Contamination experiment for EUVL optics mirrors with the use of single bunch SR

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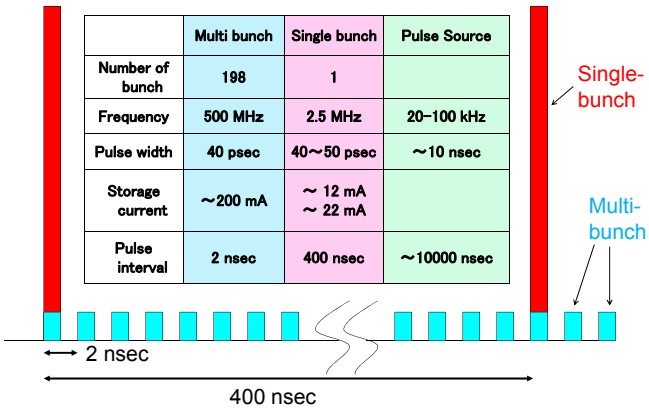
Introduction

In the contamination study for EUVL optics life time, it is said that reflectivity degrade by a pulsed LPP/DPP source will be much smaller than that by a quasi-continuous synchrotron radiation (SR) source. To obtain basic information concerning frequency dependence, single bunch(SB) mode SR has a possibility of giving useful information on the pulse sources because the pulse intervals of the SB-SR is about 200 times longer than that of multi bunch(MB) mode SR.

An EUV irradiation experiment was carried out using SB-SR to investigate optics contamination mechanism. The results were compared with those of the MB-SR irradiation experiment.

	Multi bunch	Single bunch	Pulse Source
Number of bunch	198	1	
Frequency	500 MHz	2.5 MHz	20–100 kHz
Pulse width	40 psec	40～50 psec	～10 nsec
Storage current	～200 mA	～ 12 mA ～ 22 mA	
Pulse interval	2 nsec	400 nsec	～10000 nsec

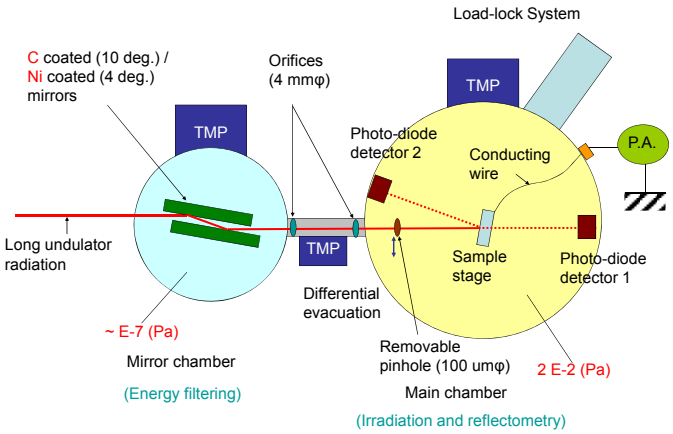


Pulse image (NewSUBARU SR facility)

Experimentals

Ru-capped Mo/Si multilayer mirrors were irradiated by SB-SR (2.5 MHz) in the presence of water vapor or hydrocarbon gas in the system at the NewSUBARU SR facility, and their reflectivities were sequentially measured. For comparison, irradiation experiment with MB-SR (500 MHz) was also carried out, the flux density of which was attenuated to have the same dose to that of SB-SR.

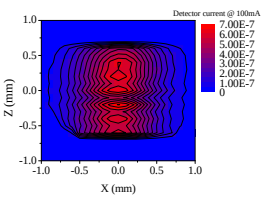
The reflectivity map and atomic concentration change of carbon (C) and oxygen (O) at the irradiated area were also measured *in situ*.



EUV irradiation and reflectivity measurement system

Irradiation condition

Condition	Carbon deposition	Surface Oxidation
Multilayer Mirror	Ru-cap	Ru-cap
Gas introduction	n-decane	H_2O
Gas pressure during irradiation	1.3E-5 Pa	1.3E-5 Pa
	5.0E-5 Pa	1.3E-4 Pa
EUV intensity (Multi bunch)	12 mW/mm^2 (reduced by low reflectance mirror)	～200 mW/mm^2 (used the data @～20 mW/mm^2 position)
EUV intensity (Single bunch)	12 mW/mm^2	22 mW/mm^2

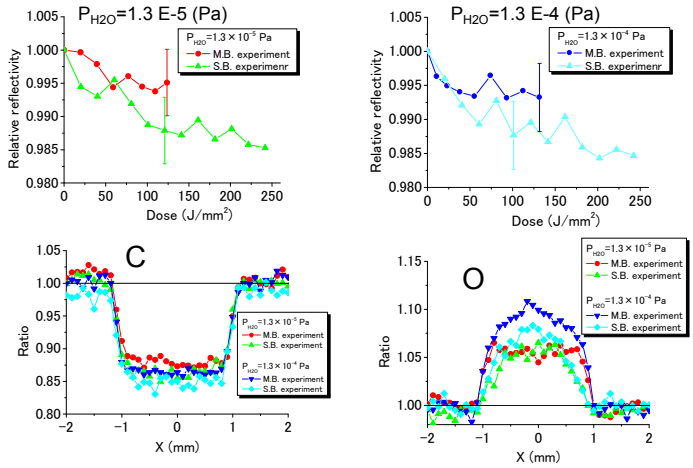


Beam profile

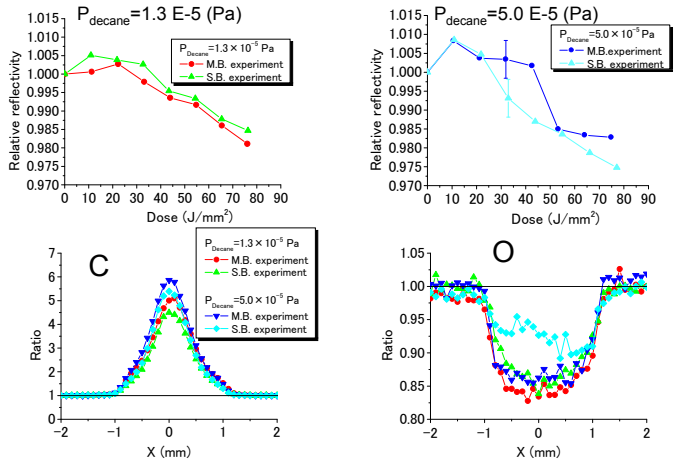
200 mW/mm^2 at center

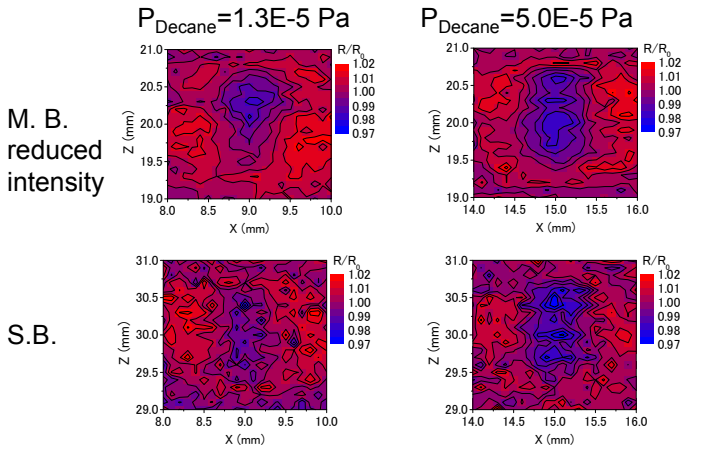
Results

Surface oxidation experiment (H_2O)



Carbon deposition experiment (n-decane)





Discussion

The instantaneous intensity of MB-SR at the irradiation center and at 200mA storage current has the same order of magnitude to that of a pulse plasma source. The duty ratios of SB-SR and of pulse plasma are almost the same.

There was no remarkable pulse frequency dependence in the reflectivity drop for EUV pulse cycle ranging from 2.5 MHz (SB-SR) to 500 MHz (MB-SR).

	Multi bunch	Single bunch	Pulse Plasma
Instantaneous intensity value	13.7 W/mm^2 @ center 200 mA	200 W/mm^2	7.2 W/mm^2
Duty ratio	50	10000	10000