Stabilization of IF characteristics by automatic alignment system for collector module alignment

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Abstract

Stable EUV light through the IF from a SoCoMo is extremely needed for EUV exposure tools. Characteristics of the EUV light through the IF such as power distribution or angular distribution are changed by thermal deformation of the collector, degradation of collector mirror reflectivity, and displacement of plasma position, etc.

The angular distribution stability is considered to be especially important for EUVL optics. Therefore, an automatic alignment algorithm to compensate the change in angular distribution has been developed. Also, an angular distribution monitoring system has been fabricated. In the alignment algorithm, fuzzy logic is applied and a learning function is also implemented to reduce the time for alignment. Also, to more shorten the alignment time, a new concept, “Distribution Library”, has been developed. Our angular distribution monitor system can be installed in the SoCoMo, since a special designed filter is used to select the significant EUV rays. Any monitor is not needed inside the exposure tool.

It has been demonstrated that a deteriorated angular distribution returns to an initial distribution within one minute by adjusting the collector position with the alignment algorithm and with the monitoring system. Also, it has been found that by using our “Distribution Library”, the alignment time is more shortened.

Automatic alignment systems with our alignment algorithm and with IADM has been confirmed to be very useful to realize a reliable HVM SoCoMo.

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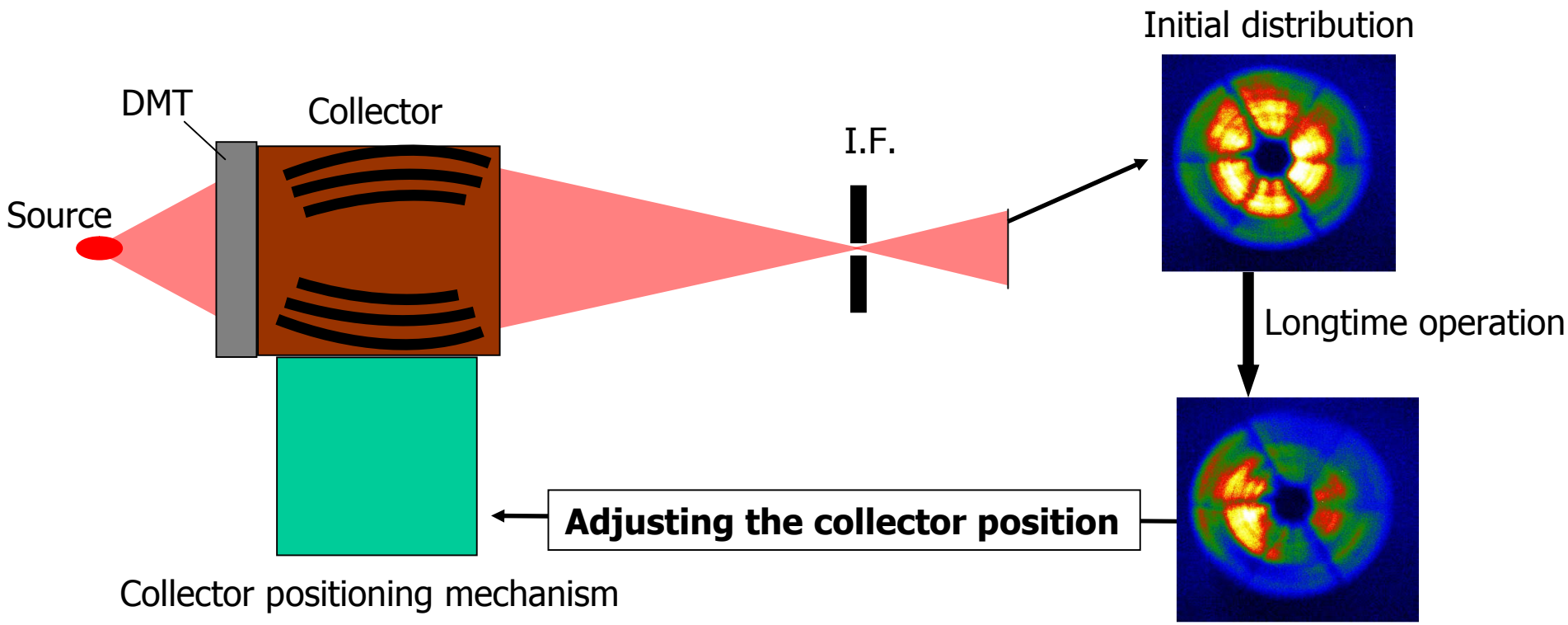
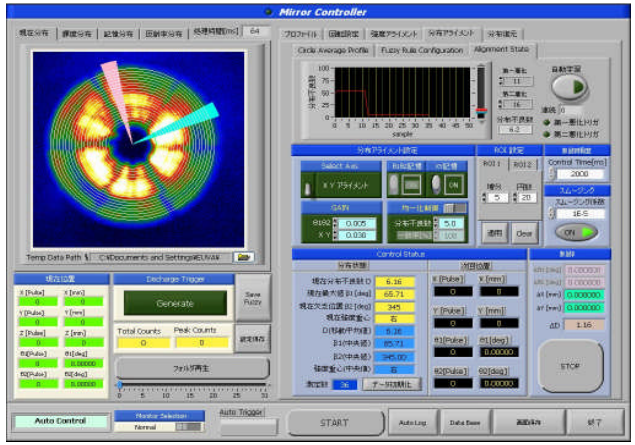
Background



IF characteristics of the EUV SoCoMo are changed during source operation.

Dynamic adjustment of collector position is necessary to get stable source performance.

Automatic alignment algorithm development



Software

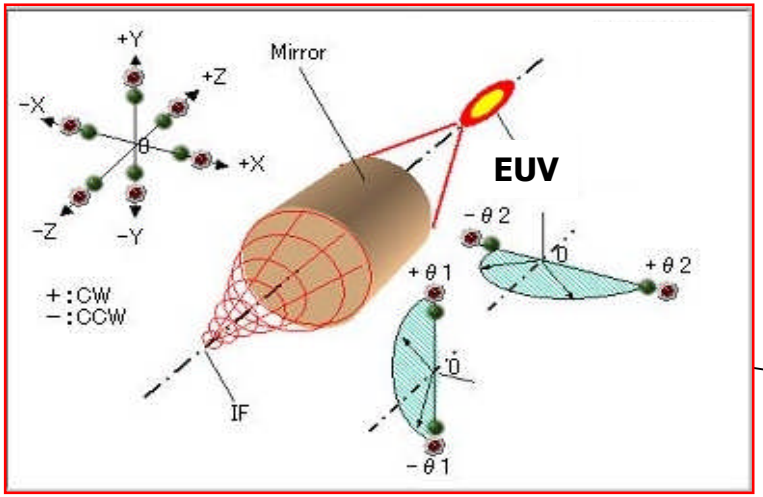
Concept of algorithm

Fuzzy logic

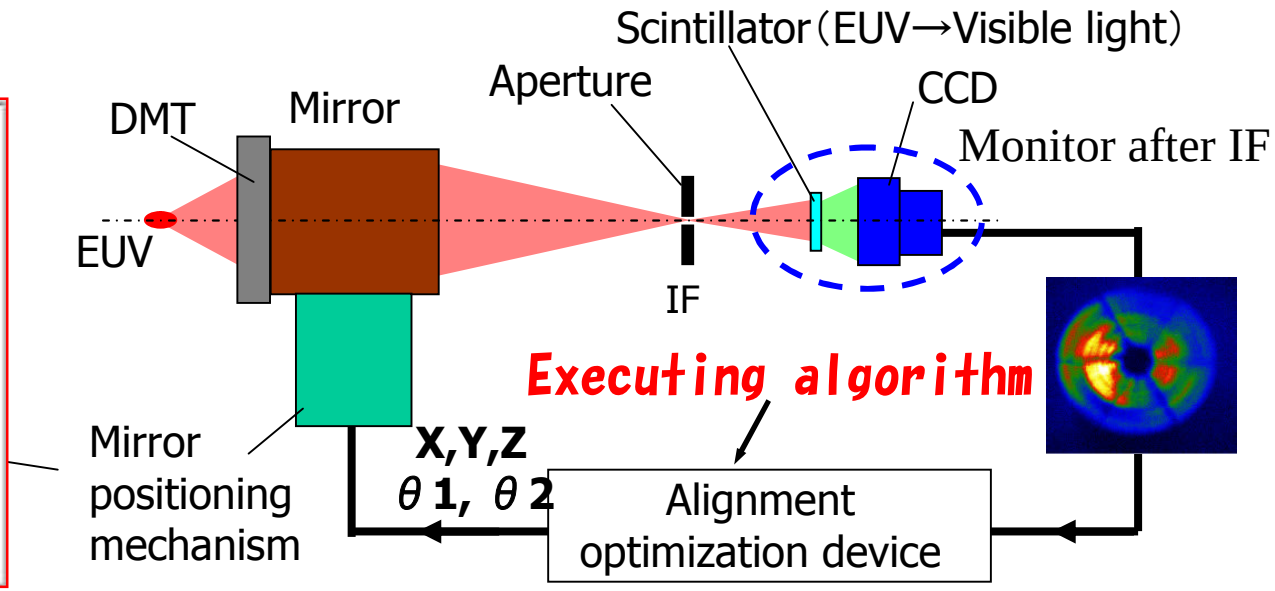
-> X, Y, Z, θ1, θ2 change corresponding to any change in distribution can be calculated instantaneously

Learning function

-> self-updating of the fuzzy logic enables the reduction of alignment time



Mirror axes



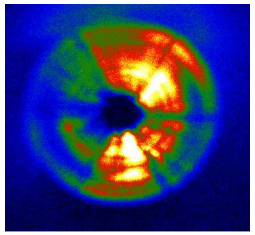
Automatic alignment system for developing the algorithm

Experimental results of automatic alignment (for mirror "tilt")

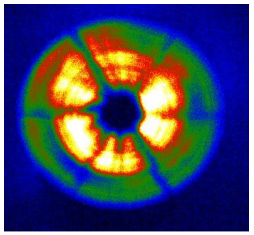
The alignment was completed within one minute

Before | After

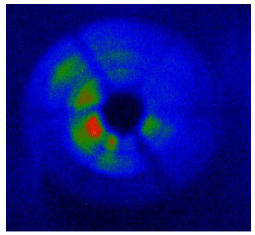
+θ1 (+0.3deg)



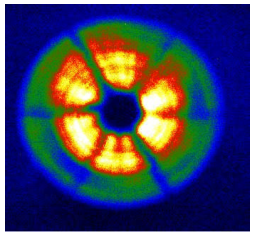
Auto alignment



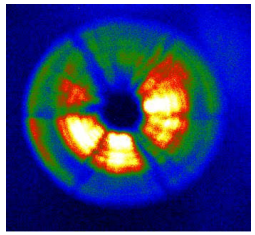
-θ1 (-0.3deg)



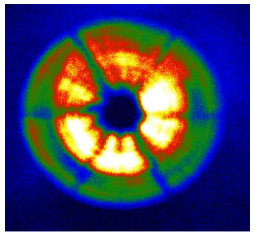
Auto alignment



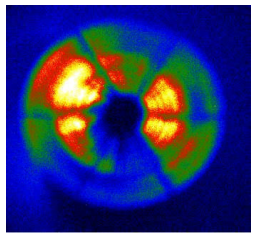
+θ2 (+0.3deg)



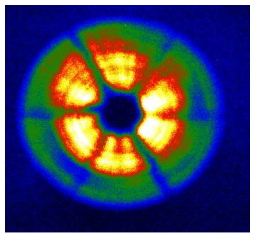
Auto alignment

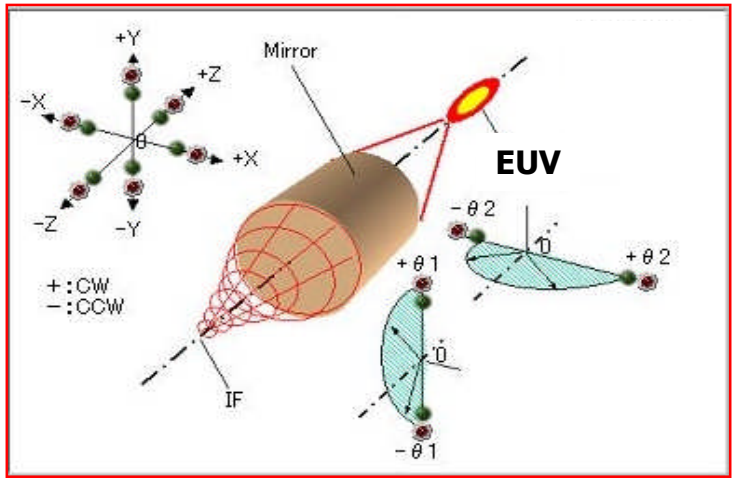


-θ2 (-0.3deg)



Auto alignment

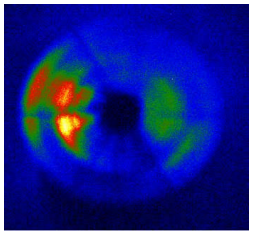
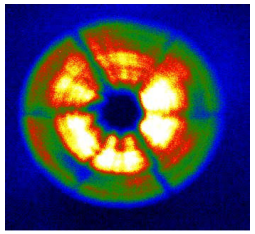
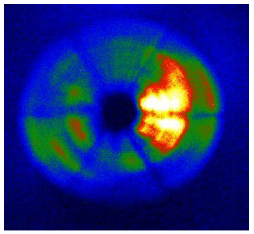
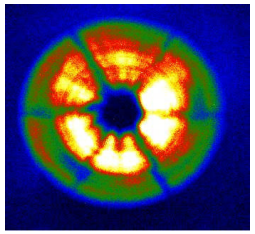
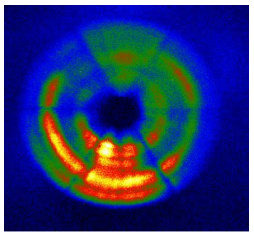
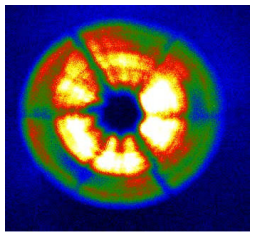
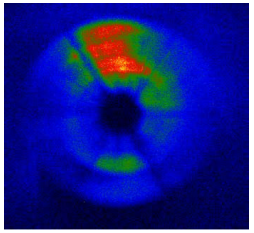
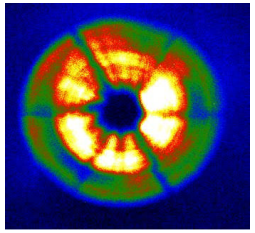


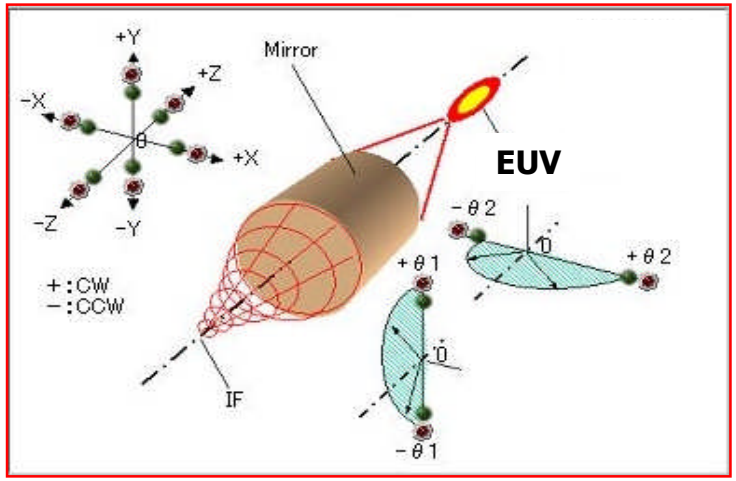


Mirror axes

Experimental results of automatic alignment (for mirror "x-y offset")

The alignment was completed within one minute

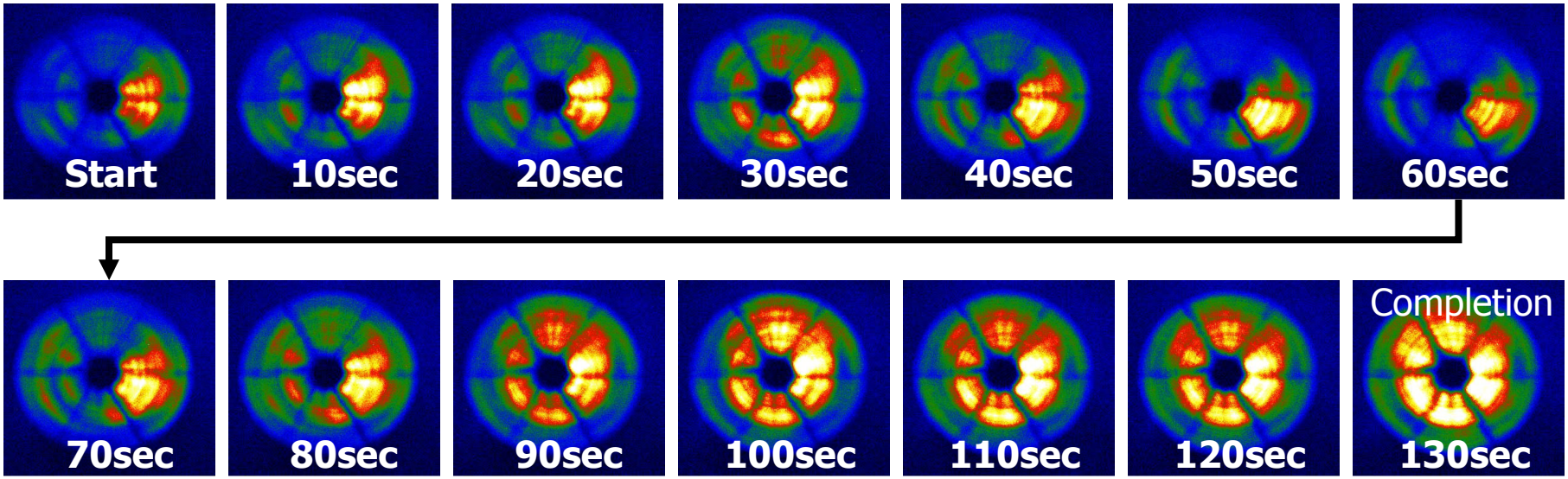
	Before		After
+X offset (+1.2mm)		Auto alignment →	
-X offset (-1.2mm)		Auto alignment →	
+Y offset (+1.2mm)		Auto alignment →	
-Y offset (-1.2mm)		Auto alignment →	



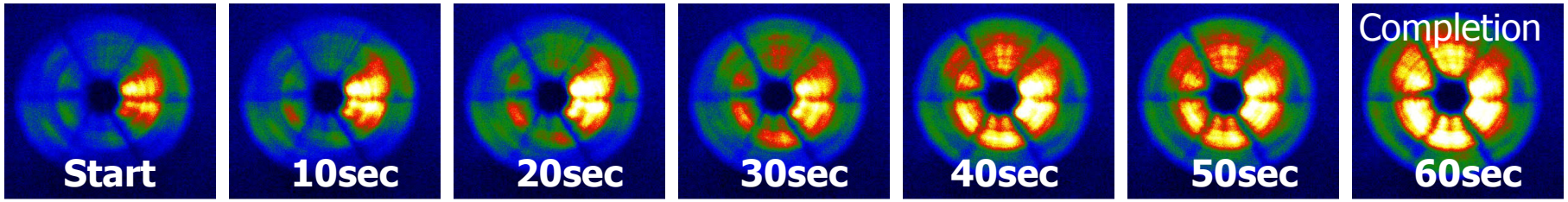
Mirror axes

Learning function to reduce the time for alignment

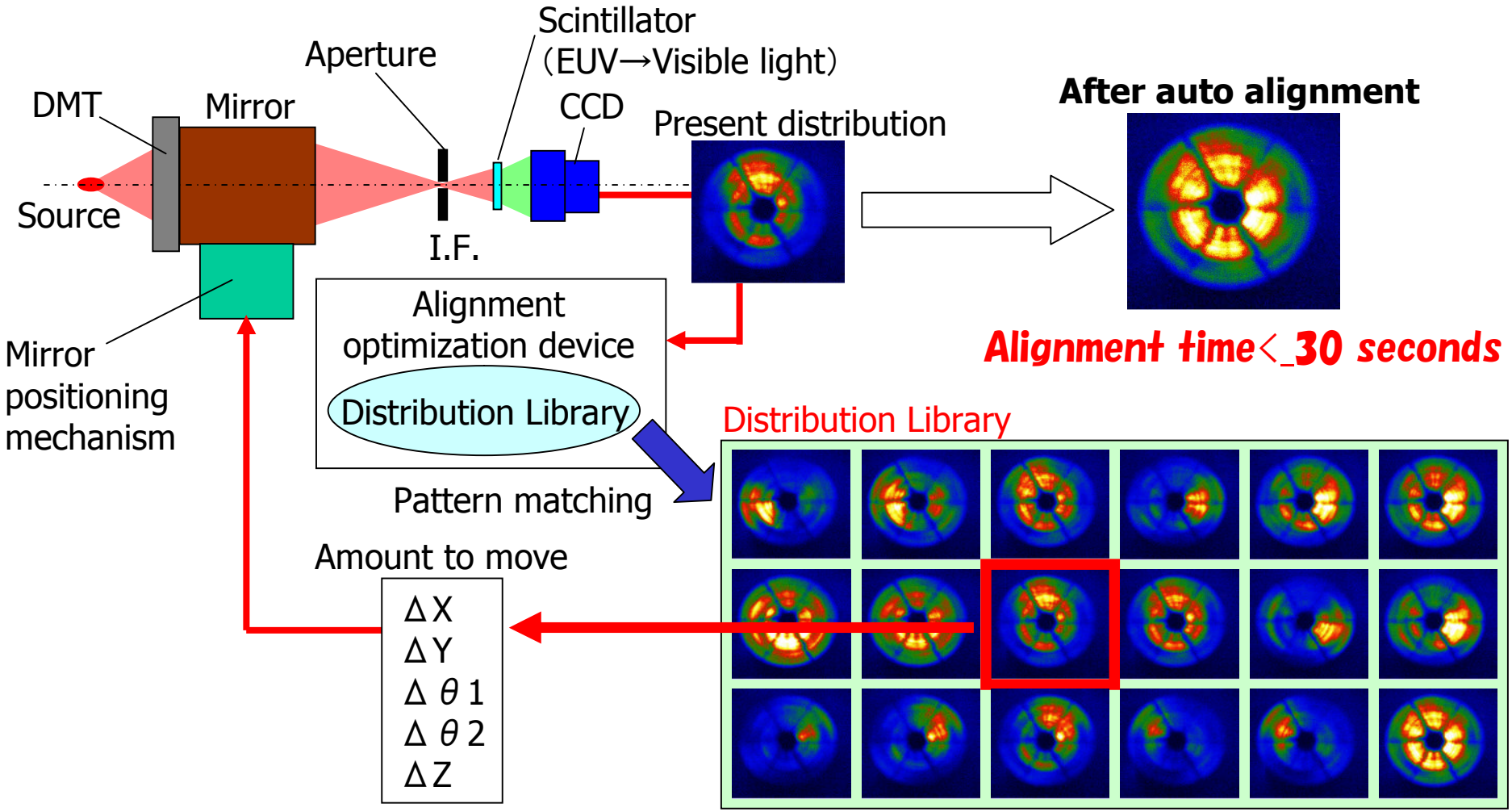
< Before learning >



< After learning >



Shortening of alignment time by using "Distribution Library"

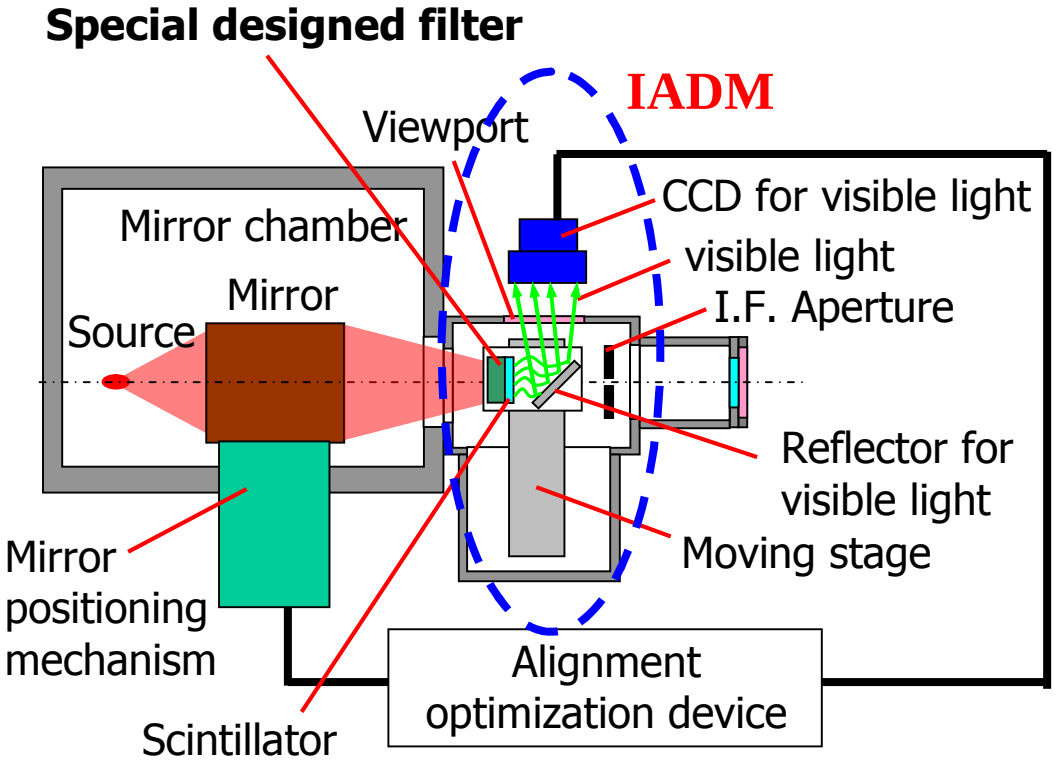


After auto alignment

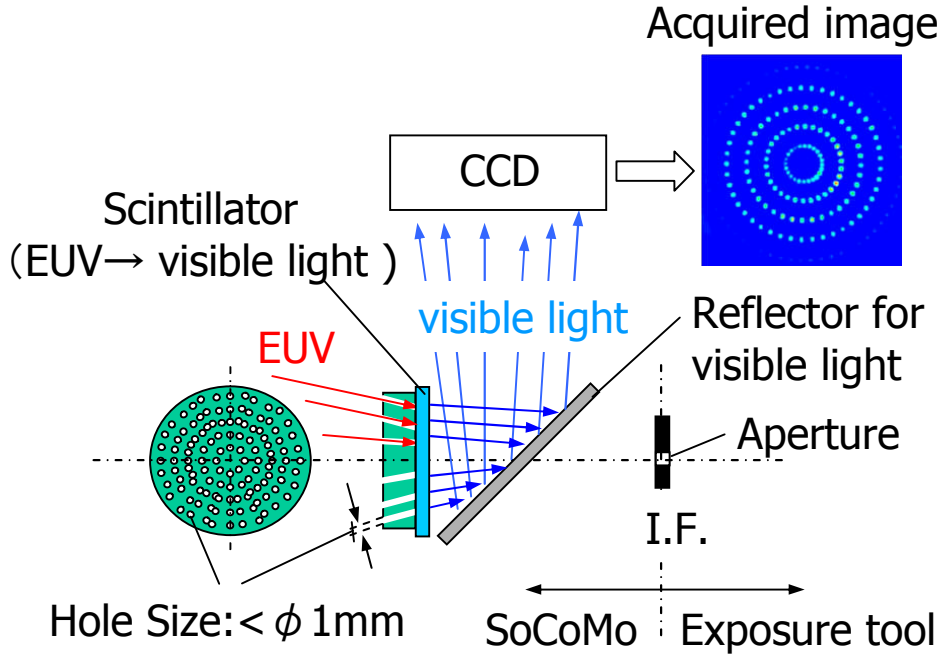
Alignment time<_30 seconds

~4000 combinations of deviation & distribution are registered

Inside angular distribution monitor development (IADM)



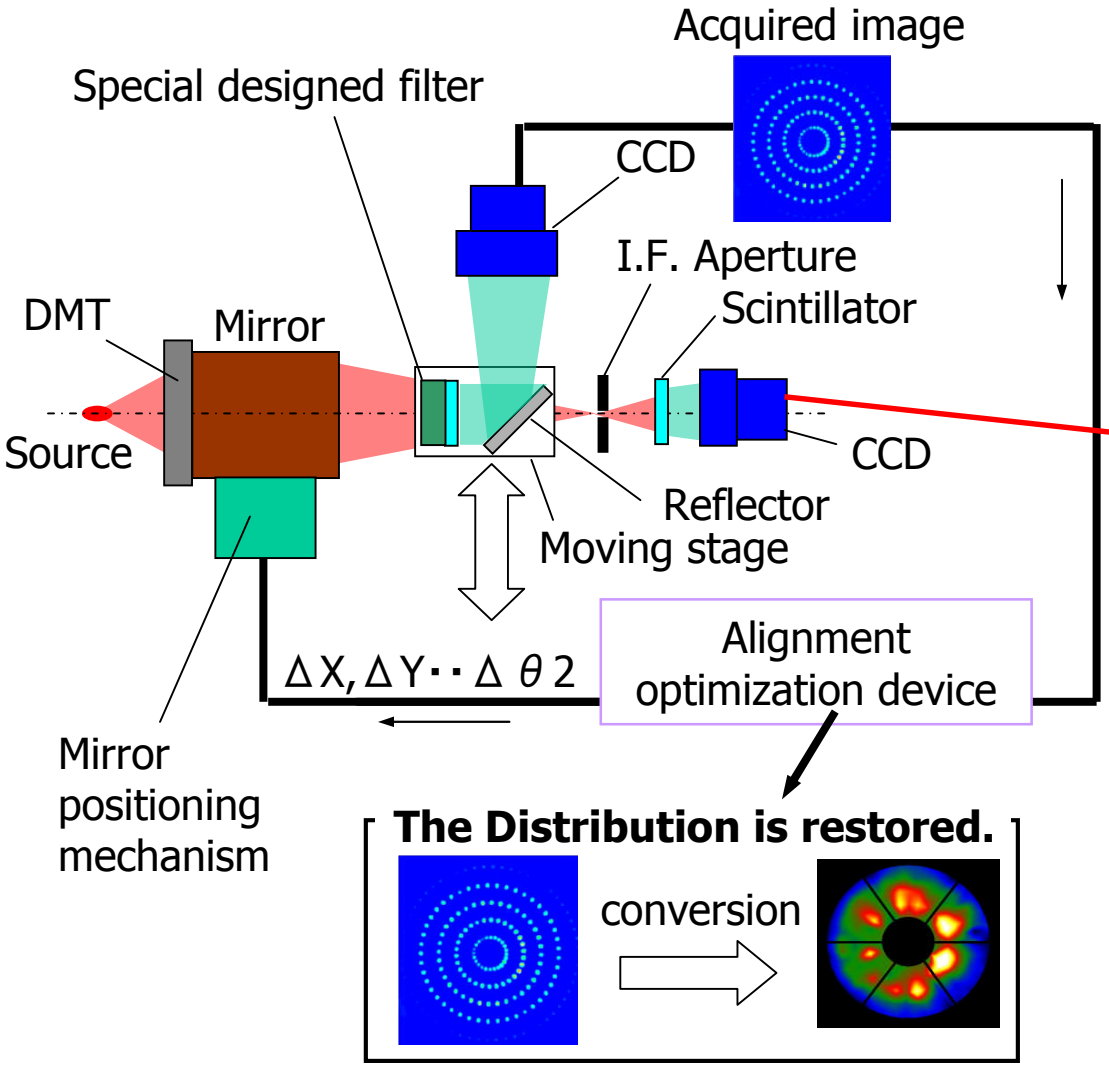
Automatic alignment system with IADM



Special designed filter

IADM (Inside angular distribution monitor) is installed in SoCoMo's, because a special designed filter is used to select the significant EUV rays. Any monitor is not needed inside the exposure tool.

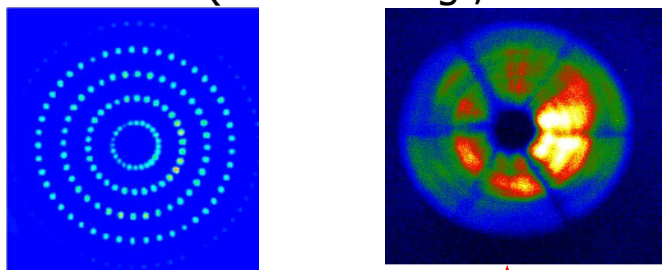
Experimental results with IADM



Automatic alignment system with IADM

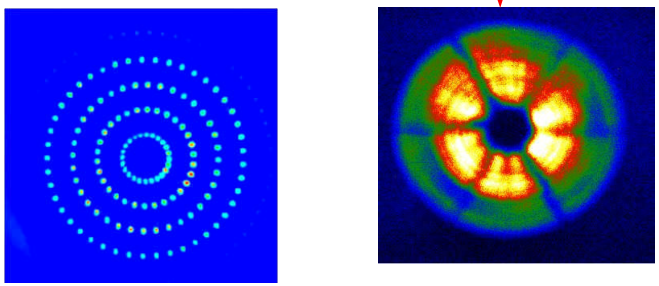
Before Auto alignment

Mirror Tilt ($\theta 1 \fallingdotseq 0.1$deg , $\theta 2$



Checked by the IF rear side monitor

After Auto alignment



The alignment with IADM was completed as good as with a monitor after the IF

Summary

・An alignment algorithm with the fuzzy logic and the learning function has been developed, for automatic alignment systems to adjust EUV light angular distribution change through the IF.
The alignment can be completed within one minute for any changes of the angular distribution.

・The alignment time is more shortened by using the " distribution library " which is registered about 4000 angular distribution patterns. Alignment is completed within 30 seconds.

・IADM, inside angular distribution monitor, has been developed, for automatic alignment systems. IADM is installed in the SoCoMo, because a special designed filter is used to select the significant EUV rays.
Any monitor is not needed inside the exposure tool.

・Automatic alignment systems with our alignment algorithm and with IADM is confirmed to be very useful to realize a reliable HVM SoCoMo.

Acknowledgments

-Members of EUVA Gotemba

-Members of EUVA headquarters

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New Energy and Industrial Technology Development Organization (NEDO).