

Applications of Multilayer optics

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Outline

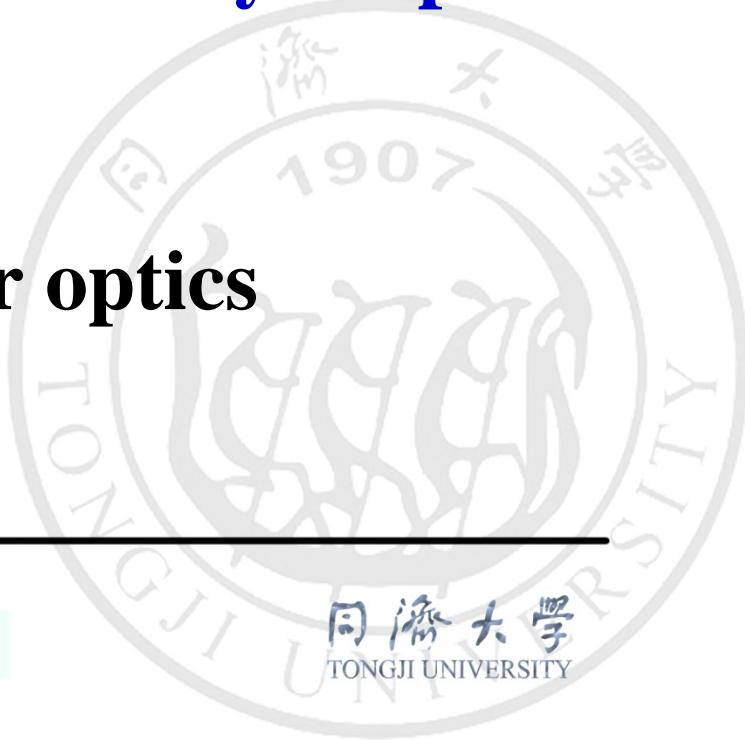
- Motivations
- { ➤ Design
➤ Fabrication
➤ Characterization } **Multilayer optics**
- Applications of multilayer optics
- Summary and outlook



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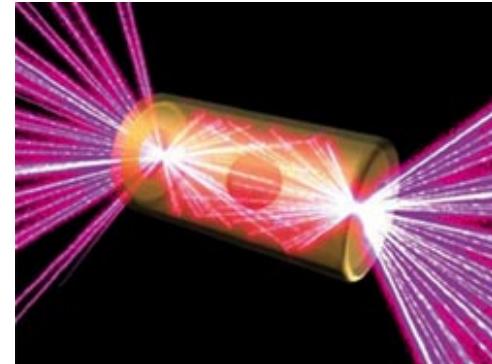
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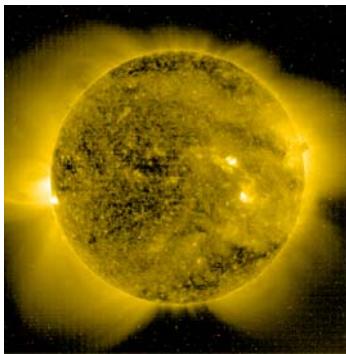
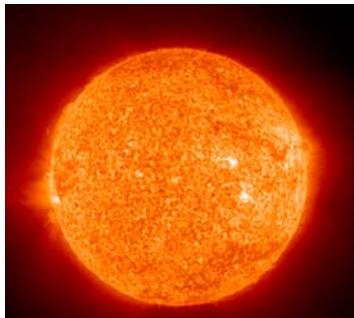


Motivations

X-ray lasers



inertial confinement fusion



Astronomical observation



Synchrotron Radiation

Non-periodic multilayer coatings: special requirements



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Design of multilayer optics

Keys of design

Merit functions

Different applications need different merit functions

Optimized algorithms

- 1 simulated annealing algorithm
- 2 Random search method
- 3 Local optimized algorithms

Starting structures

- 1 Quarter wave periodic multilayers
- 2 Multilayer stacks with a varieties of periods
- 3 Initial solutions made by analytical expression



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Fabrication of multilayer optics



Magnetron Sputtering systems



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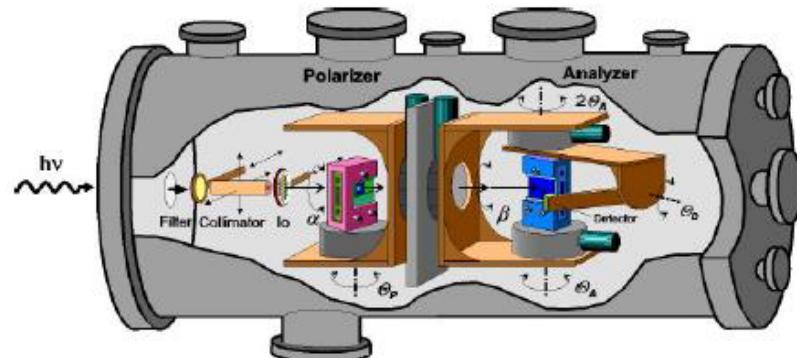
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Characterization of multilayer optics

XE-100 atomic force microscope



D1 X-ray diffractometer
made by Bede Company



Soft X-ray polarimeter in BESSY II



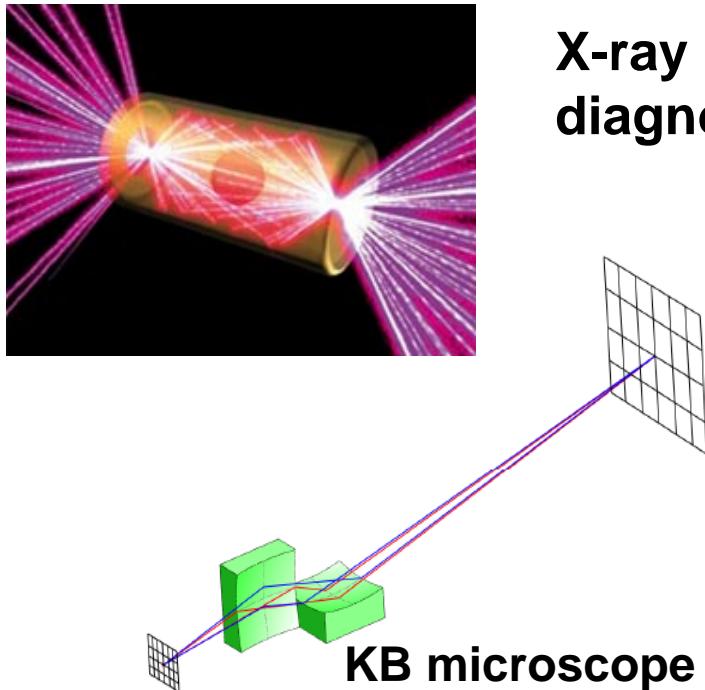
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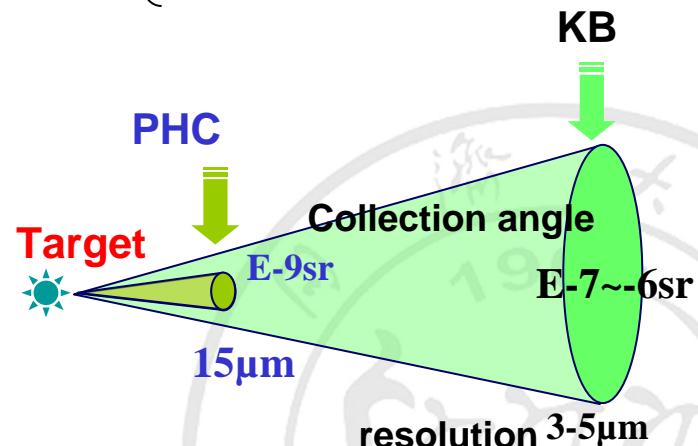
1. X-ray KB microscopes



X-ray imaging diagnostics

Pinhole camera

KB microscope



KB microscope is one of essential diagnostic tools in ICF research.



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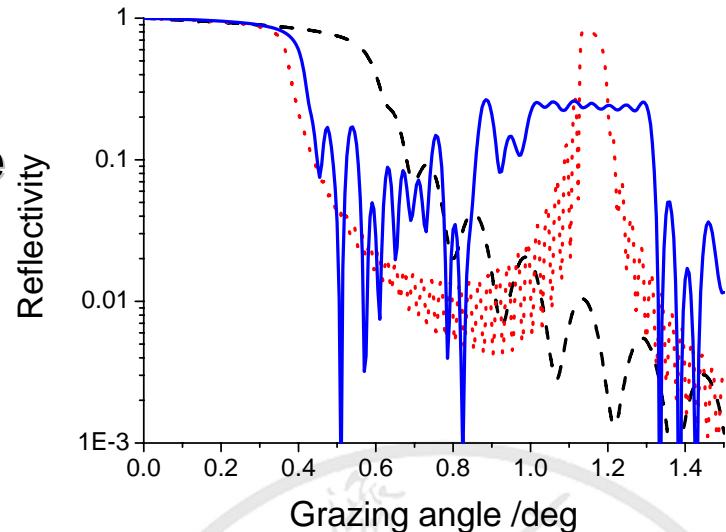
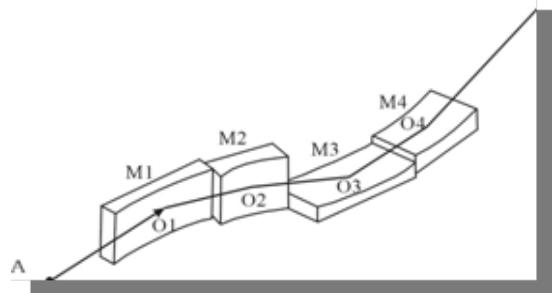
Applications of multilayer optics

1. X-ray KB microscopes

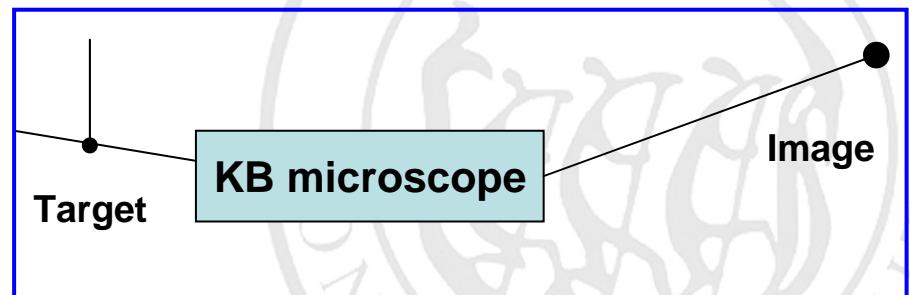
Difficulties in making KB microscope

- High quality mirrors
 - a) Mirror fabrication
 - b) Coating
- Assembly and alignment

a) How to assemble the mirrors?



b) How to adjust the assembly in diagnostics experiments?



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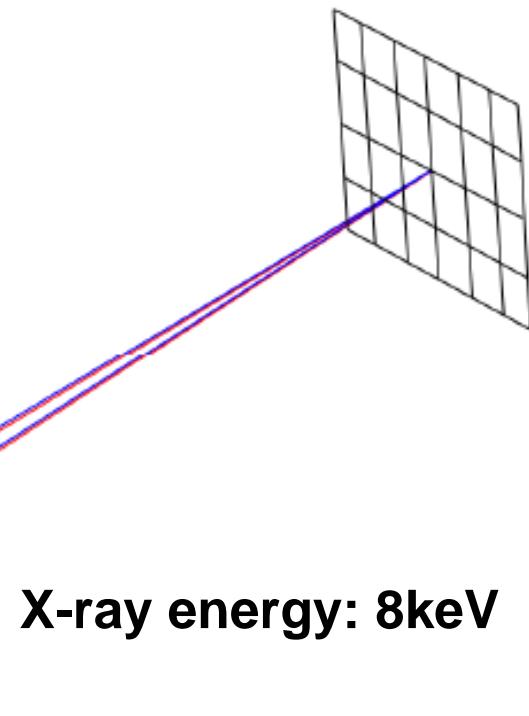
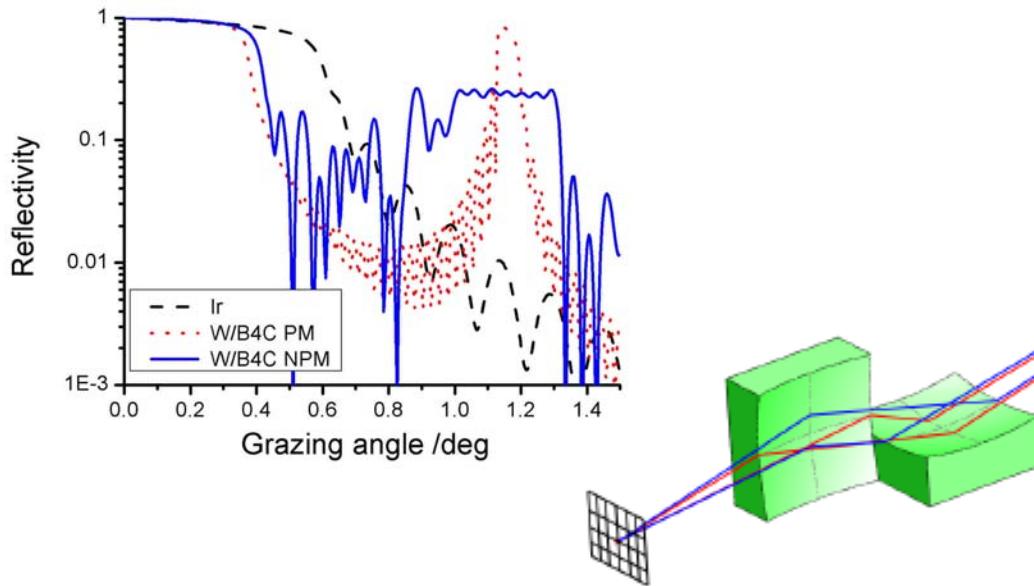
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Applications of multilayer optics

1. X-ray KB microscopes

Mirrors: Ir single layer,
W/B4C periodic multilayers
non-periodic multilayers



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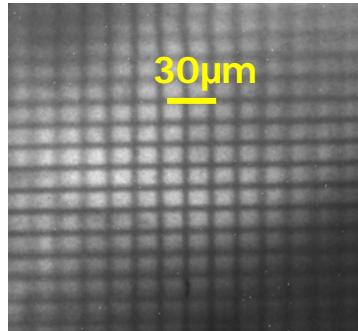
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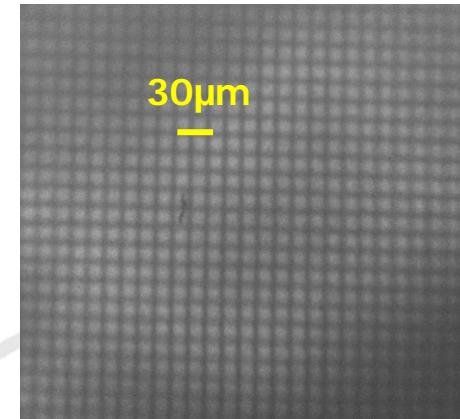
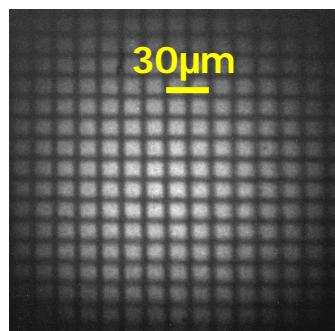
1. X-ray KB microscopes

Comparison of three kind of microscopes

X-ray energy: 8keV



Magnification: 10×



Performance	Single layer	W/B ₄ C periodical multilayer	W/B ₄ C non-periodical multilayer
Spatial resolution (μm)	6	4	5
Field of view (μm)	±100	±100	±200
Spectral resolution (E/ΔE)	none	40	10



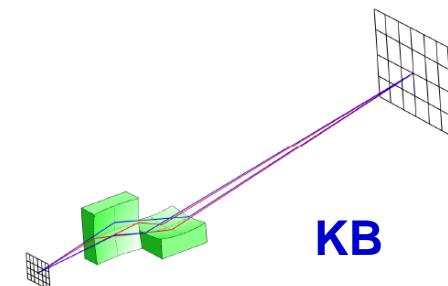
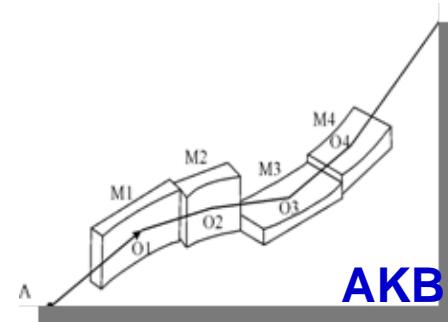
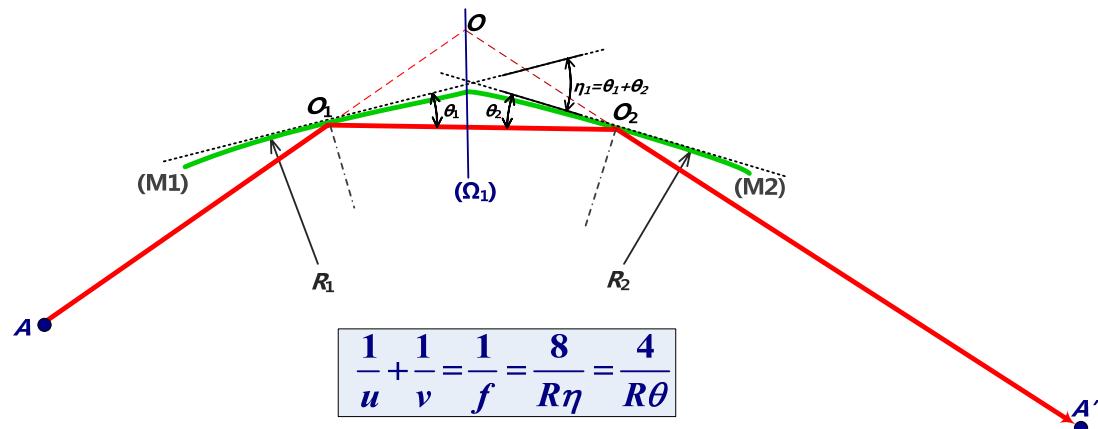
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Applications of multilayer optics

1. X-ray KB microscopes



Advanced KB microscope:

Better resolution, large field of view



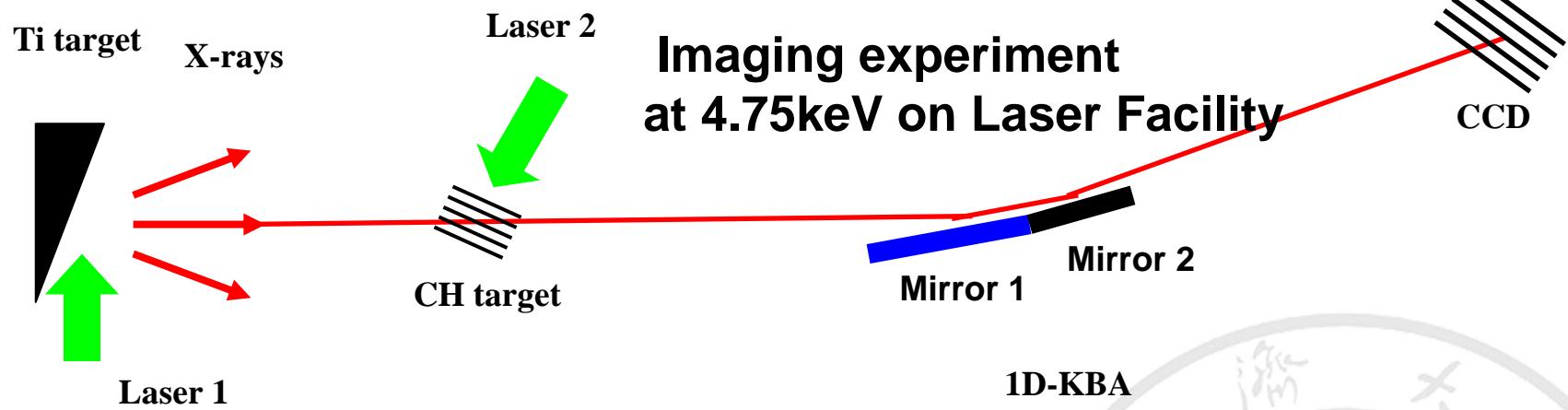
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Applications of multilayer optics

1. X-ray KB microscopes



- Diagram of 1D-AKB diagnostics



CH target was fixed on the reference plane, the best object position.



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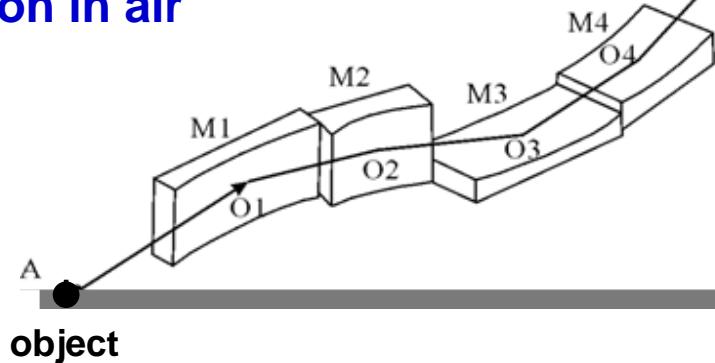
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Applications of multilayer optics

- X-ray imaging experiments is necessary
- The determination of best grazing incidence angle and best object point is complicated.

Hard x-ray KB microscope

Operation in air



Soft x-ray KB microscope

Operation in vacuum

We proposed a multilayer method to play the alignment of soft x-ray KB microscope in air.

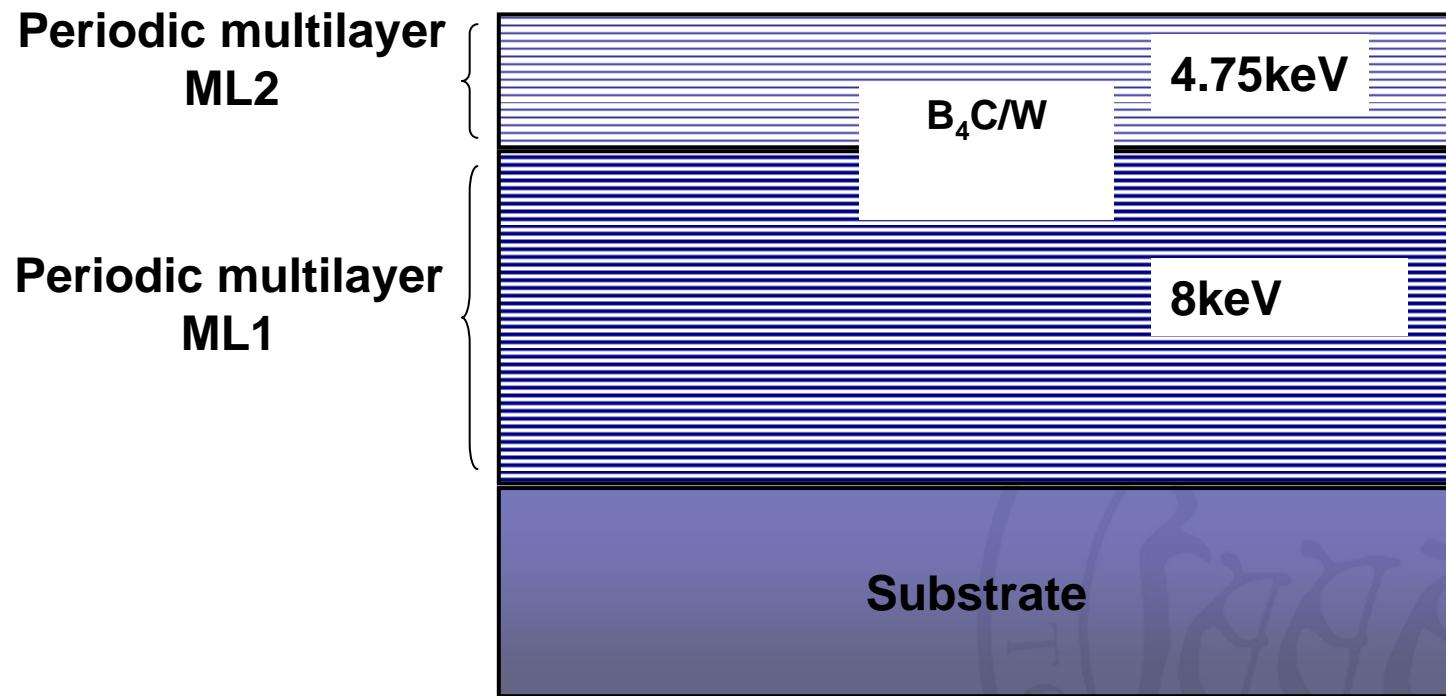


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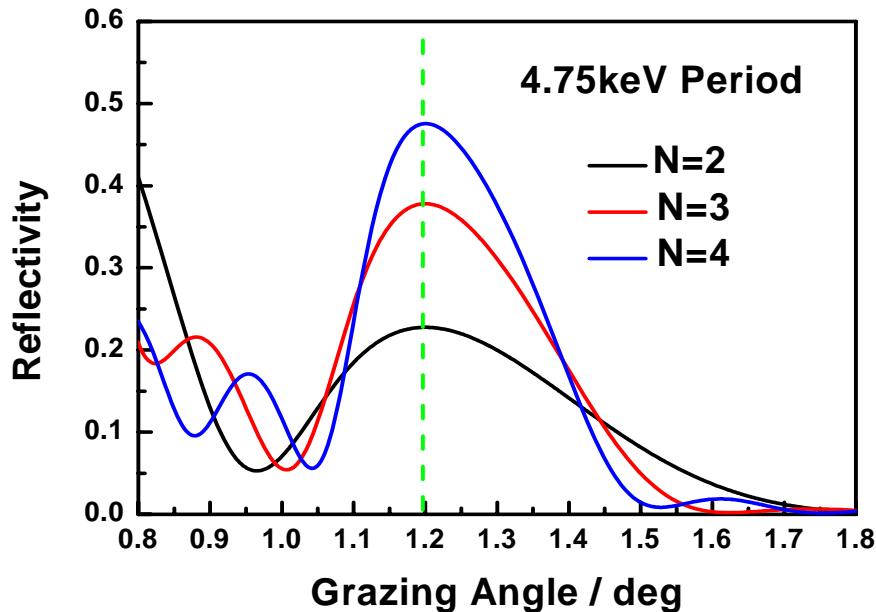


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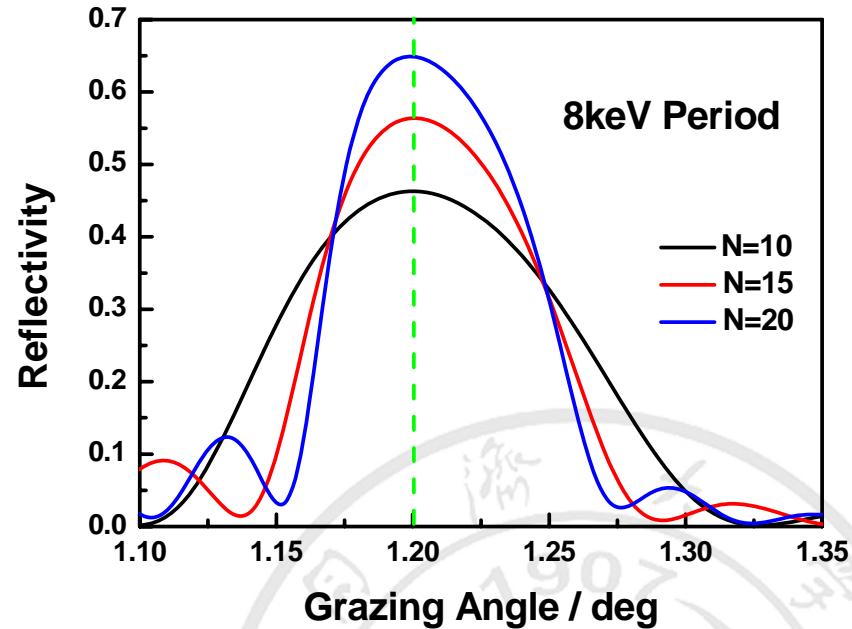
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Applications of multilayer optics



Calculated reflectivity of various number of periodic layers working at 4.75keV



Calculated reflectivity of various number of periodic layers working at 8keV

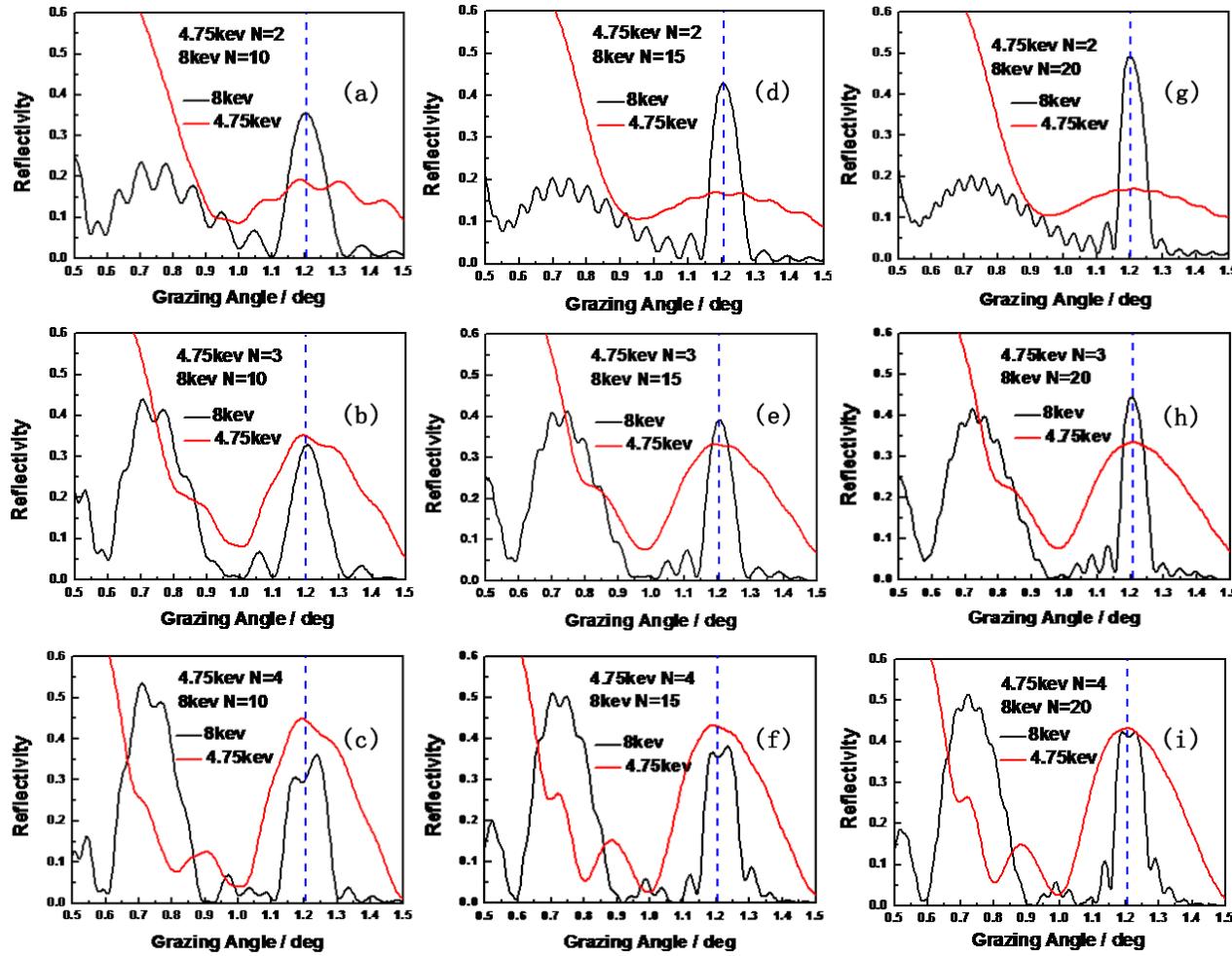


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Applications of multilayer optics

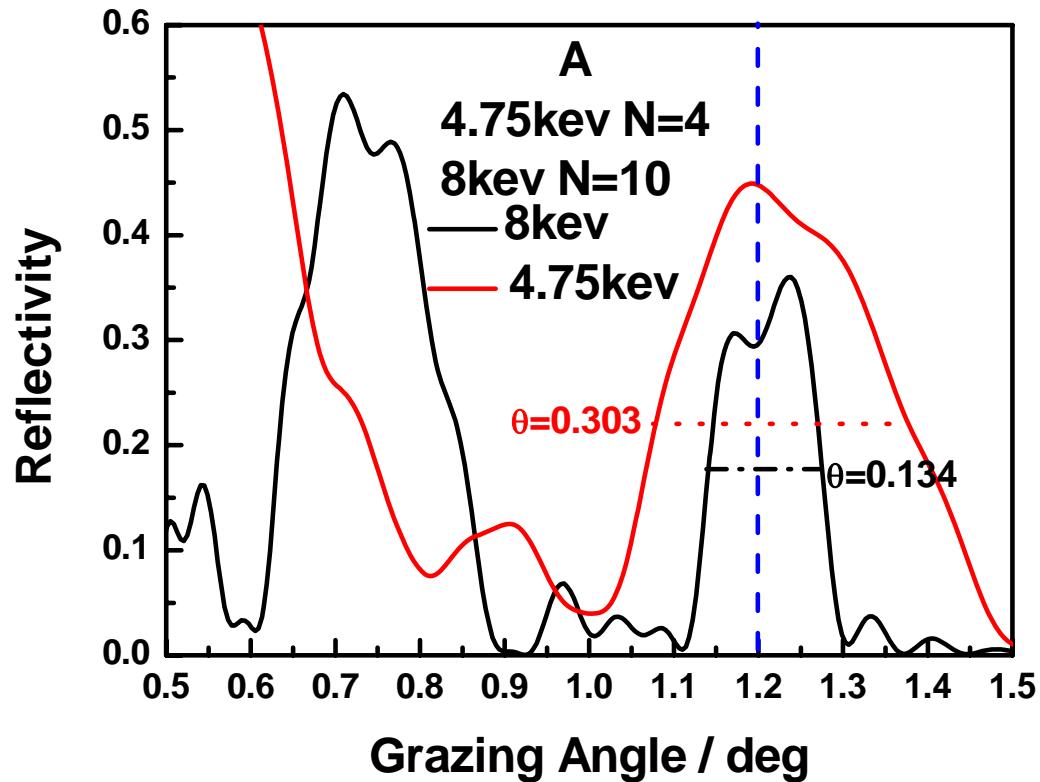


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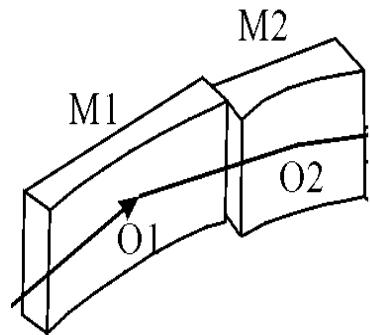


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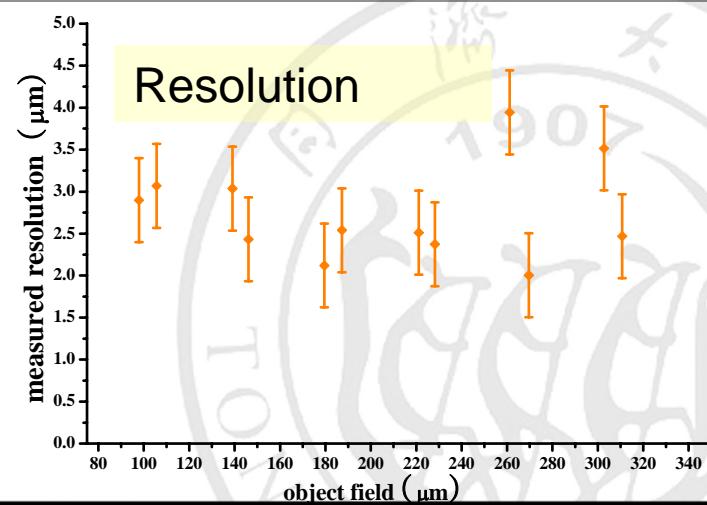
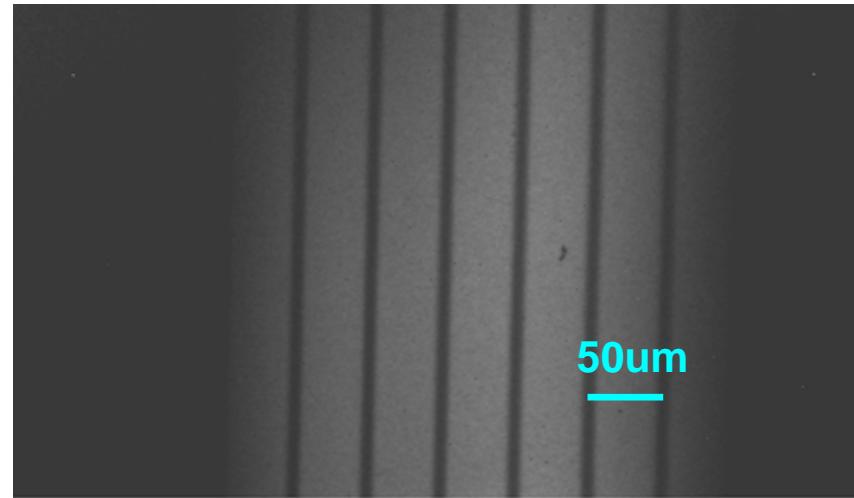
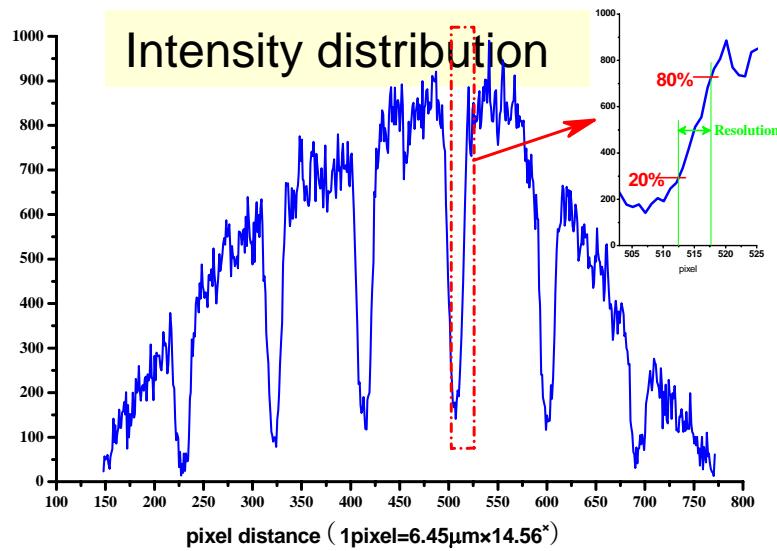
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• Imaging experiments at 8keV energy



Object is 600lp/inch Au mesh.

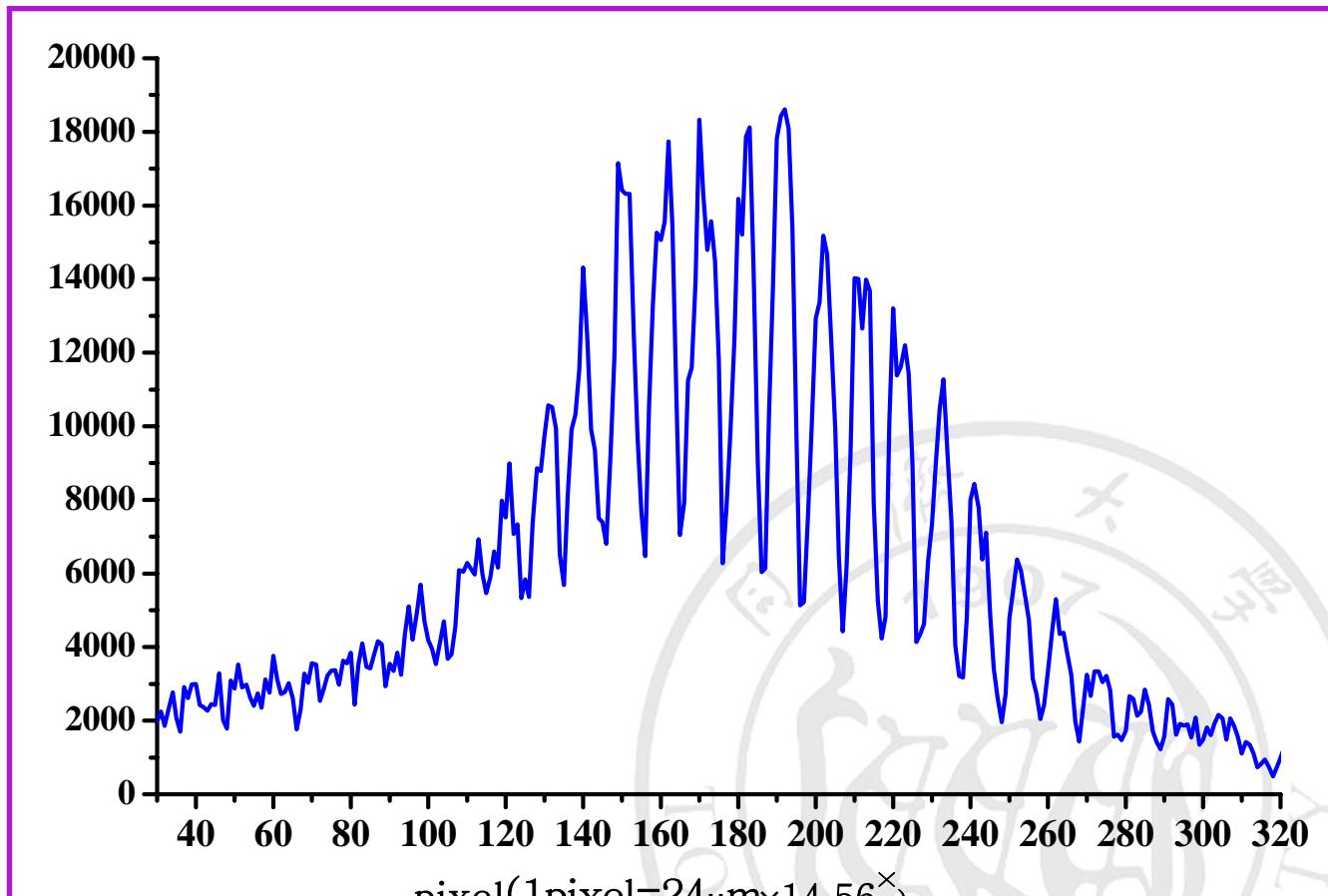
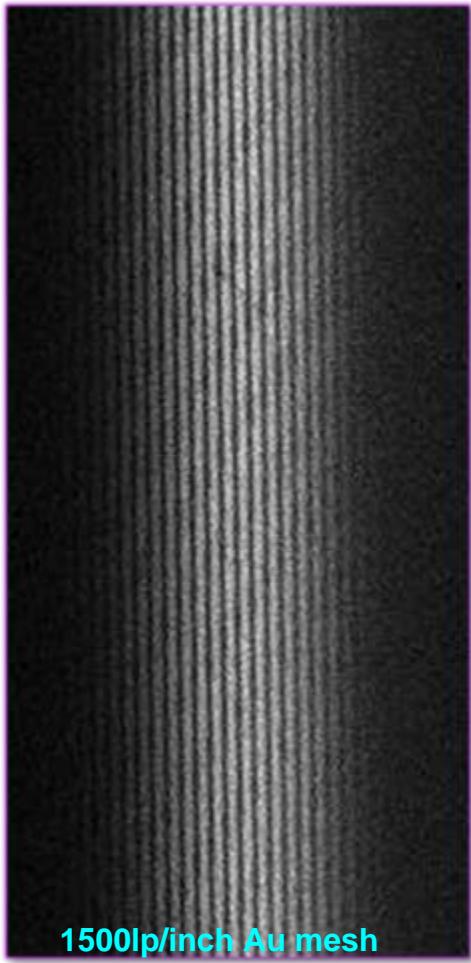


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Imaging results at 4.75keV on Laser Facility



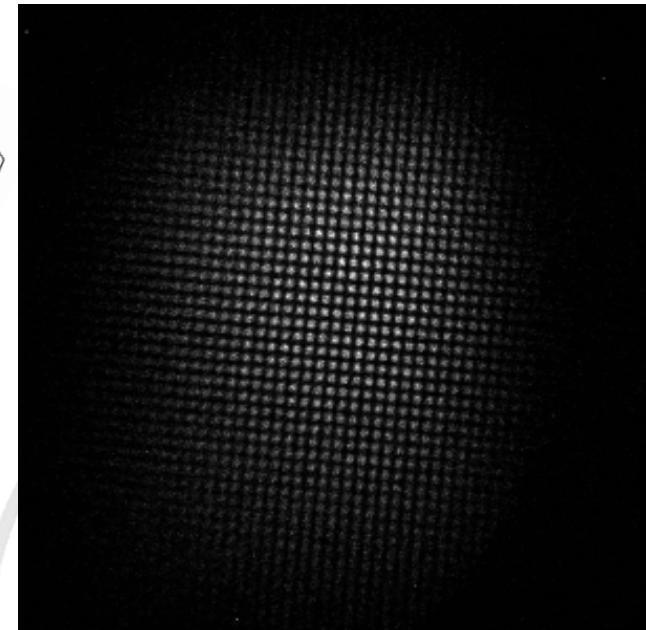
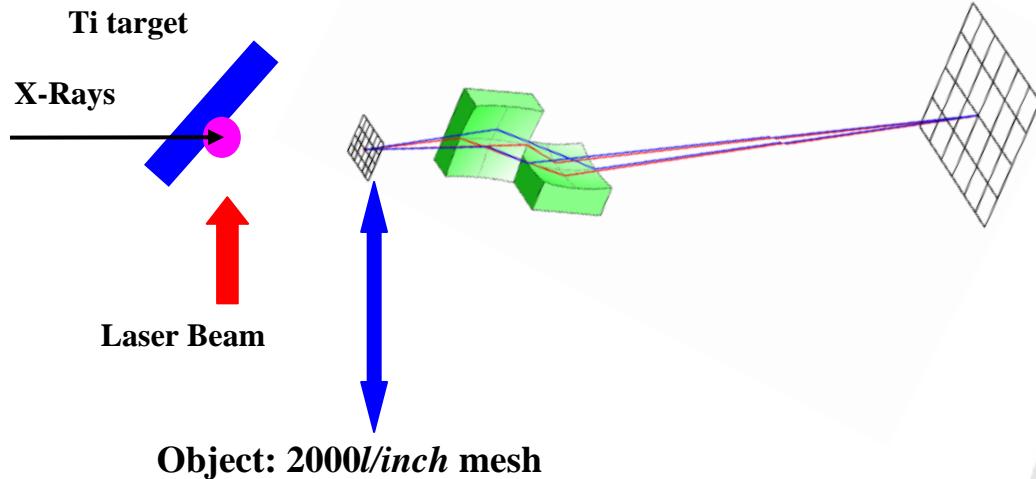
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Applications of multilayer optics

- 2D-KB microscope working at 4.75keV



Experimental schematic of 2D-KB microscope in Laser Facilities



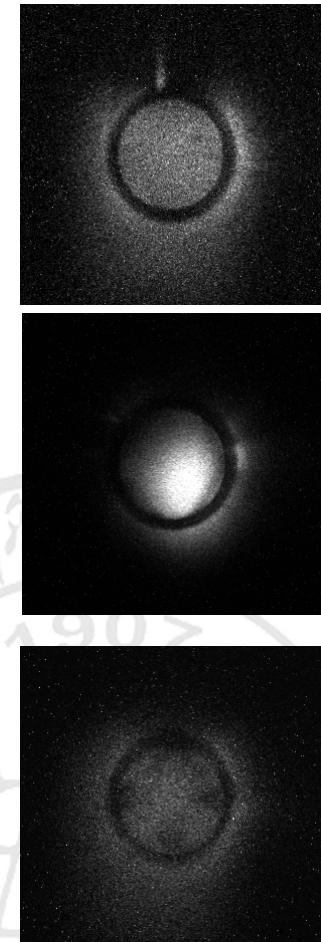
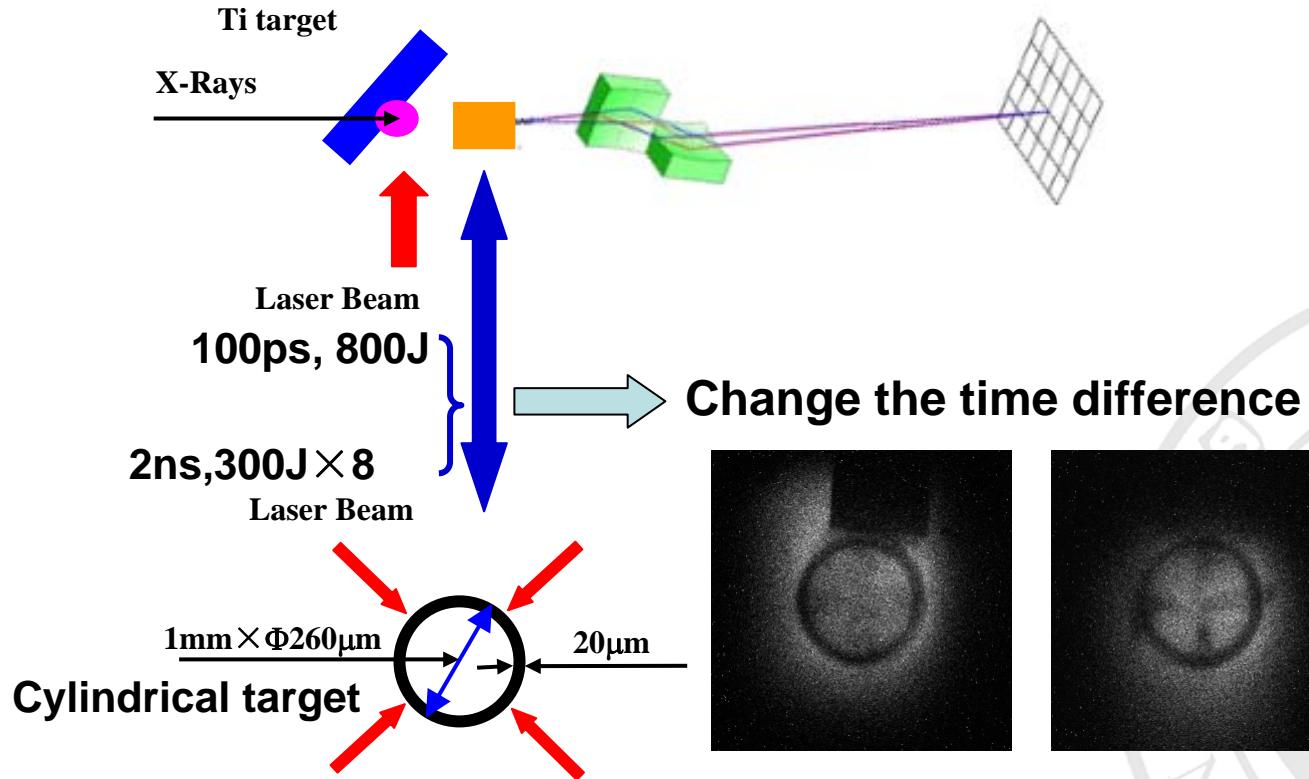
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Applications of multilayer optics

- 2D-KB microscope working at 4.75keV

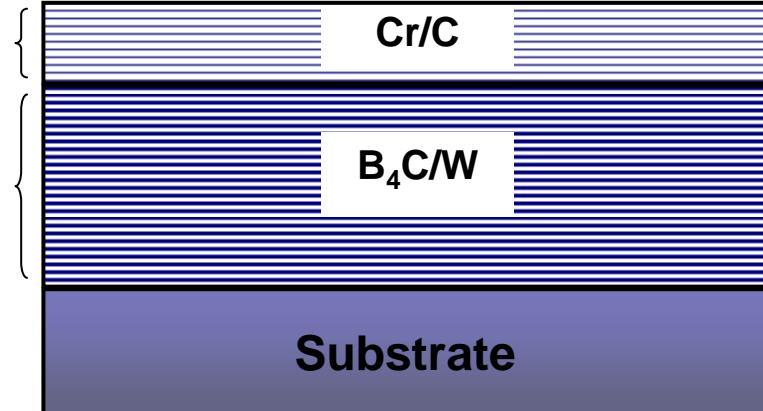


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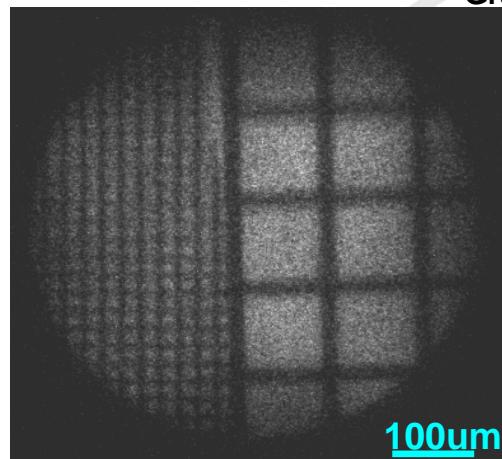
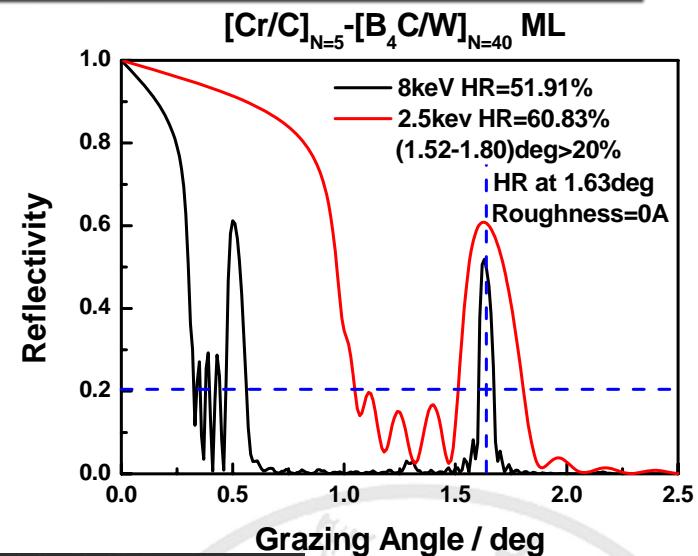
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• Application in 2.5keV KB microscopes

Periodic multilayer
ML2 N=5



8keV imaging results



100um

2.5keV
imaging
results



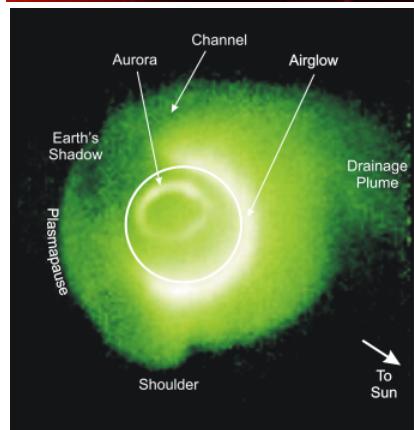
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Applications of multilayer optics

2 HR@30.4nm for He-II , AR@58.4nm for He-I



A EUV telescope on the moon

30.4nm imaging of magnetosphere

58.4nm light from ionsphere



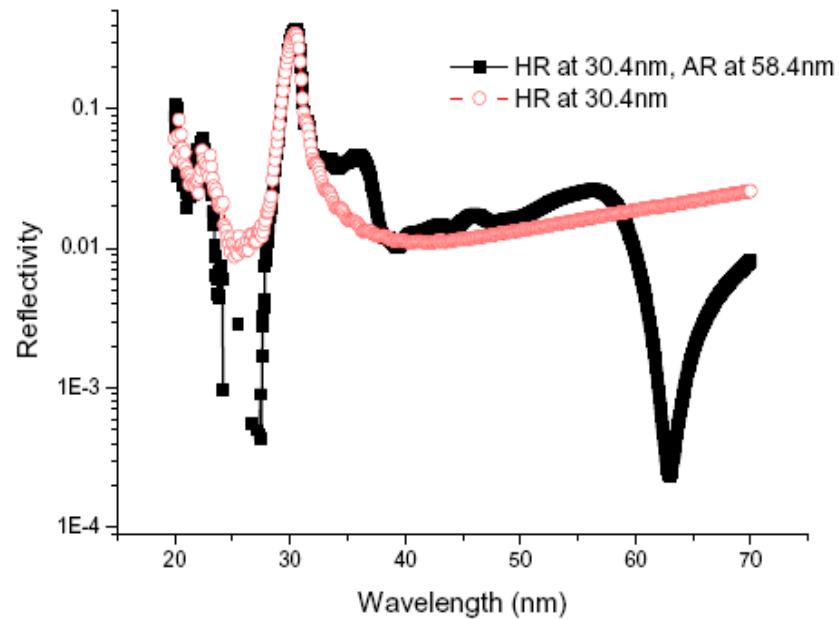
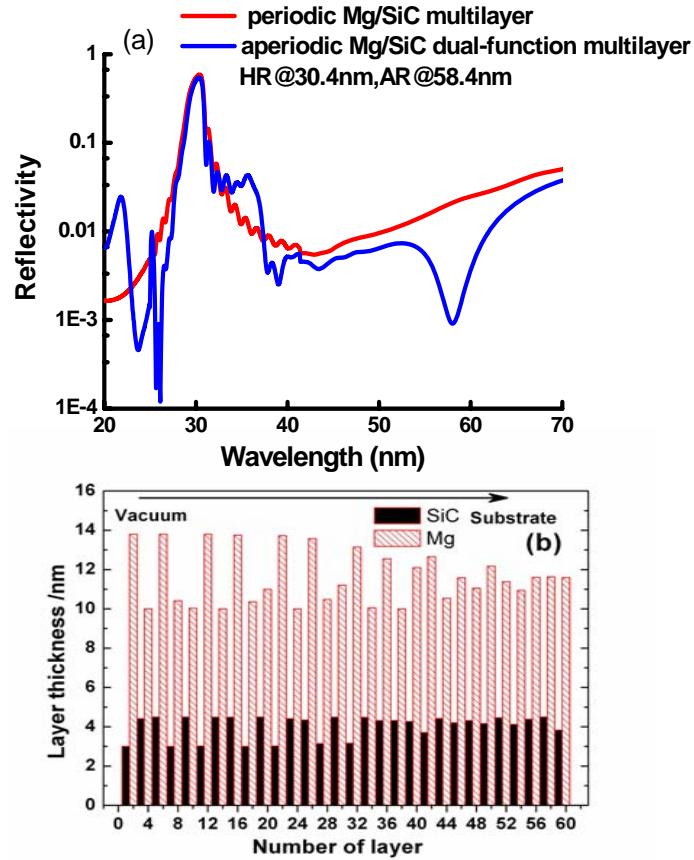
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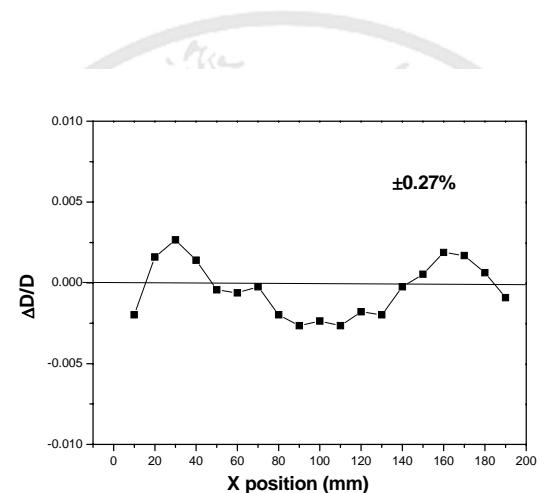
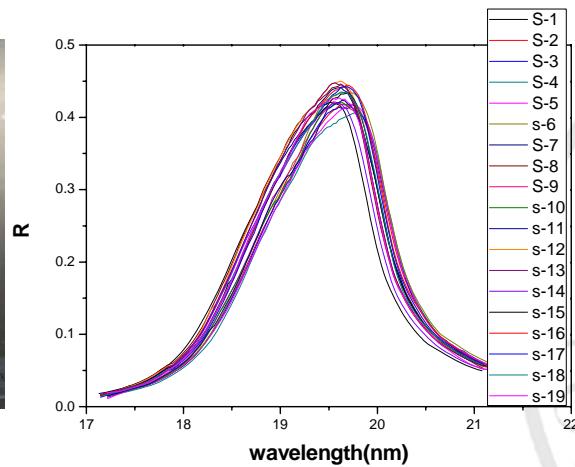
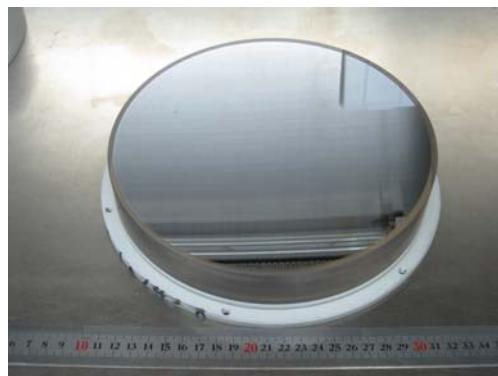
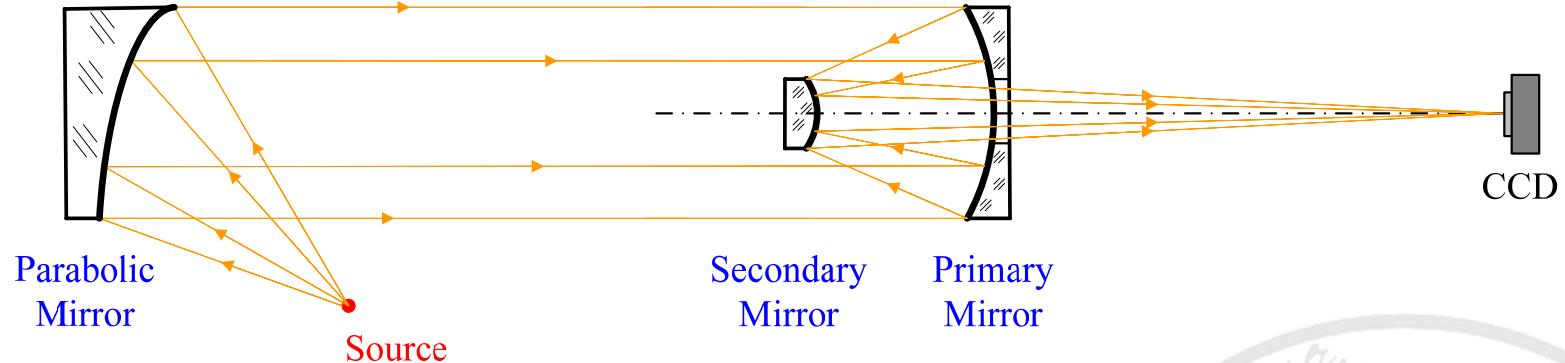
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2 HR@30.4nm for He-II , AR@58.4nm for He-I



Applications of multilayer optics

3 Multilayer Collimator at 19.5nm



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Summary and outlook

The multilayer coatings have been designed and successfully fabricated.

The experimental results agree with the design ones and show good property.

Improving the performance of multilayers and new multilayer applications



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