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Update on SFET Optics Contamination Learning

- Analysis of carbon contamination -

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This work was supported by NEDO

Small Field Exposure Tool : SFET

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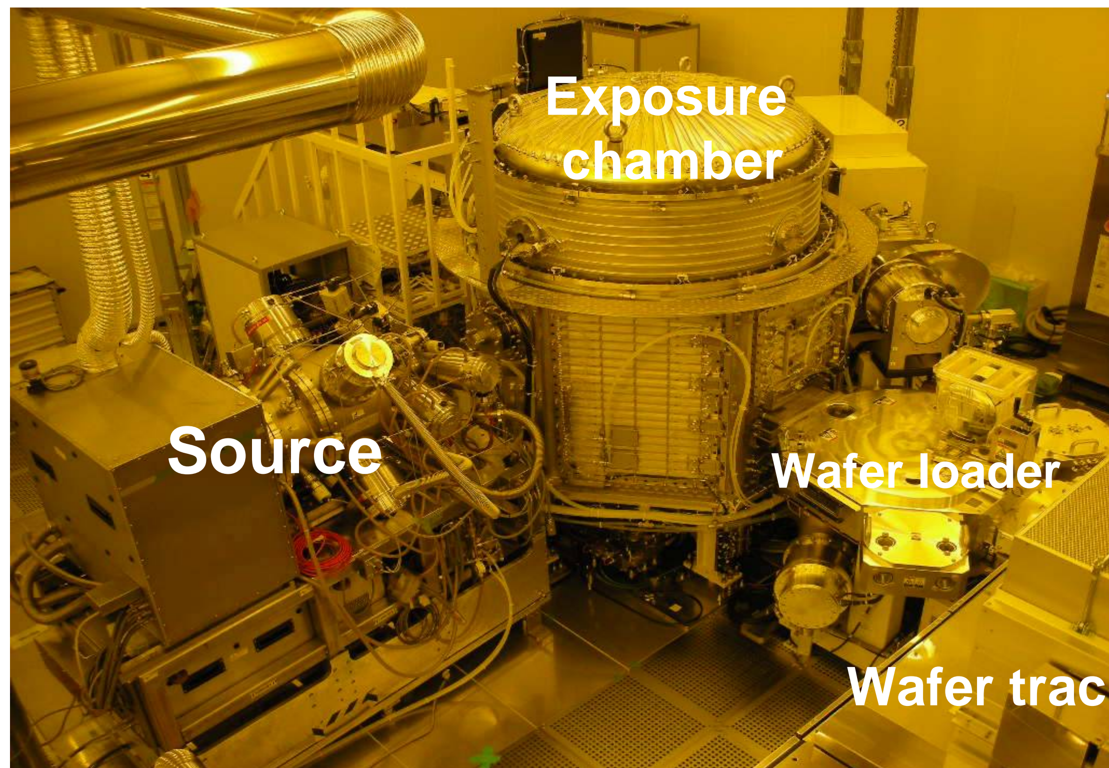
Purposes

- Optimize mask structure
- Develop resist materials
- Evaluate optics & source lifetime

Items	Specification
NA	0.3
Field size	0.2 x 0.6 mm
Magnification	1/5
Wafer size	300mm



SFET Illumination Optics

SA1, SA2

SG1

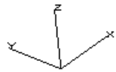
PO

SG2

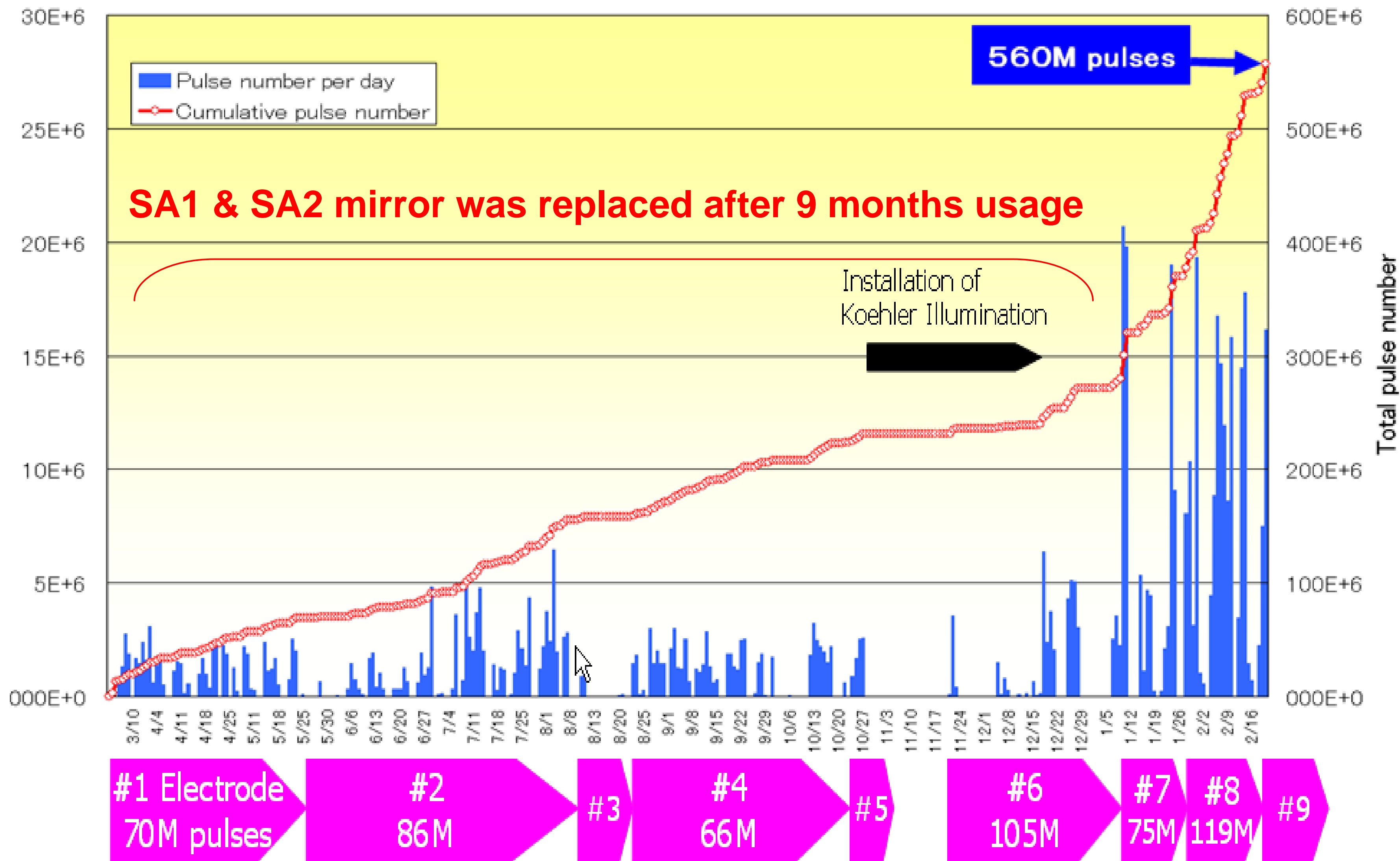
IF

EUV Source

Supported by NEDO



SFET Operation Log



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Analysis of SFET optics contamination

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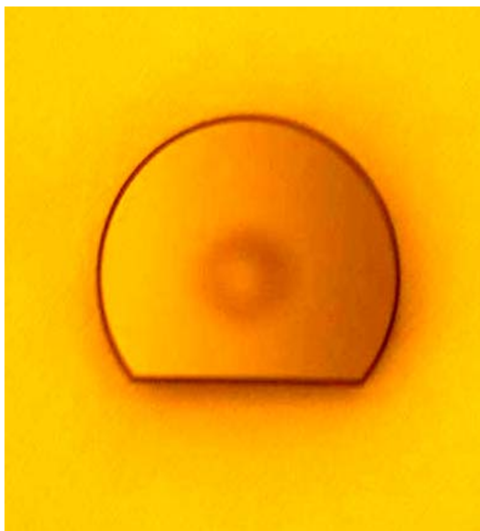
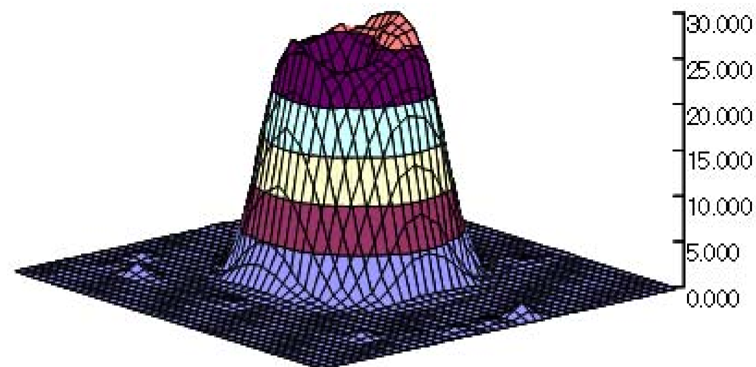
- Ellipsometry
- TEM (transmission electron microscopy)
- Micro beam GIXR (Grazing Incidence X-ray Reflectometry)
- XPS (X ray photoelectron spectroscopy)
- Raman spectroscopy
- EELS (electron energy-loss spectroscopy)
- RBS (Rutherford backscattering spectroscopy)
- ERDA (Elastic Recoil Detection Analysis)
- TOF-SIMS (Secondary ion-microprobe mass spectroscopy)
- ATR-FTIR (attenuated total reflectance Fourier transform infrared spectroscopy)

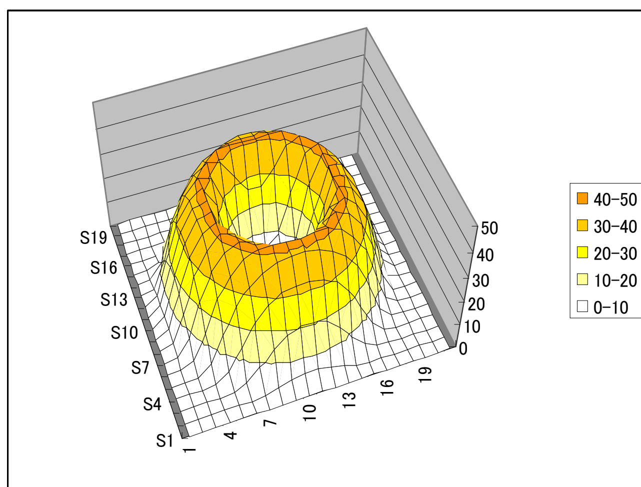
Contaminated SA2 Mirror



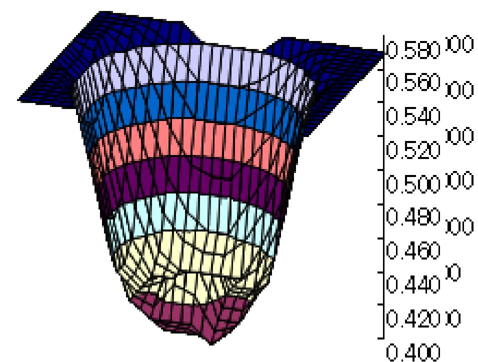
Film thickness



Estimated intensity distribution

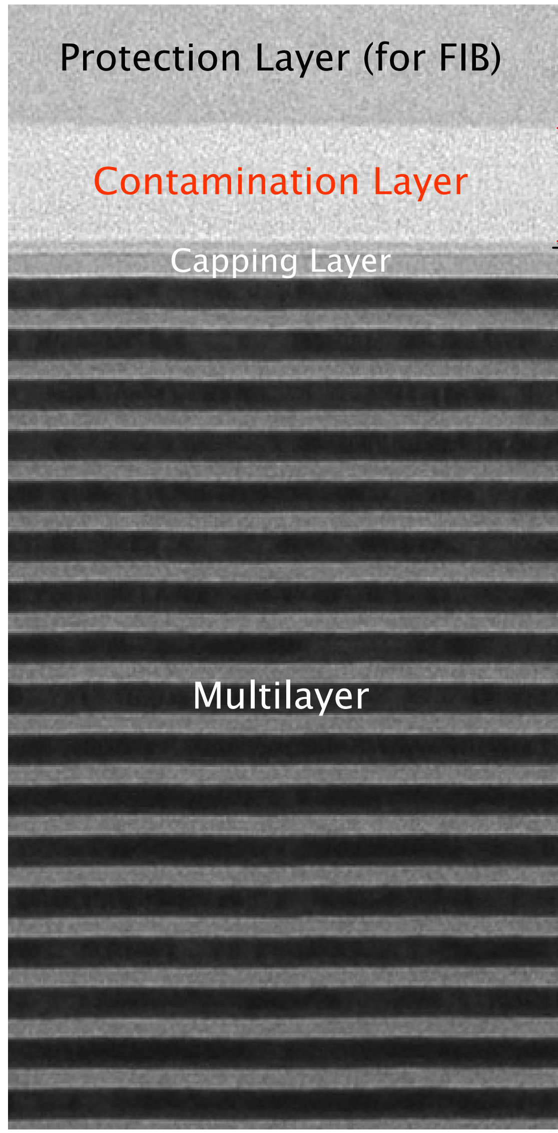


Reflectivity loss

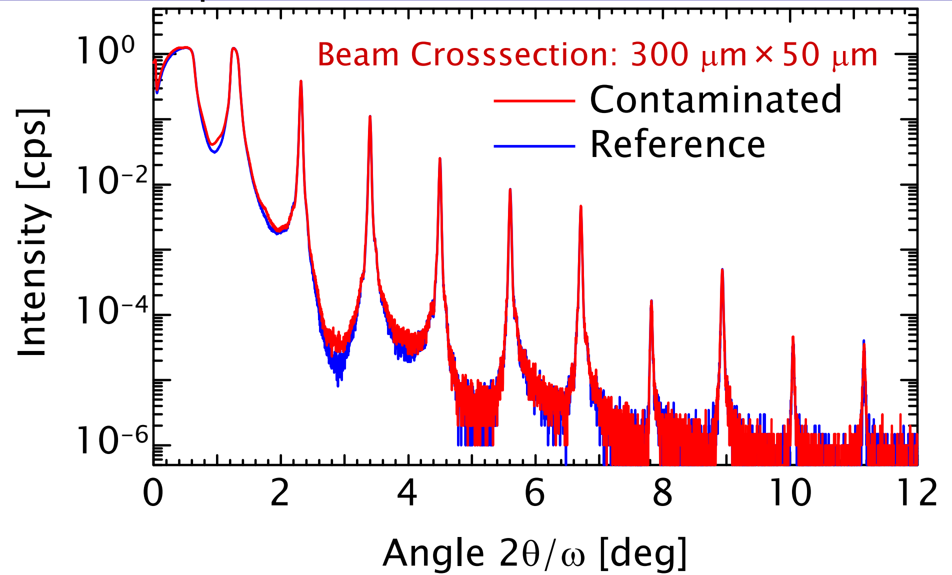


Micro Beam GIXR of SFET Contamination (by RIGAKU)

■ Crosssectional TEM Image



■ Measured Spectra

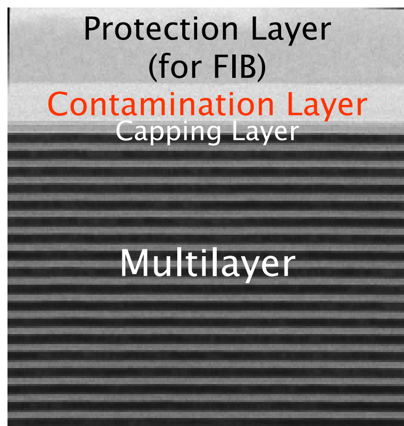


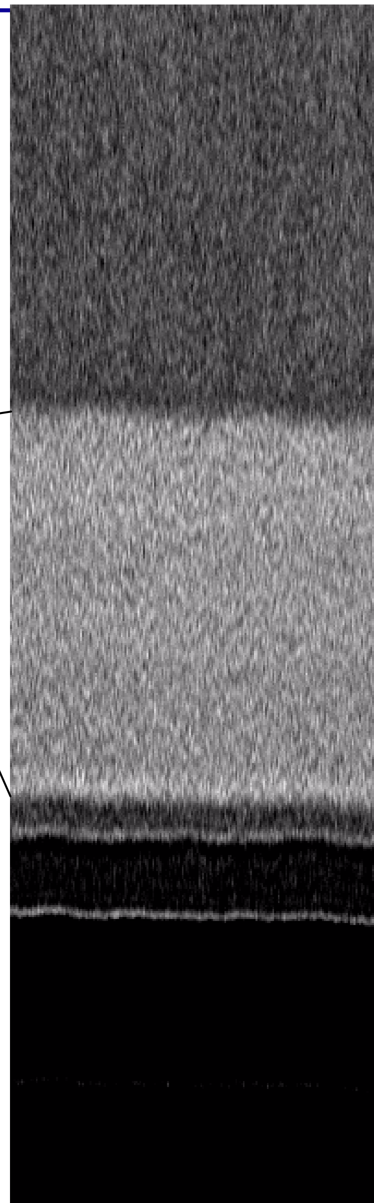
■ Results of Simulation Fitting

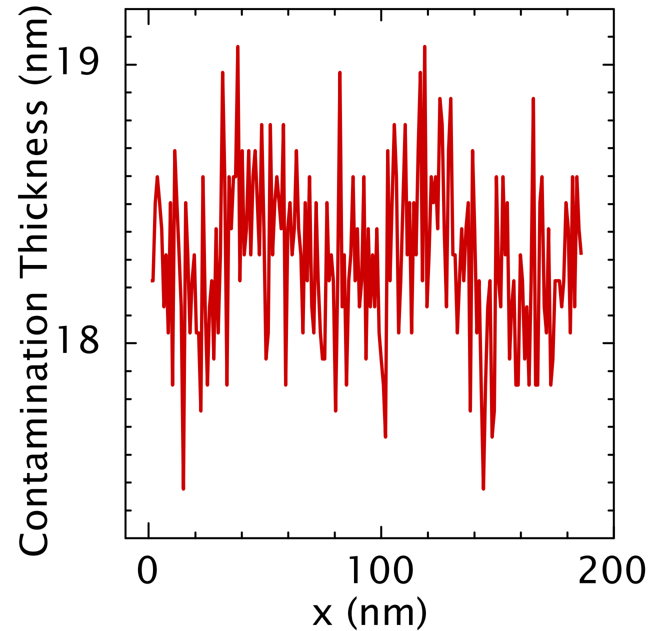
	Density (g/cm^3)	Thickness (nm)		Roughness (nm)
C	1.35	20.60		1.60
SiO_2	2.20	2.787		0.82
Si	2.33	5.827		0.30
MoSi	4.51	0.145	7.934 ×50	0.19
Mo	10.20	3.162		0.95
MoSi	9.74	0.130		0.00
Si	2.33	4.497		0.28
SiO_2	2.20	–		0.20

Thickness of SFET Contamination Measured by TEM

@Most Thick Region







Average Thickness (nm)	18.3
Standard Diviation (nm)	0.30

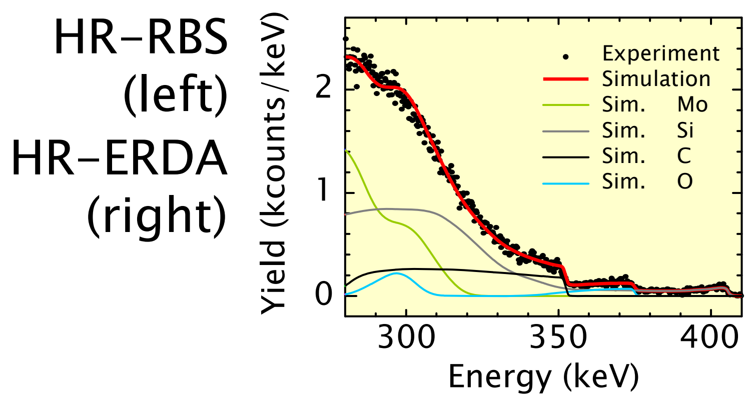
Weight Density: 1.27 g/cm^3
(combination with RBS)

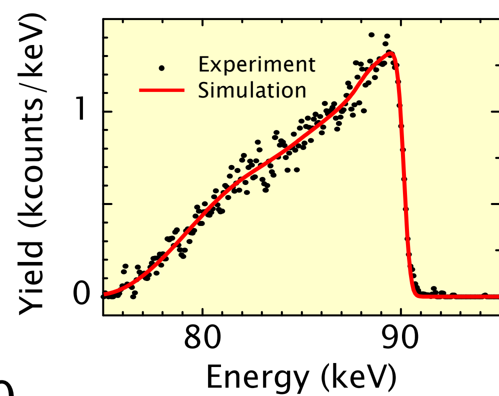
1/10 Compression in horizontal axis →
214 data points = 20 nm (virtical)
214 data points = 200 nm (horizontal)

HR-RBS / HR-ERDA of SFET Contamination

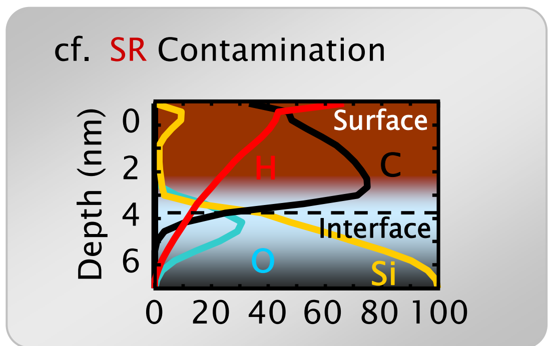
Element Analysis by Scattering Simulation Fitting

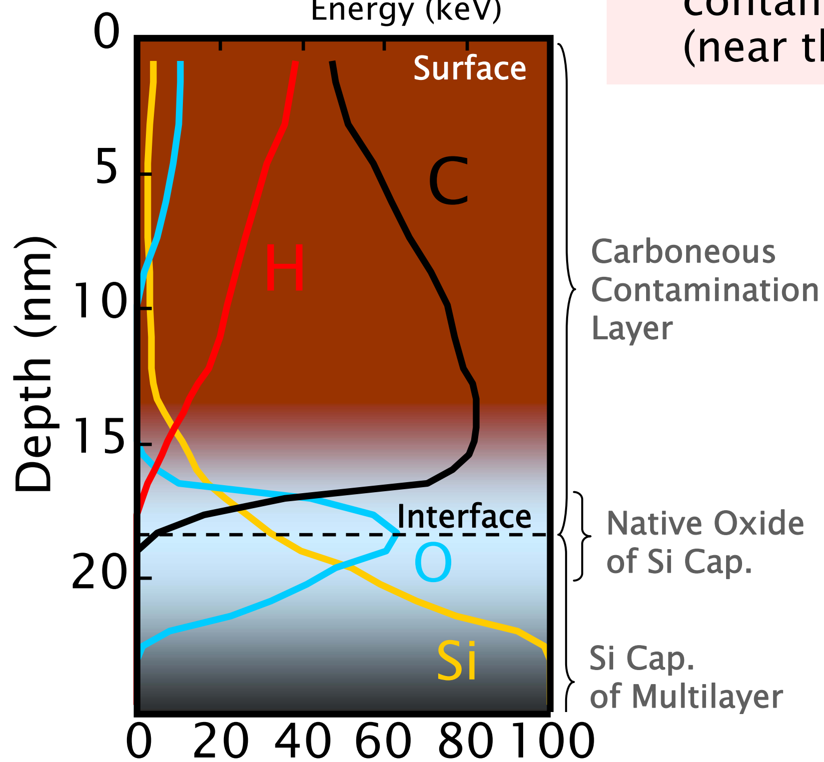
HR-RBS (left)
HR-ERDA (right)



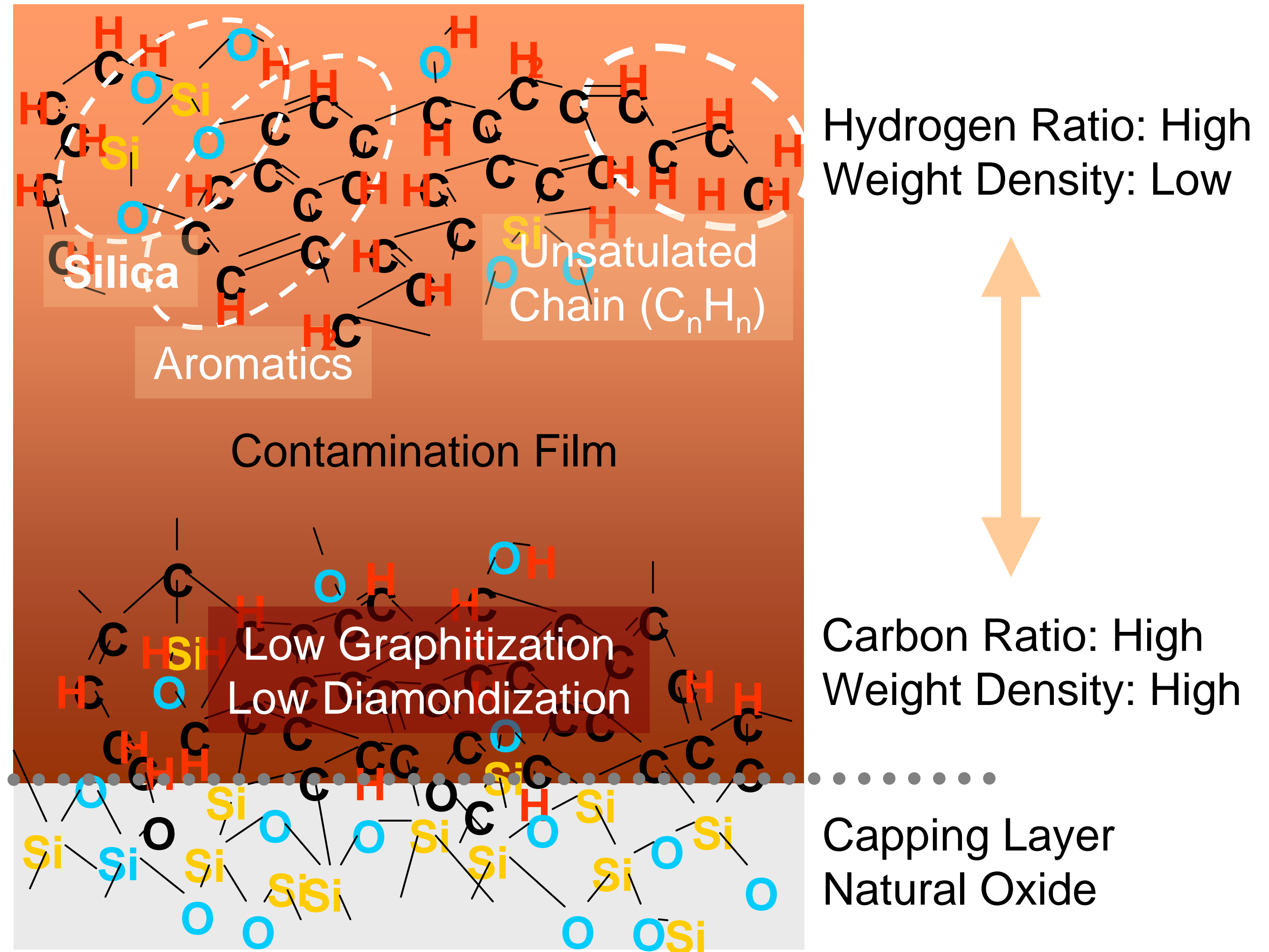


- Contamination film contains much H.
- Ratio of C/H increases with the depth.
- Si is detected within contamination.
- O is detected within contamination (near the surface).





A Schematic Model of Contamination Film



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Summary of Characterization

- A real contamination of SFET mirror and a model contamination deposited with SR have been characterized.
- The thickness and weight density of contamination film was:
  - 18.3 nm and 1.27 g/cm^3 for SFET
  - 5.68 nm and 1.87 g/cm^3 for SR
- Elemental composition (ratio) of both contamination films are similar and they consist of:
  - Mainly Carbon and Hydrogen
  - Percent of Oxygen and Silicon (Silicon seems inorganic)
  - Trace of Fluorine
- Fraction of C/H increases in deeper region.
- Degrees of carbonization are low and SFET contamination preserves polymer character in surface region.
- Reflectivity distribution is explainable by film thickness distribution (but decline seems somewhat larger than simulation calculation).