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Outline

1. Motivation
2. Laser system
3. LPP setups
   1. Liquid jet technology
   2. Rotating cylinder target
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1 Motivation: soft X-rays

X-ray emission spectroscopy
Grazing incidence for nm-resolution

X-ray absorption spectroscopy
L-edges of transition metals in solution
Biological samples

EUV metrology
Reflectivity
Foil thickness

Imaging
Microscopy in the water window
Coherent imaging
Holography

...
1 Motivation: soft X-rays

**X-ray emission spectroscopy**
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Goal: lab-based equipment
Outline

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   2. Rotating cylinder target
2 Pump Laser

High brilliance:
1. High single shot intensity
2. High repetition rate
3. Good beam quality & stability

⇒ diode-pumped YAG-laser systems
   slab system          thin disk laser system
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2 Laser system

- Pulse energy: 220 mJ
- Pulse duration: 10 ns
- Repetition rate: >100 Hz
- Mean power: > 15 W
- $M^2$: <1.2
2 Laser system

- Pulse energy: 220 mJ
- Pulse duration: 1 ns
- Repetition rate: >100 Hz
- Mean power: > 15 W
- $M^2$: <1.2

Modification

Diagram showing the components of the laser system, including pump radiation, Yb:YAG thin disc, and laser beam.
Stable performance: 235 mJ @ 1.1 ns
Regenerative system: shorter pulse durations possible
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3.1 Liquid jet system

- Nozzle
- Focused laser beam
- Plasma
- Nitrogen cryojet

**Source size**

- Slab laser
  - Size: 18x40µm
  - Power: PL = 60 W

- Thin disk laser
  - Size: 18x21µm
  - Power: PL = 10 W
3.1 Liquid jet system

→ for EUV imaging and metrology:

use water jet* instead of liquid nitrogen !

<table>
<thead>
<tr>
<th></th>
<th>Slab laser</th>
<th>Thin disk laser (100 Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (mJ)</td>
<td>65</td>
<td>170</td>
</tr>
<tr>
<td>τ (ps)</td>
<td>450</td>
<td>1000</td>
</tr>
<tr>
<td>P (W)</td>
<td>90</td>
<td>17</td>
</tr>
<tr>
<td>ph/s sr</td>
<td>6*10^{14}</td>
<td>7*10^{13}</td>
</tr>
<tr>
<td>ph/s mrad^2 mm^2</td>
<td>8*10^{11}</td>
<td>2*10^{11}</td>
</tr>
</tbody>
</table>

3.1 X-ray microscope

- Pinhole
- Laser
- Shutter
- Vacuum pump
- Multilayer condensor mirror
- Plasma source
- Pinholes + filter
- XUV CCD camera
3.1 X-ray microscope

- Pinhole
- Vacuum pump
- XUV CCD camera
- Plasma source
- Pinholes + filter
- Shutter
- Multilayer condensor mirror
- Laser
- Vacuum pump

Graph showing reflectivity vs. wavelength for different multilayer coatings and a circular pattern indicating an image or output from the X-ray microscope.
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3.2 Cylinder target

Optimal heating for 2 nm

Variable-line spaced grating spectrograph & Transmission grating spectrograph
3.2 EUV/XUV spectra

3.2 EUV/XUV spectra

3.2 VLSG spectrograph

<table>
<thead>
<tr>
<th>XUV: 1 nm region</th>
<th>XUV: water window</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
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</table>

EUV: 13.5 nm region

| ![Graph](image3) |

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<tr>
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<th>XUV 1 nm region</th>
<th>XUV water window</th>
<th>EUV 13 nm region</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>Cu</td>
<td>Mo</td>
<td>Cu</td>
</tr>
<tr>
<td>ph/ s sr line</td>
<td>$8 \times 10^{12}$</td>
<td>$6 \times 10^{14}$</td>
<td>$2 \times 10^{14}$</td>
</tr>
<tr>
<td>ph/ s mm$^2$ line</td>
<td>$10^{10}$</td>
<td>$7 \times 10^{11}$</td>
<td>$3 \times 10^{11}$</td>
</tr>
</tbody>
</table>
3.2 TG spectrograph

Broadband source: Filter calibration
XANES/NEXAFS
Selection of suitable energy
3.2 Current setup

Laser in clean room environment

Flexible design with two beamlines and changeable target material

Plasma chamber with beam propagation optics

Control units

TG spectrograph

Pinhole setup
Summary

1. Diode-pumped thin disk laser system
   - Compact and robust systems
   - High average power
   - High stability and beam quality
   - Flexible pulse duration for optimized plasma heating

2. LPP sources:
   - Liquid jet technology:
     - Low debris, intense line emission, different liquids
   - Cylinder target technology:
     - Broadband & line emission, different metals, high CE
Collaborations

1. Laser system
2. X-ray microscope
3. BLiX LPP source
4. Funding
Thank you for your attention!