



An Ellipsometric **Picometer Sputtering-Rate Monitor** for Exact EUV Multilayer Fabrication

Masaki Yamamoto, Toshihide Tsuru, and Takashi Tsutou

Research Center for Soft X-ray Microscopy, IMRAM, Tohoku University, Sendai 980-8577, JAPAN

The 1st results **Mo:0.9162nm/min Si:4.752nm/min**
 $D_{\text{rate}\times\text{time}}:7.27\text{nm}$ matches $D_{\text{XRD}}:7.22\text{nm}$ with **0.7% error**

Background of this work

In our center, **an EUV interferometer** of laboratory use is under development for figure measurement[1], which is to be followed by an **Å figure error correction** system with multilayer surface milling[2]. For the EUV interferometer, we developed **a mechanical debris stopper**[3] for a solid LPP source, a computer control shuttering system for **0.1% thickness distribution control** over a curved substrate[4], and then, **a sputtering rate monitor of picometer sensitivity**[5] for reflection wavelength matching.

[1] Optics and Precision Engineering 9(2001)405.

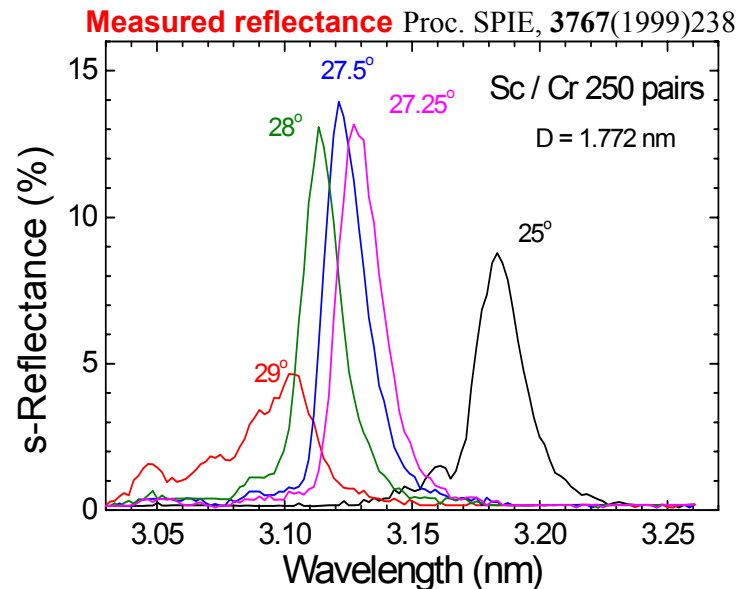
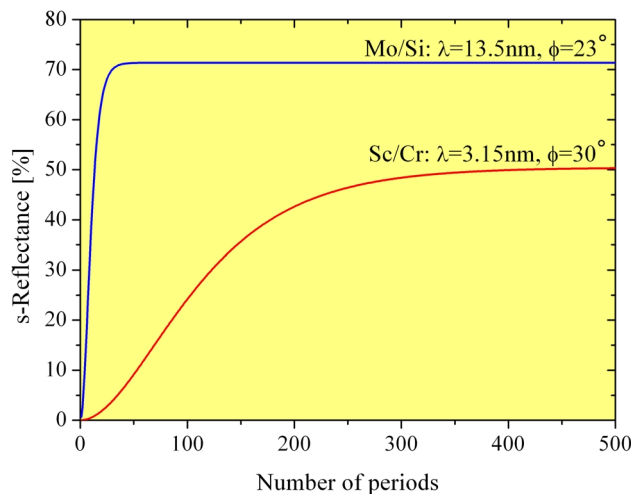
[2] NIM A, 467-8(2001)1282

[3] Proc. SPIE, 4146(2000)128

[4] in Precision Science and Technology for Perfect Surfaces Y. Furukawa, Y. Mori, & T. Kataoka(Eds.), Japan Society for Precision Engineering, Tokyo, 1999, pp. 292-297

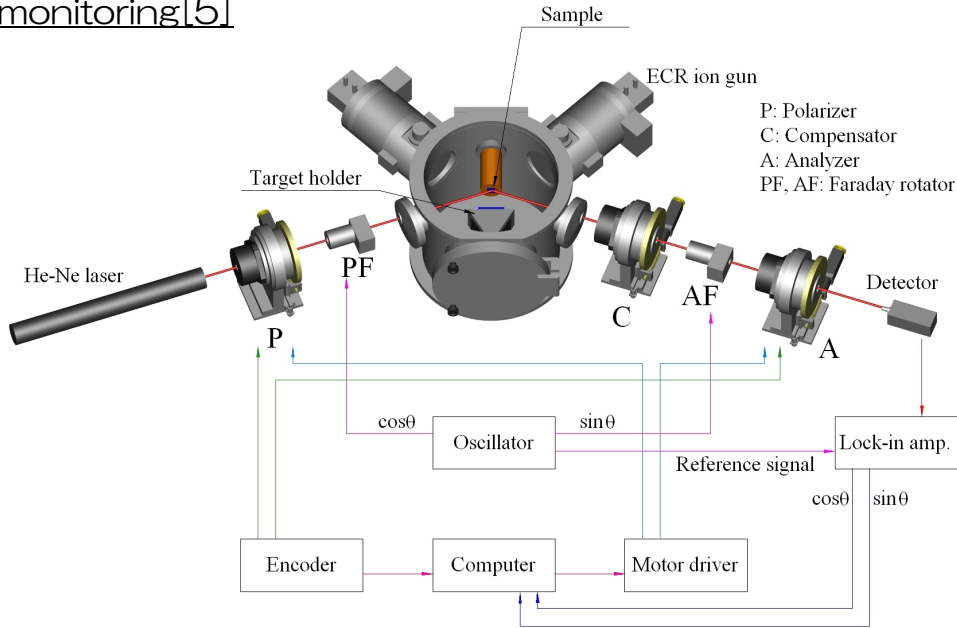
[5] Thin Solid Films 433 (2003)224

Requirement of thickness monitoring



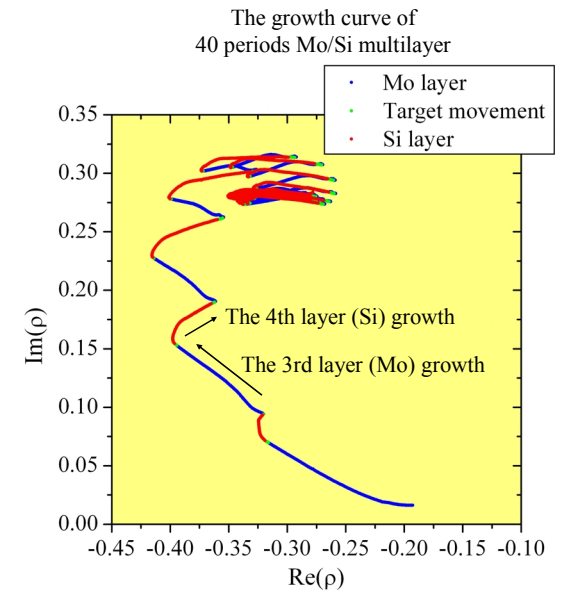
- A large number of periods is necessary for a water window Sc/Cr multilayer mirror as demonstrated by the measured reflectance in Proc. SPIE, 3767(1999)238.
- For constructive interference, a cumulative thickness error over whole layers should be within an inverse of the number of layers. Thickness of each layer should be controlled with sensitivity of **better than 0.005nm**.

An in-situ ellipsometer for thickness monitoring [5]



In-situ monitoring of 40 periods Mo/Si multilayer fabrication

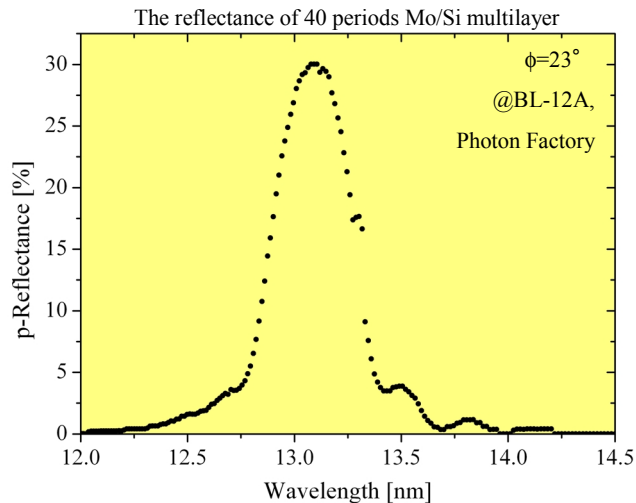
- The ellipsometer is automatic for measurements at every 200msec.
- New layer-by-layer analysis gives thickness during sputtering.



The sputtering rates of Mo and Si were observed to be **0.9162nm/min** and **4.752nm/min**, respectively. These rates yield **7.27nm** as the average period thickness by multiplying the sputtering time.

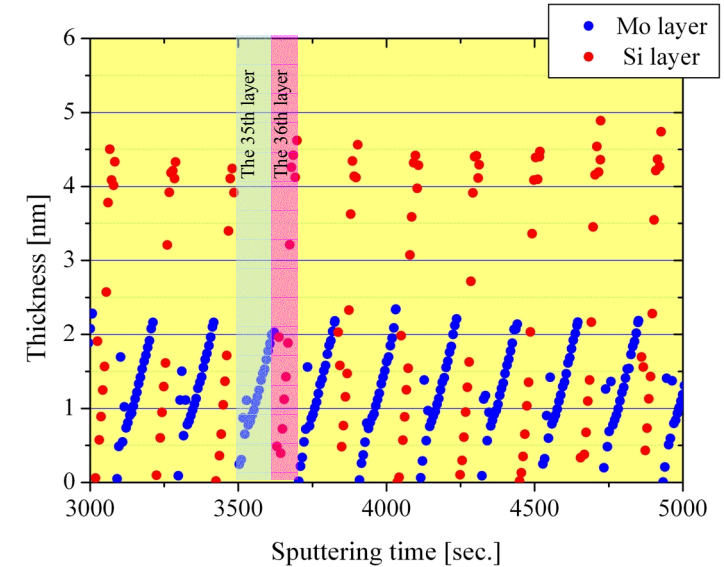
The total thickness by ellipsometry divided by 40 periods yields **6.98nm**, which can be attributed by silicide layer formation at the boundary as observed by ellipsometry.

Soft X-ray reflectance



The period thickness was estimated to be **7.22nm** by curve fitting.

The thickness analyzed by ellipsometric data



Summary

- We have developed an automatic null ellipsometer of **picometer sensitivity** for sputtering rate monitor of EUV multilayer fabrication.
- The rates times sputtering duration yields **7.27nm** as the period thickness, which demonstrates matching by **0.7% error** to **7.22nm** by EUV reflectometry.