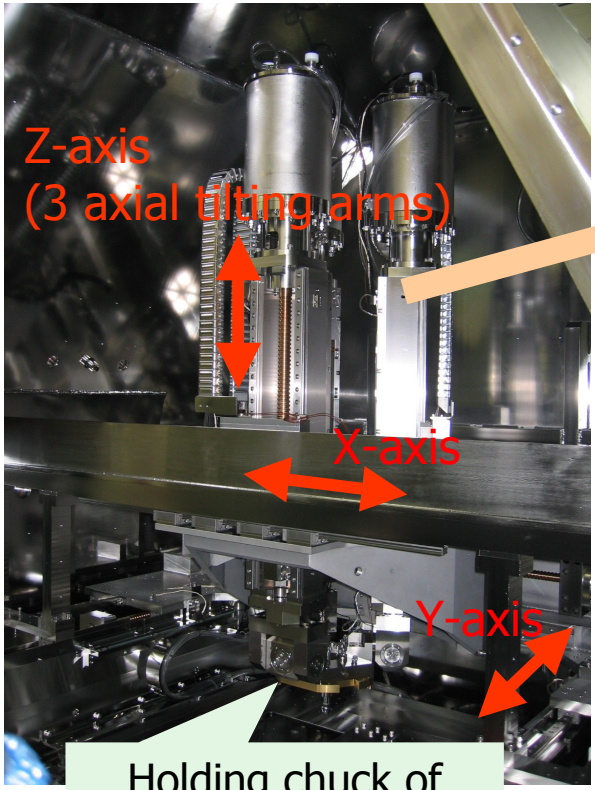
IBF Technology Development for EUVL Mirrors

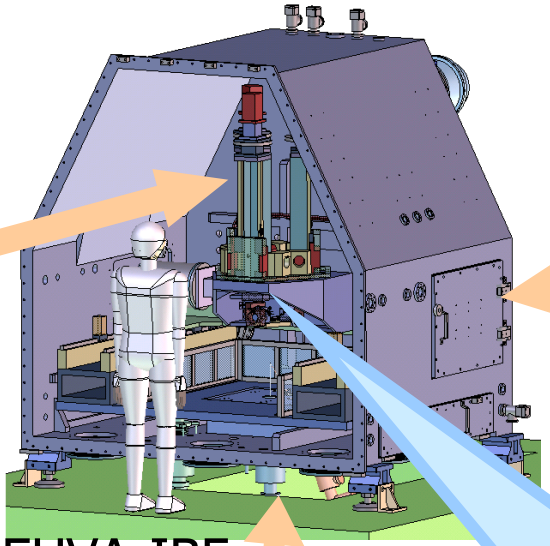
Manabu Ando[1)], Atsushi Numata[1)], Ko Kamachi[1)] , Yuji Moriyama[1)]
Yuichi Kurashima[2)], Iwao Miyamoto[2)], and Jun Taniguchi[2)]

[1)] CANON INC. Production Engineering Research Laboratory
[2)] Tokyo University of Science, Department of Applied Electronics

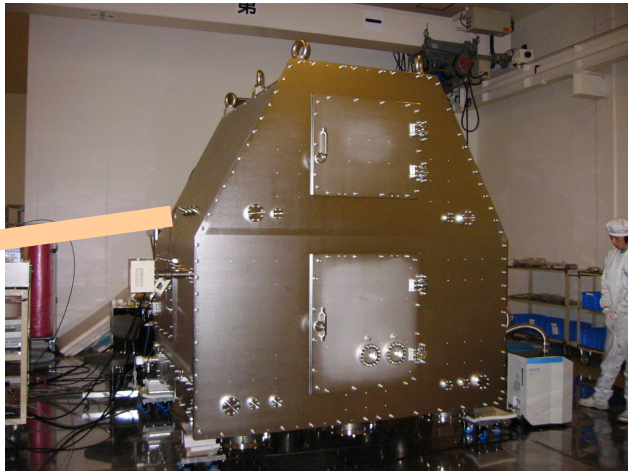
Outline of the Ion Beam Figuring machine



5-axis scanning stage

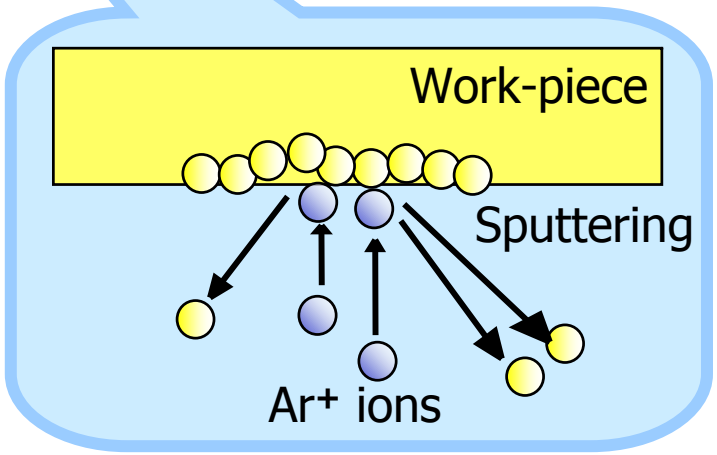


EUVA-IBF



Vacuum chamber

Ion-gun



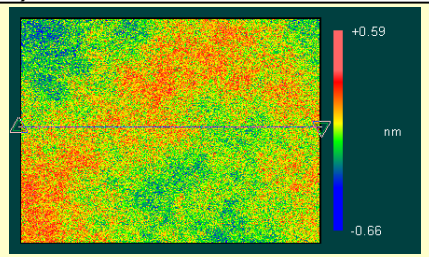
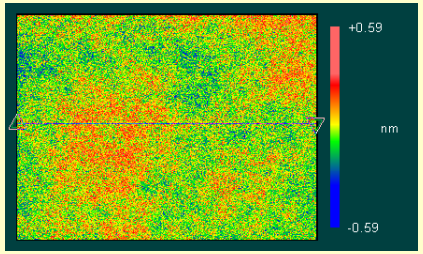
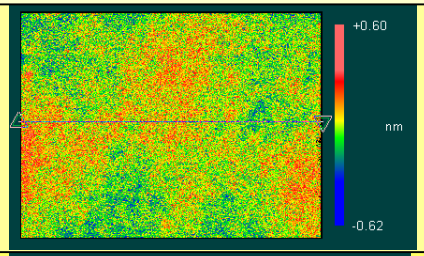
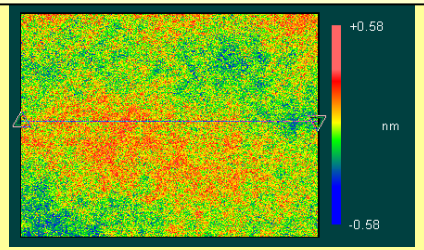
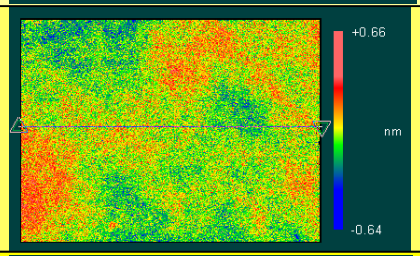
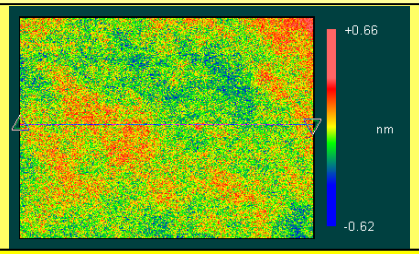
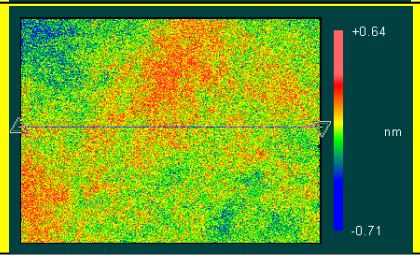
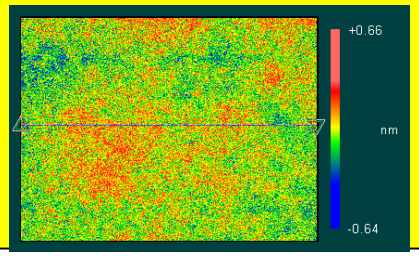
Principle of the IBF

Process advantages of IBF

1. Small ion beam spot size
   - Correction of spatial wavelength down to 2mm is possible.
2. Stable removal rate during one operation
   - It is possible to correct figure errors in a single operation.
3. No change in MSFR and minimal change in HSFR
   - It is suitable for a final figure correction process.

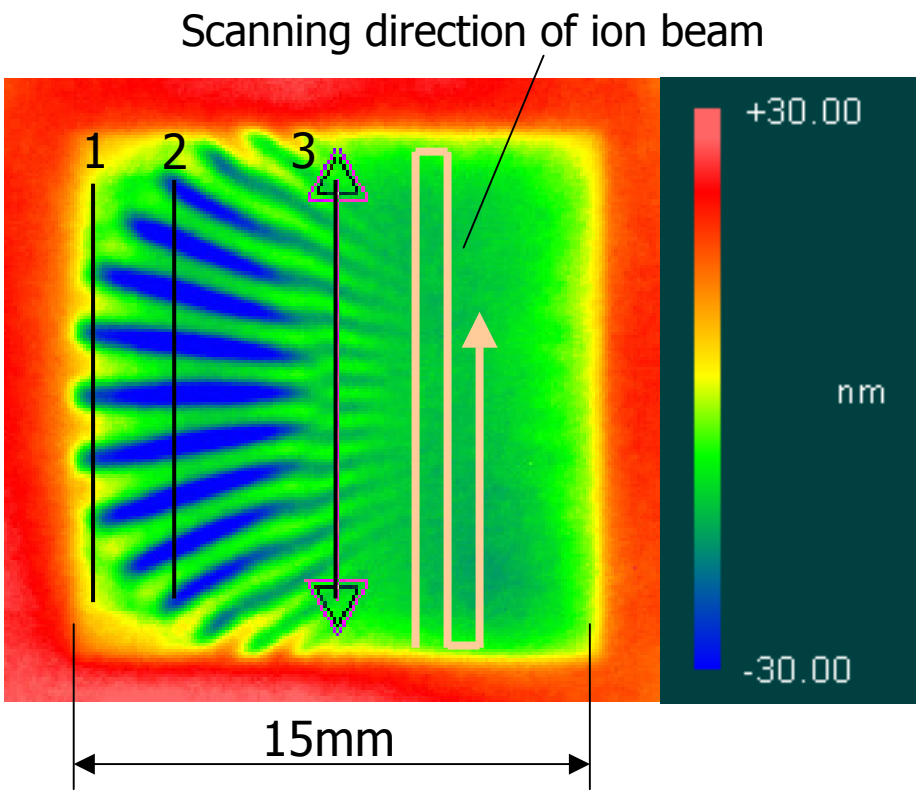
EUVA MSFR before and after ion beam processing

(measurement area : 100 μm × 140 μm)

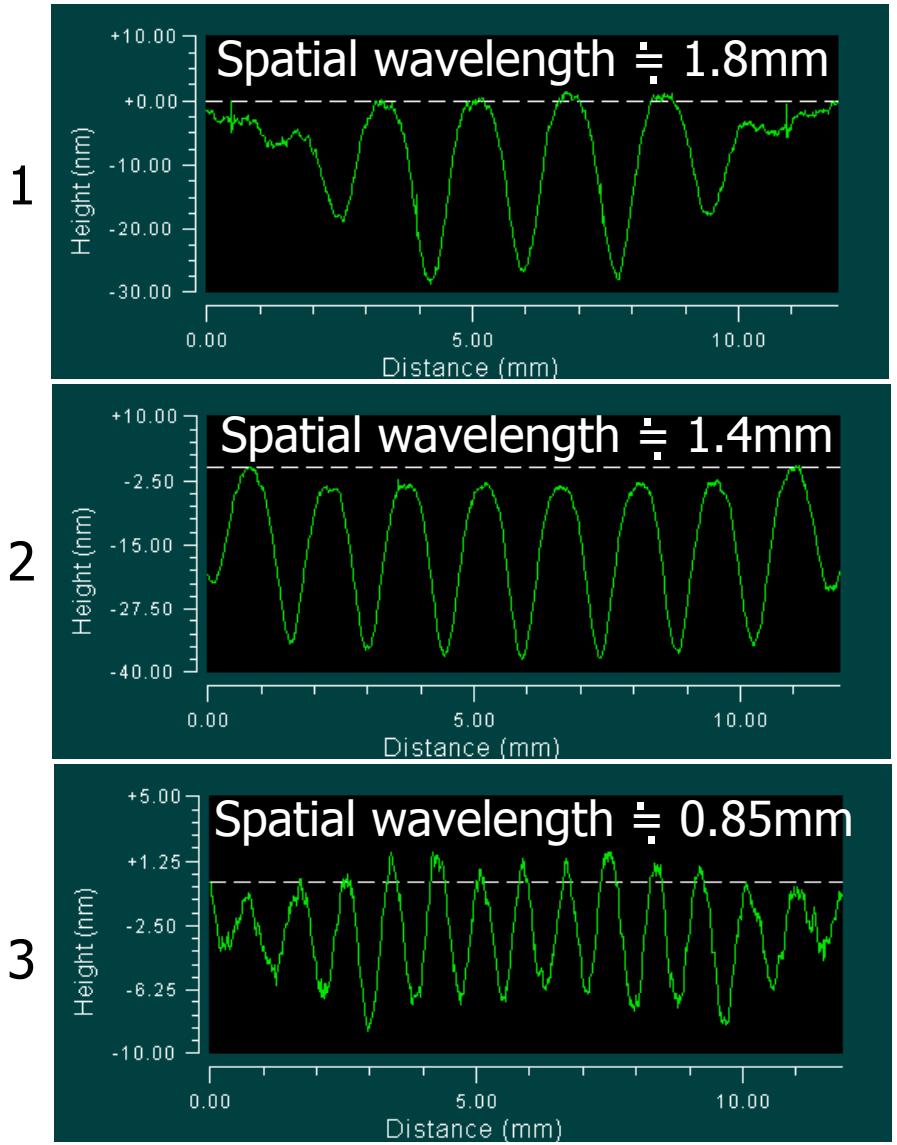
	Before IBF		After IBF
depth of processing 2nm		same point 0.14 nmRMS →	 0.13 nmRMS
depth of processing 5nm		same point 0.14 nmRMS →	 0.14 nmRMS
depth of processing 10nm		same point 0.15 nmRMS →	 0.14 nmRMS
depth of processing 15nm		same point 0.14 nmRMS →	 0.14 nmRMS

It is possible to maintain MSFR values during IBF removal processing.

Spatial resolution of the IBF



Making "shell pattern" using "shell pattern" dwell time distribution.



Lateral spatial resolution of our IBF is smaller than 1mm (with small beam IB-gun).

Fabrication process for EUVL mirrors

Pre-polishing: figuring base surface

↓

Polishing 1: correcting figure errors

↓

Polishing 2: smoothing MSFR & HSFR

repeat

↓

Coating process

To smooth high frequency roughness is incompatible to correct figure errors, and this dilemma often causes to repeat polishing process.

Traditional polishing process

Pre-polishing: figuring base surface

↓

Polishing 1: correcting figure errors

↓

Polishing 2: smoothing MSFR & HSFR

↓

IBF: correcting figure errors

↓ two operations

Coating process

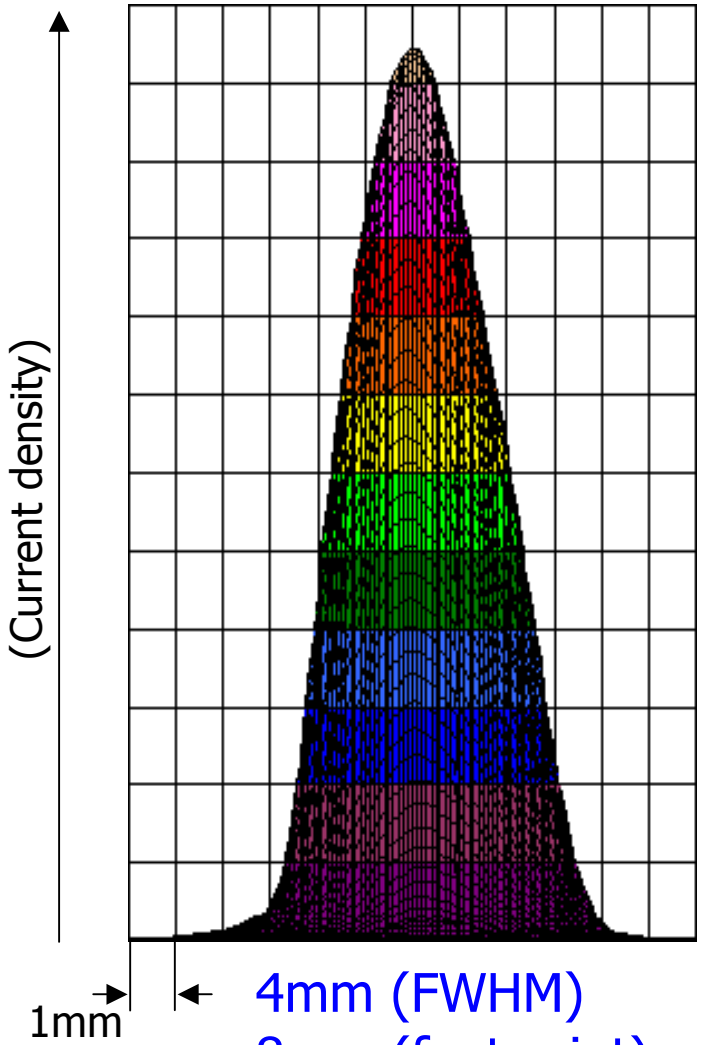
IBF process is able to correct figure errors to better than 0.2nmRMS without changing MSFR, and minimal change in HSFR.

Including IBF process

The aim of new IBF technology development is to establish a well-balanced fabrication process for EUVL mirrors.

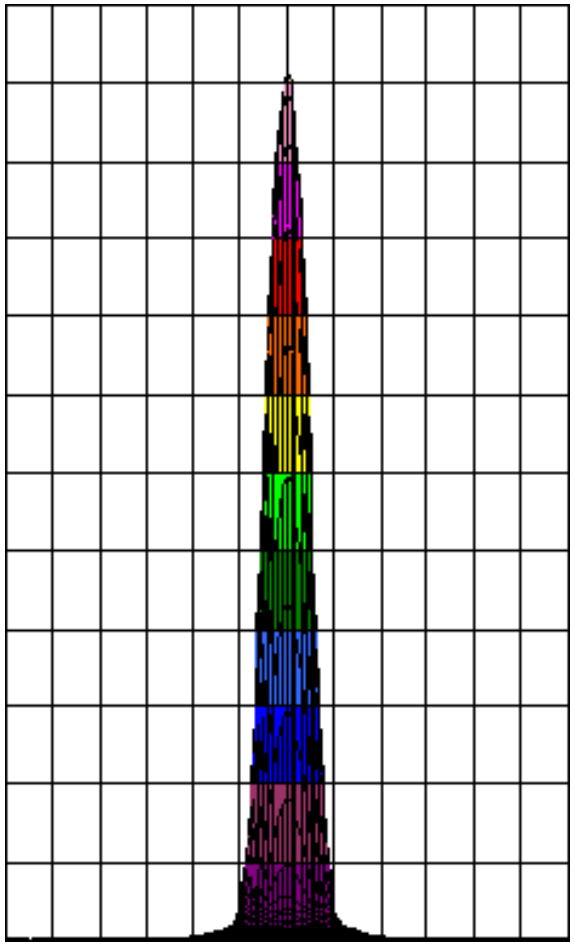
Profile of the ion beam current density

Large beam



4mm (FWHM)
8mm (foot print)

Small beam



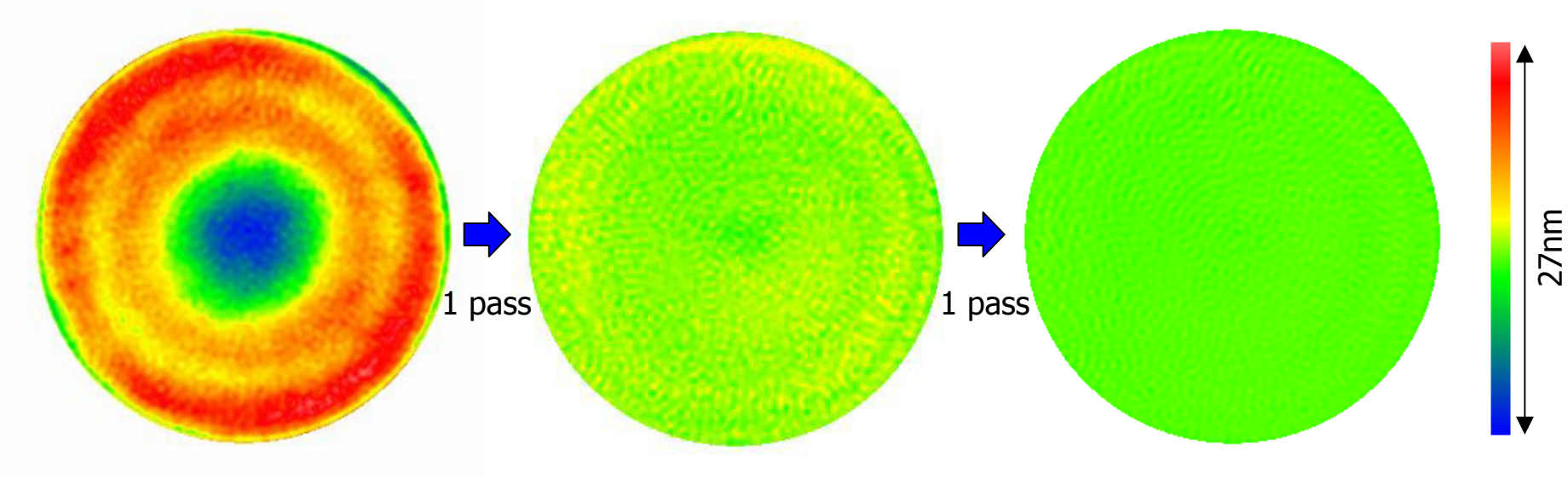
1mm (FWHM)
3mm (foot print)

Figure correction test

Before processing

After large beam operation

After small beam operation



5.03 nm RMS
27.13 nm PV

0.61 nm RMS
5.66 nm PV

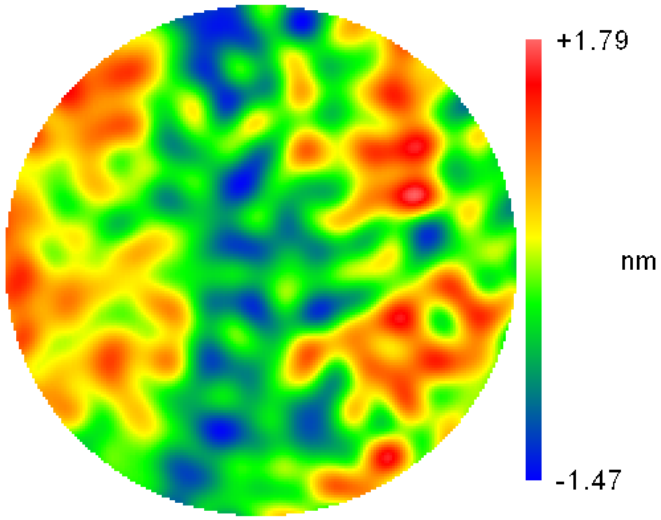
0.19 nm RMS
2.13 nm PV

Flat work piece (90mm in diameter)

Figure error of better than 0.2nm RMS in 2 operations is achieved.
(1 large beam operation & 1 small beam operation each)

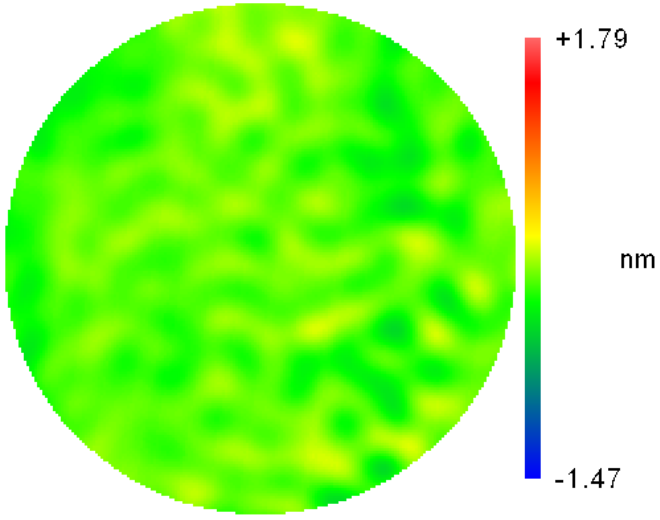
IBF process improvement 1

Achieved 0.10 nm RMS in figure correction !



PV	3.254	nm
rms	0.619	nm
Size X	19.96	mm
Size Y	19.96	mm

Before IBF



PV	0.618	nm
rms	0.102	nm
Size X	19.96	mm
Size Y	19.96	mm

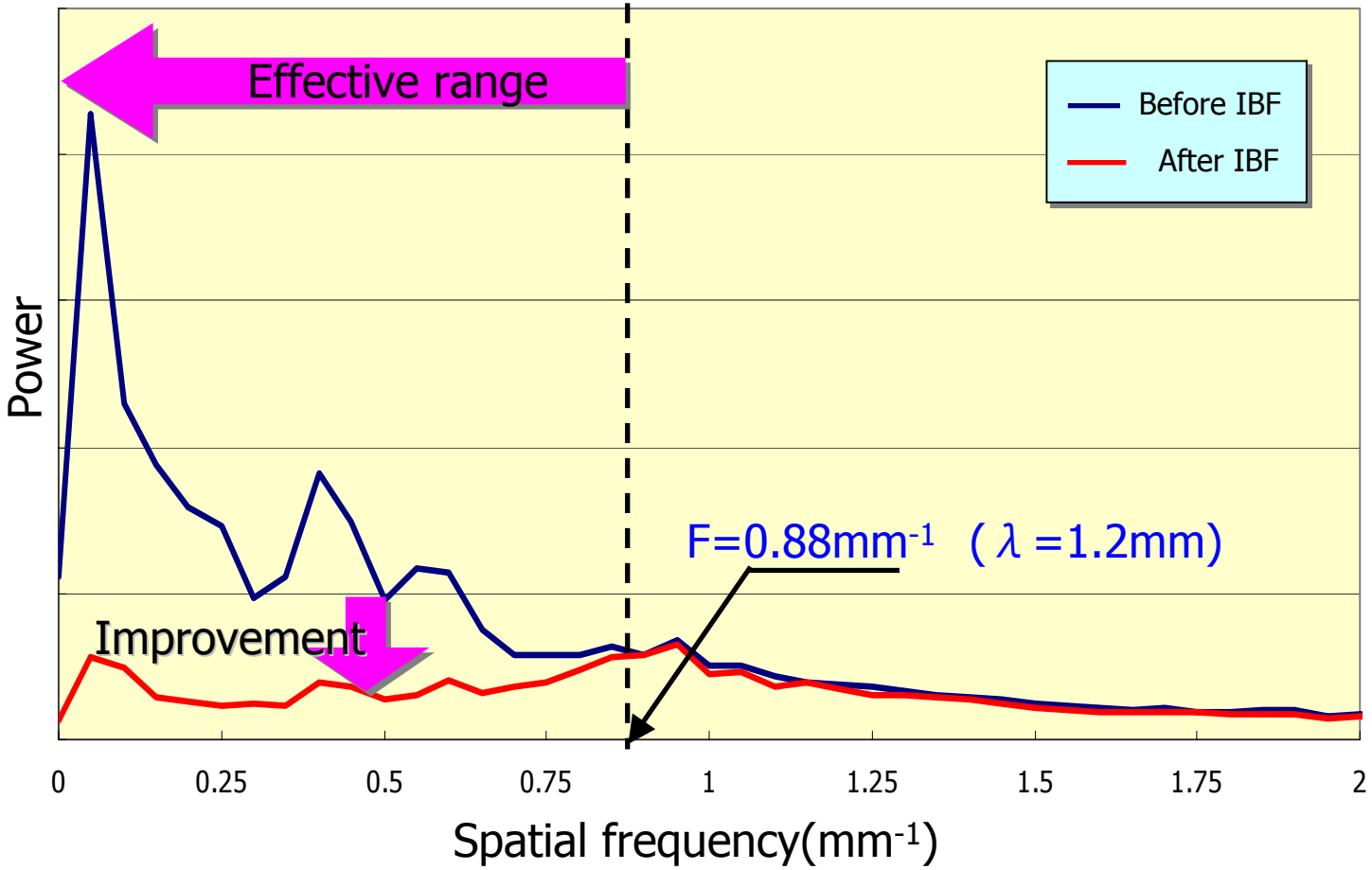
after IBF

One small beam operation on a flat work piece (20mm in diameter)

Points of process

- Resolution improvement for measuring ion beam current density profile
- Stability improvement for ion beam current control

Effective spatial resolution range ; small beam IBF



Small beam operation has 1.2mm wavelength resolution.

Conclusion

IBF system development for the figure correction of EUVL mirrors is completed.

- Two ion beam guns were developed with beam diameters of 1mm FWHM for 3mm foot print, and 4mm FWHM for 8mm foot print.
- IBF process is able to correct figure errors to better than 0.2nmRMS without changing MSFR, and less change in HSFR.
- The performance of the IBF for fabricating SFET mirrors were discussed.

Acknowledgement

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