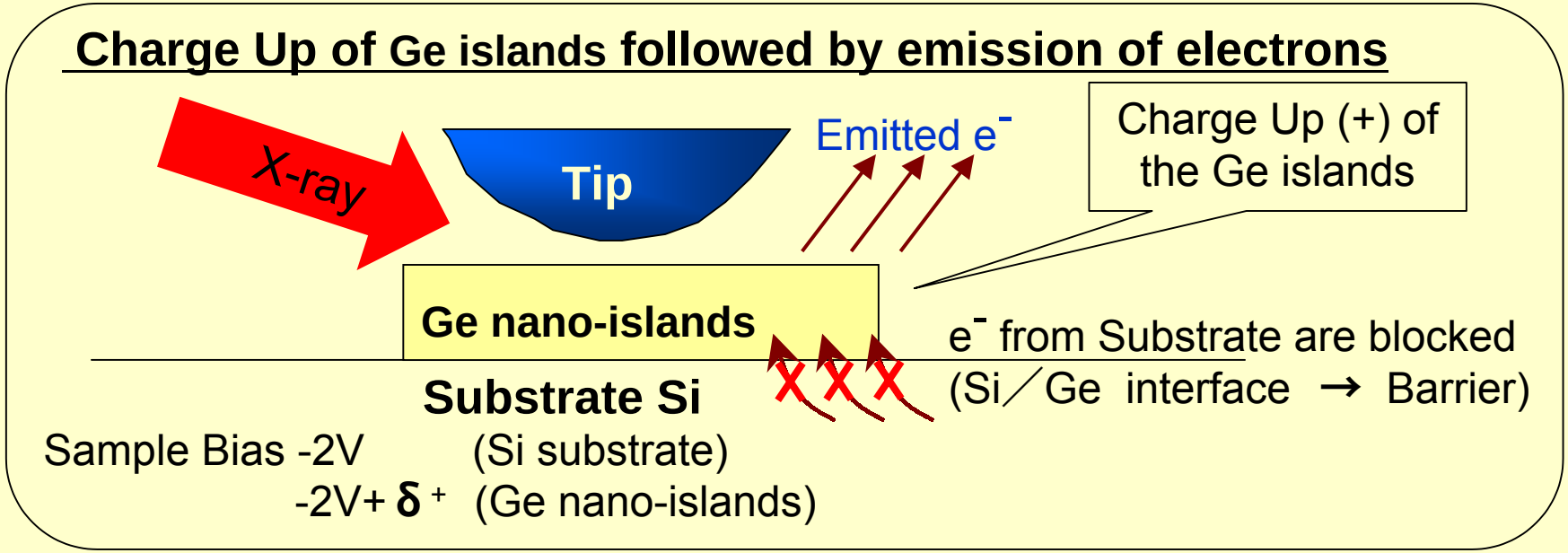
Vs=-2V,It=0.5nA,50×50nm^2

One-point spectra (previous page)

⇔ agreement

Ge nano-islands look dark only for the Tip Current Image @ higher energy.

Possible Origin of the Feature



Conclusion

-Specific change of the Tunneling signal between the Ge nano-islands and the surrounding Si surface was observed across the Ge absorption edge. Spatial resolution is < ~10 nm.

-Independently obtained data (One-point Spectra & Tip-Current Image) were in good agreement with each other.

c.f. Reproducibility was confirmed

-The phenomenon cannot be explained by emitted electrons.