

Influence of Glass Substrate Surface Roughness on EUV Reflectivity of Mo/Si Multilayer

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Abstract

The influence of the surface roughness of a glass substrate on the EUV reflectivity of Mo/Si multilayer deposited on it by ASET's helicon sputtering system was investigated.

Deposition by helicon sputtering was found to produce a smoothing effect on the multilayer. That is, surface roughness with a spatial period below 100 nm is smoothed out, but that with a spatial period longer than 100 nm is not. The result is that the RMS roughness of a Mo/Si multilayer is slightly smaller than that of the substrate.

The EUV reflectivity of the multilayer improved as the RMS roughness decreased down to 0.30 nm, and then leveled off at about 65% below that value, indicating that the EUV reflectivity is limited by some factor(s) other than surface roughness. However, a relatively high EUV reflectivity of 65% was obtained, even for an RMS roughness of about 0.30 nm.

EUVL mask substrate: Severe requirements for flatness

SEMI Standard P37-1102

Flatness = 50 nm P-V

Local slope = 1.0 mrad

HSFR(high spatial frequency roughness) = 0.15 nm rms



Cost-up for mask substrate

Purpose

HSFR leads to EUV reflectivity loss.

Can HSFR requirement be reduced by using smoothing effect of Mo/Si multilayer coating?

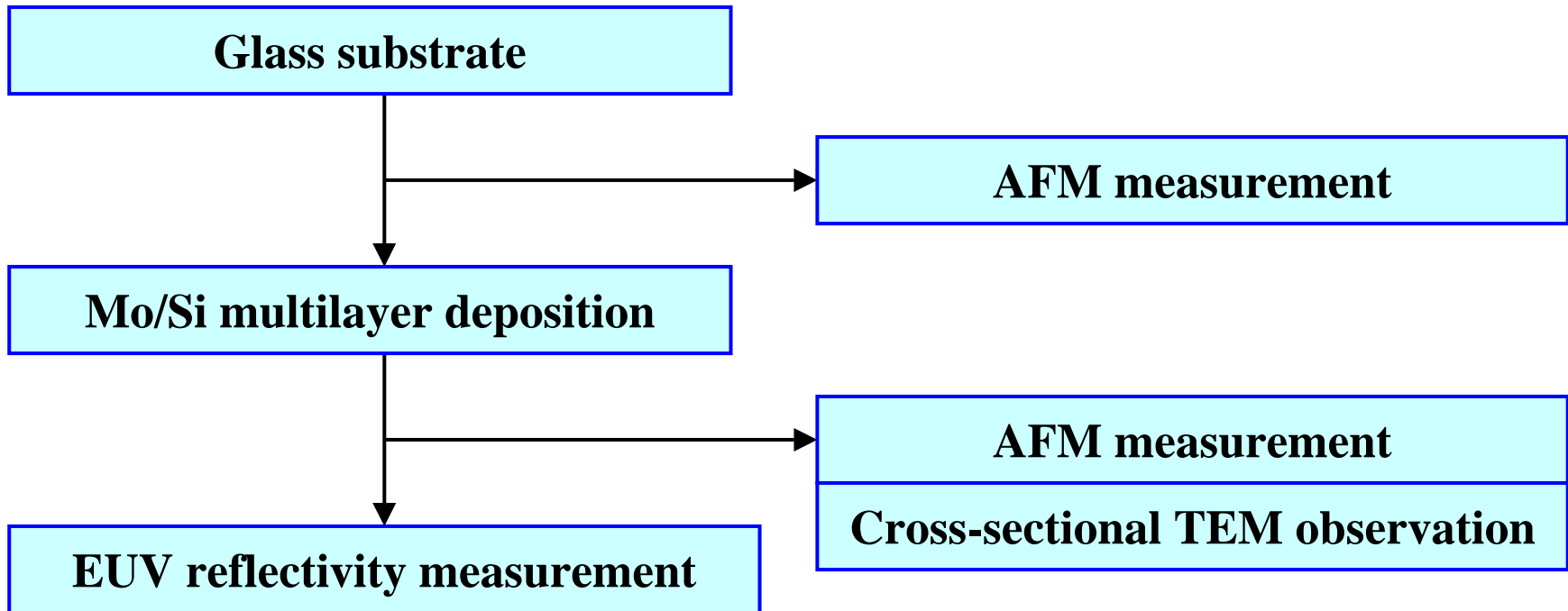


We investigate

- 1) Surface roughness before/after Mo/Si multilayer coating,**
- 2) Relationship between EUV reflectivity and surface roughness,**

using two types of glass substrates with various degrees of surface roughness.

Experimental Procedure



Glass substrate: 6025 quartz glass, 6025 glass ceramics

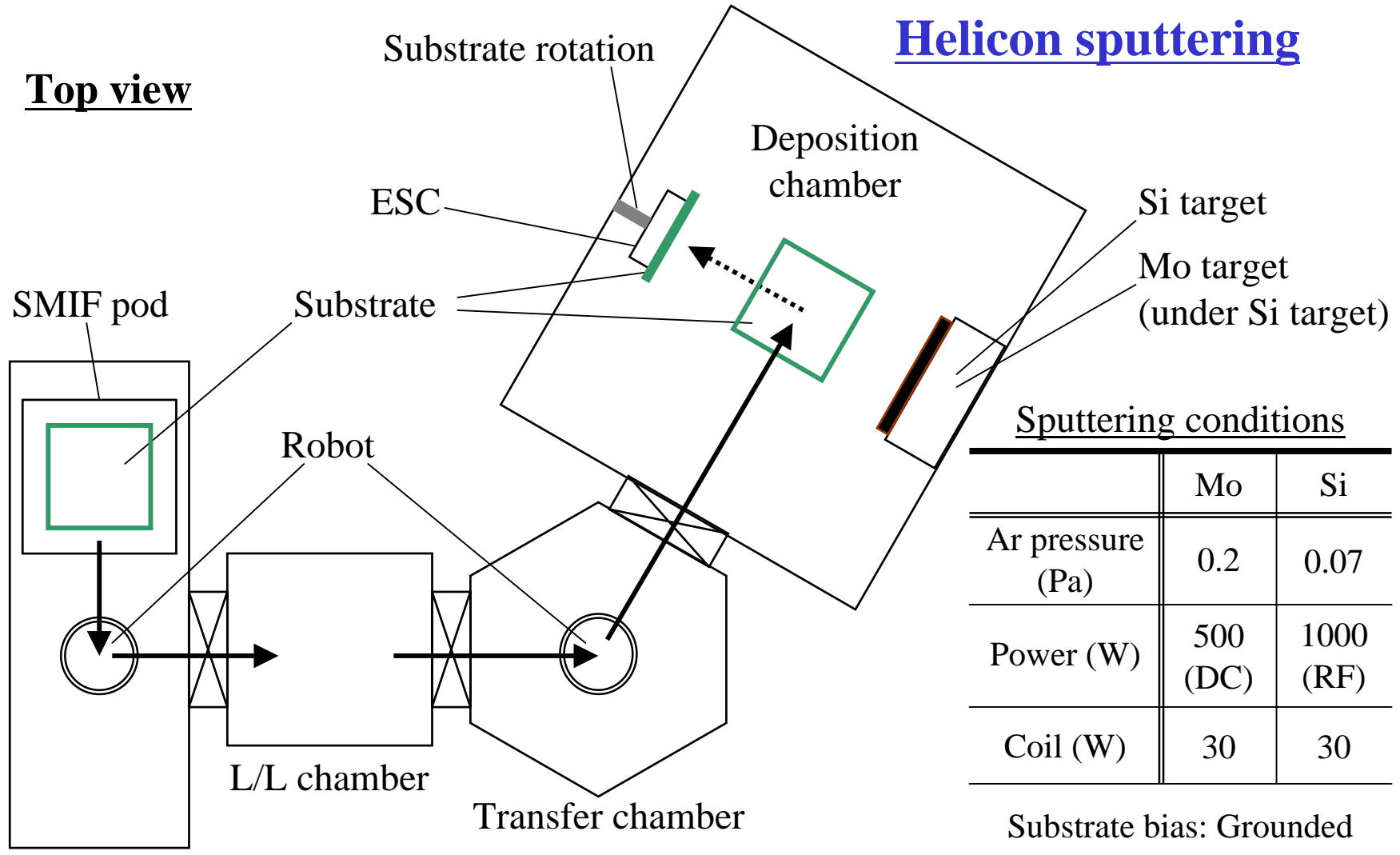
Mo/Si multilayer: Helicon sputtering, 40 periods

AFM: NanoScope IIIa controller? Dimension 5000 stage system

Mo/Si Multilayer Sputtering System

Helicon sputtering

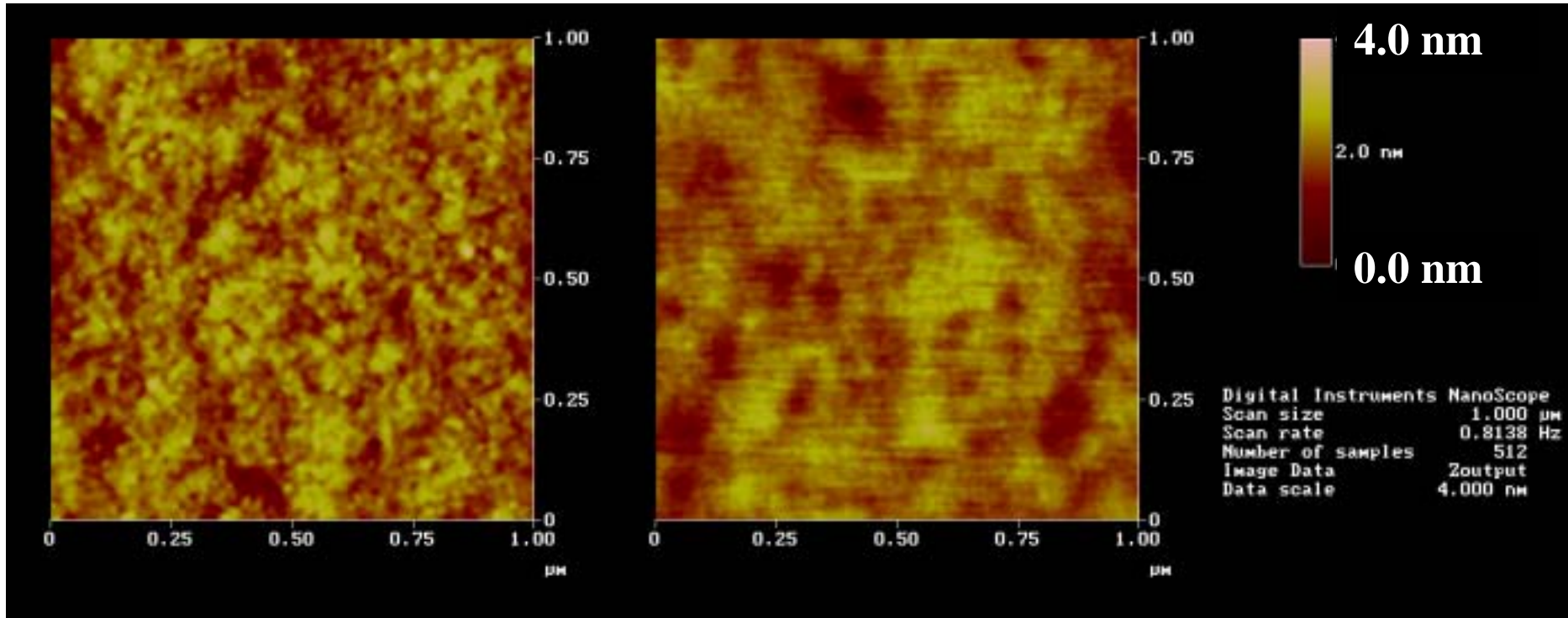
Top view



AFM Measurement (Top View)

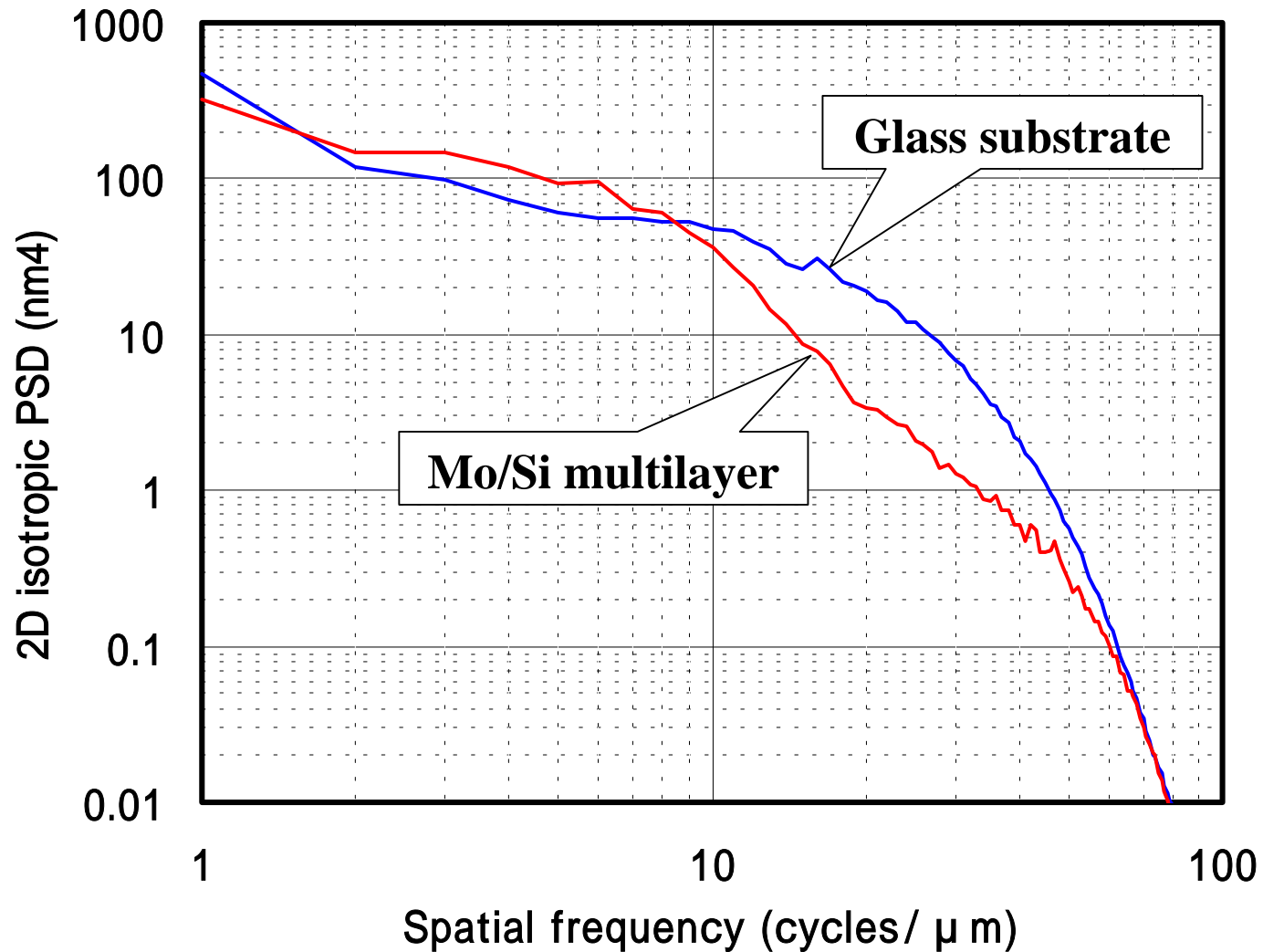
Glass substrate

Mo/Si multilayer? Glass substrate

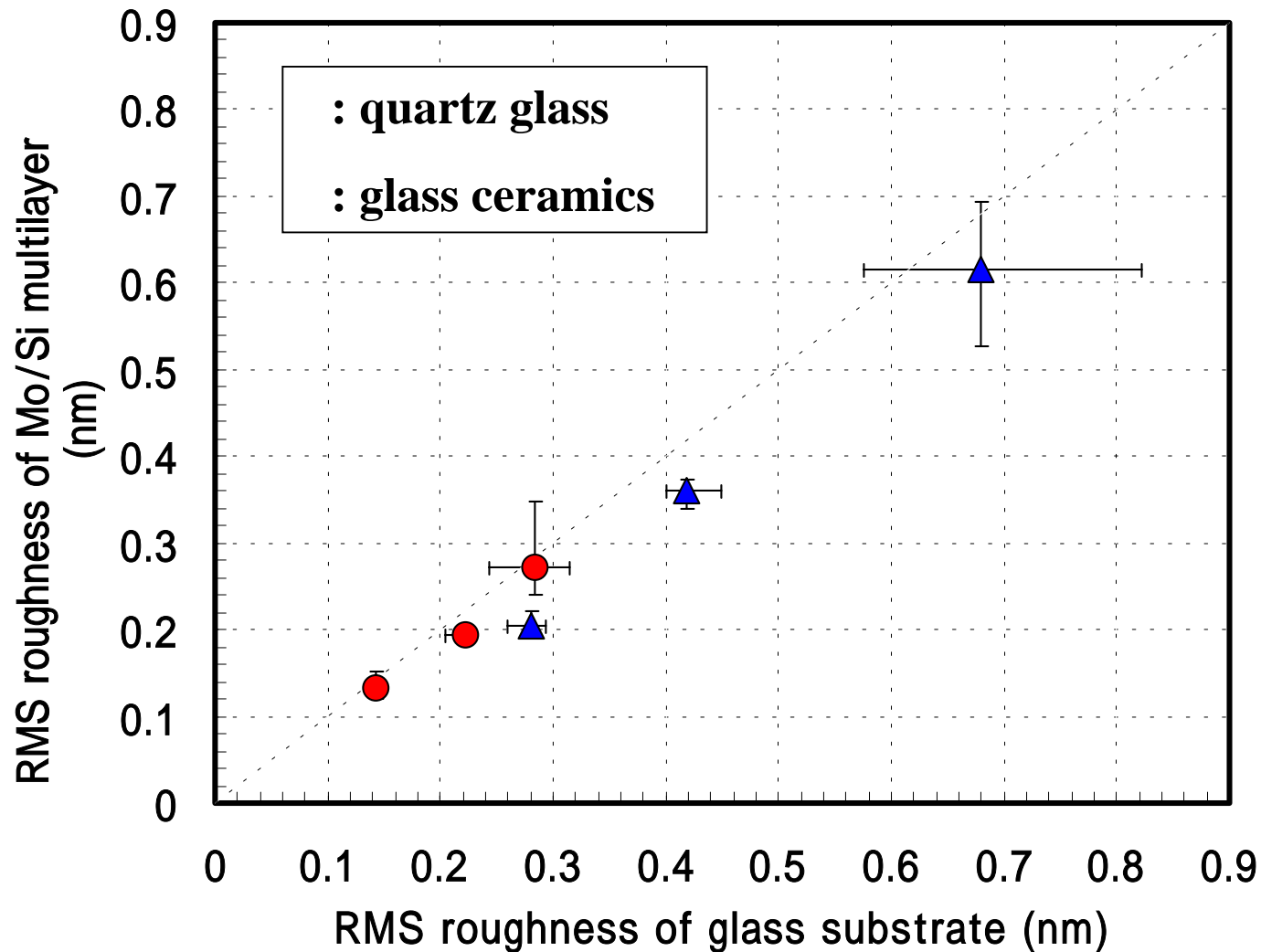


(1 μm \square)

AFM Measurement (Power Spectral Density)



Surface Roughness (Multilayer vs. Substrate)

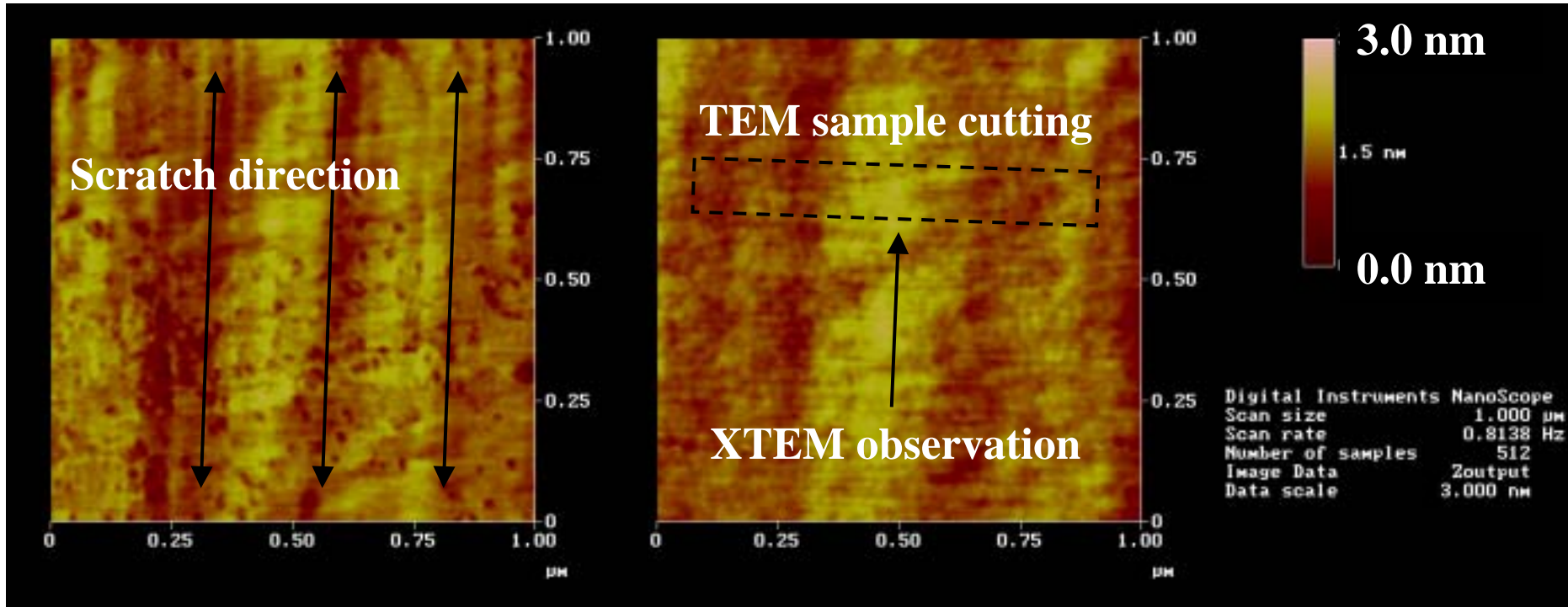


Cross-sectional TEM Observation

AFM images (top view)

Glass substrate

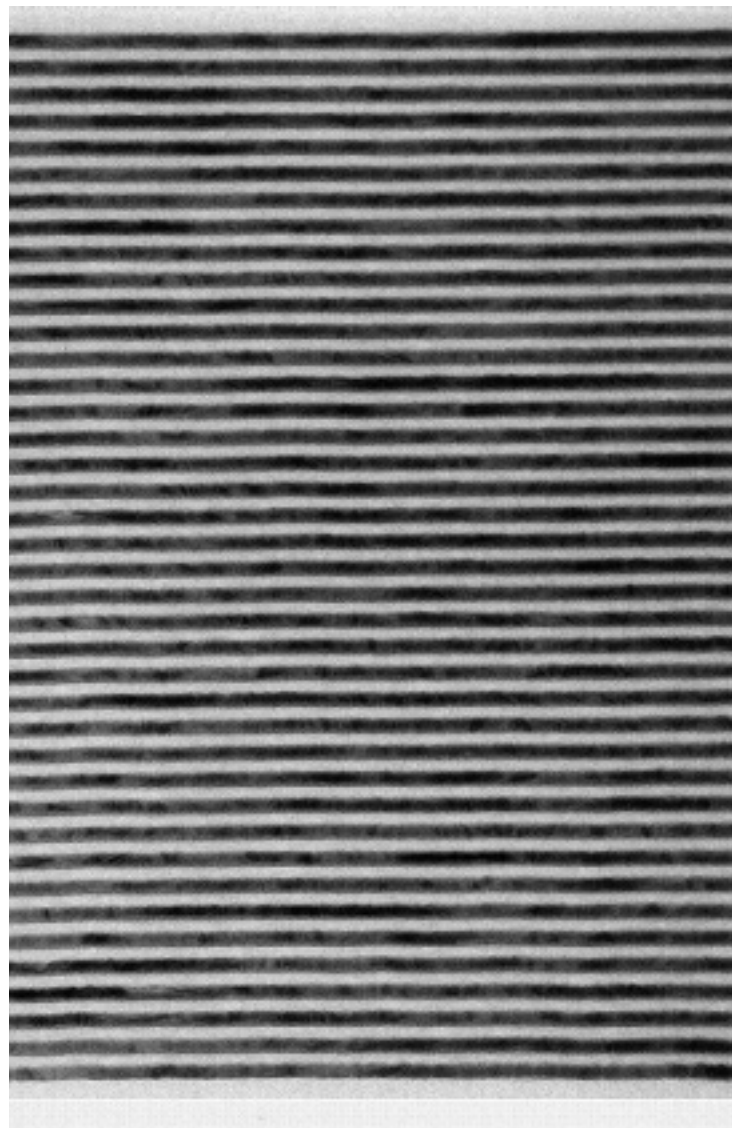
Mo/Si multilayer? Glass substrate



Substrates without final polishing have scratches along the certain direction.

Cross-sectional TEM observation is carried out along this scratch direction.

Cross-sectional TEM Image of Mo/Si Multilayer



← Mo/Si multilayer surface

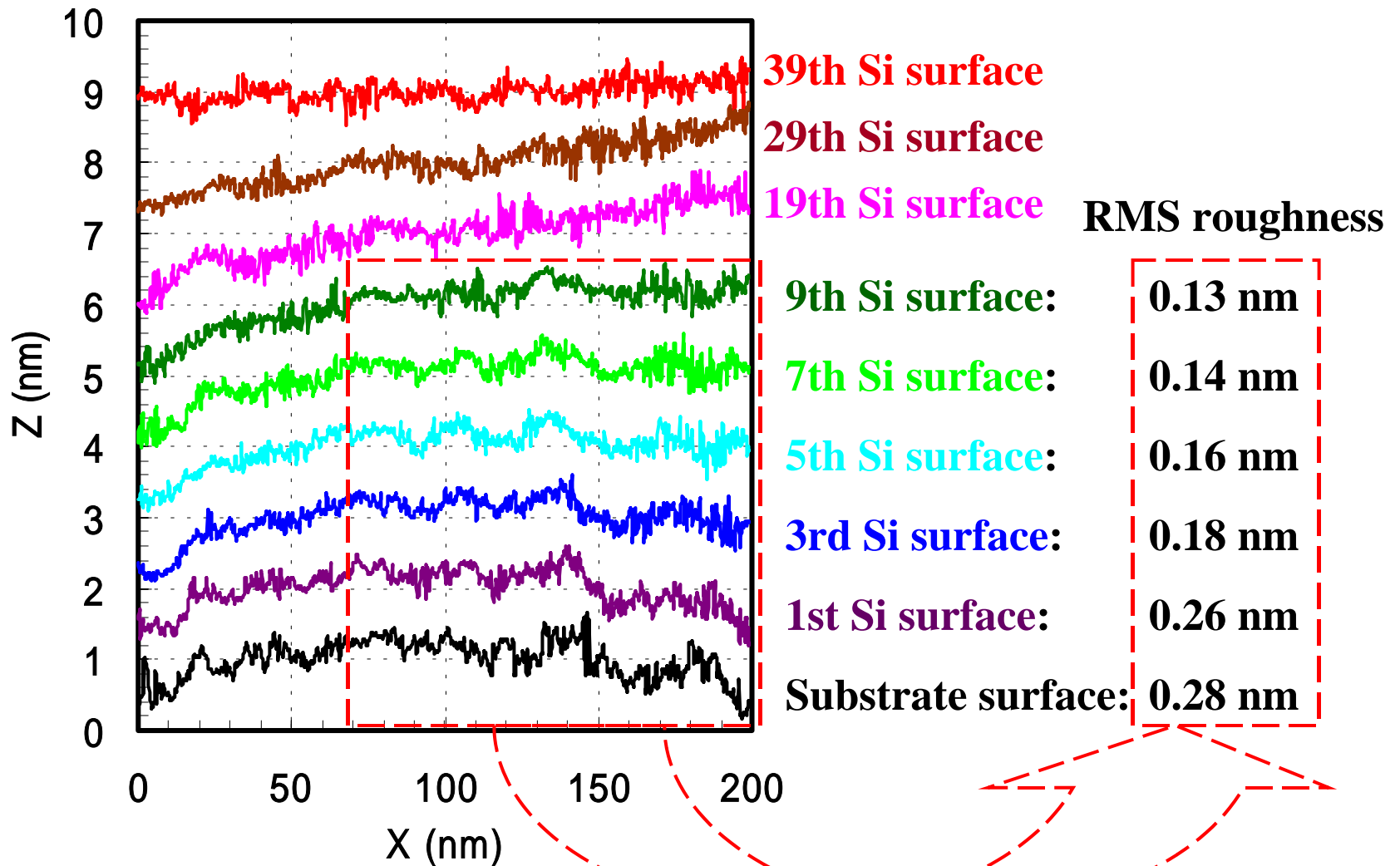
**Bright: Si layers
(amorphous)**

**Dark: Mo layers
(polycrystalline)**

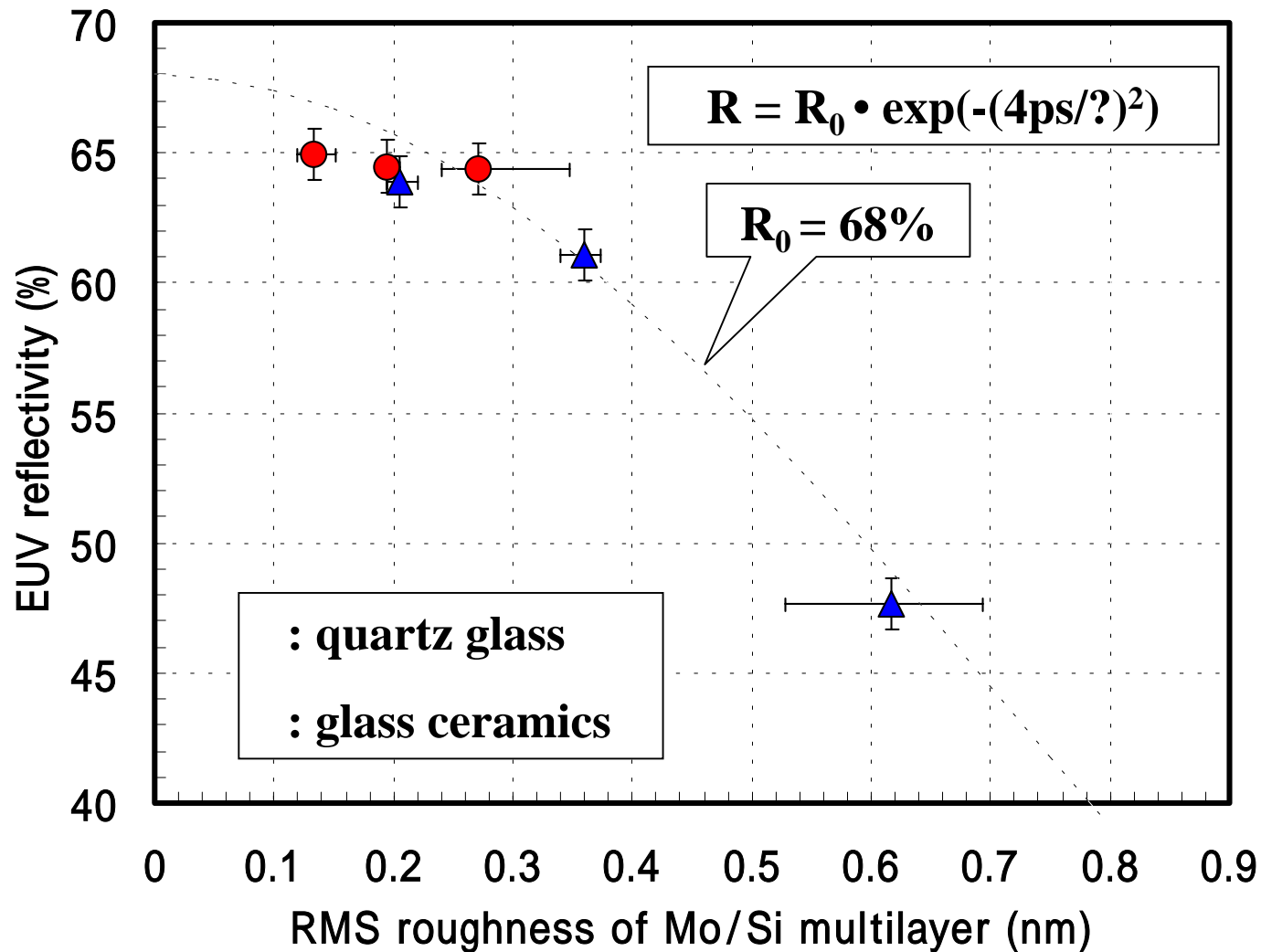
100 nm

← Glass substrate surface

Interfaces Extracted from Cross-sectional TEM



EUV Reflectivity vs. Surface Roughness



Summary

For a Mo/Si multilayer with ASET's helicon sputtering system, the following was found.

- 1) Surface roughness with a spatial period below 100 nm is smoothed out, but that roughness with a spatial period longer than 100 nm is not.**
- 2) As a result, the RMS roughness of a Mo/Si multilayer is somewhat smaller than that of a glass substrate.**
- 3) The smoothing of short-period roughness occurs only in about the first 10 bilayers deposited on a substrate.**
- 4) The EUV reflectivity improves as the RMS roughness decreases down to around 0.30 nm, below which it levels off at about 65%. The EUV reflectivity is limited by some other factor(s).**
- 5) A relatively high EUV reflectivity of 65% is obtained, even though the RMS roughness is about 0.30 nm. This value satisfies the SEMI P38-1102, Class B for EUV reflectivity.**

Acknowledgements

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