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High-brightness LDP source for actinic patterned mask inspection

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Applying Light to Life

Outline

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- LDP source overview
- Dynamics EUV-emitting plasma
- Optical performance
  - Emission size and spectrum
  - Brightness scaling
  - Brightness stability
- Source availability
- Summary

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Laser-assisted Discharge-produced Plasma source

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- High brightness
- Relatively large plasma size: broad profile, high single-shot photon
- Stable: no spatial and timing synchronization needed
- Reliable: 24/7 operation
- Clean: multi-stage debris shield is used

Laser

Tin Film

Tin Supply Disc

Current

EUV

Tin Supply Disc

Liquid Tin Bath (circulated)

Cooling

Capacitor

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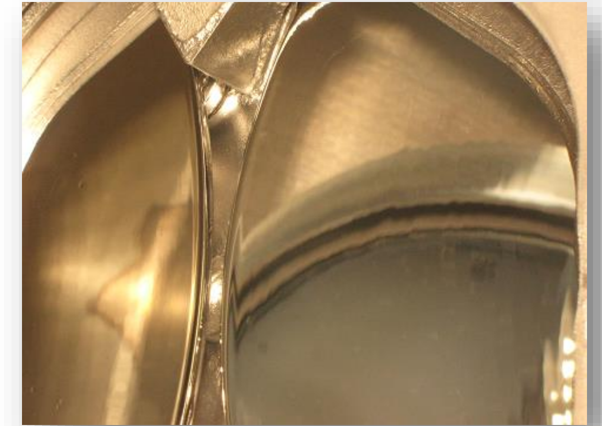

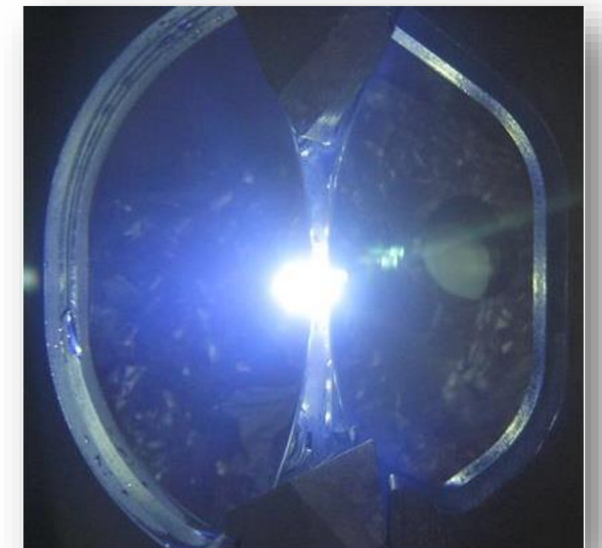

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Laser-assisted Discharge-produced Plasma source

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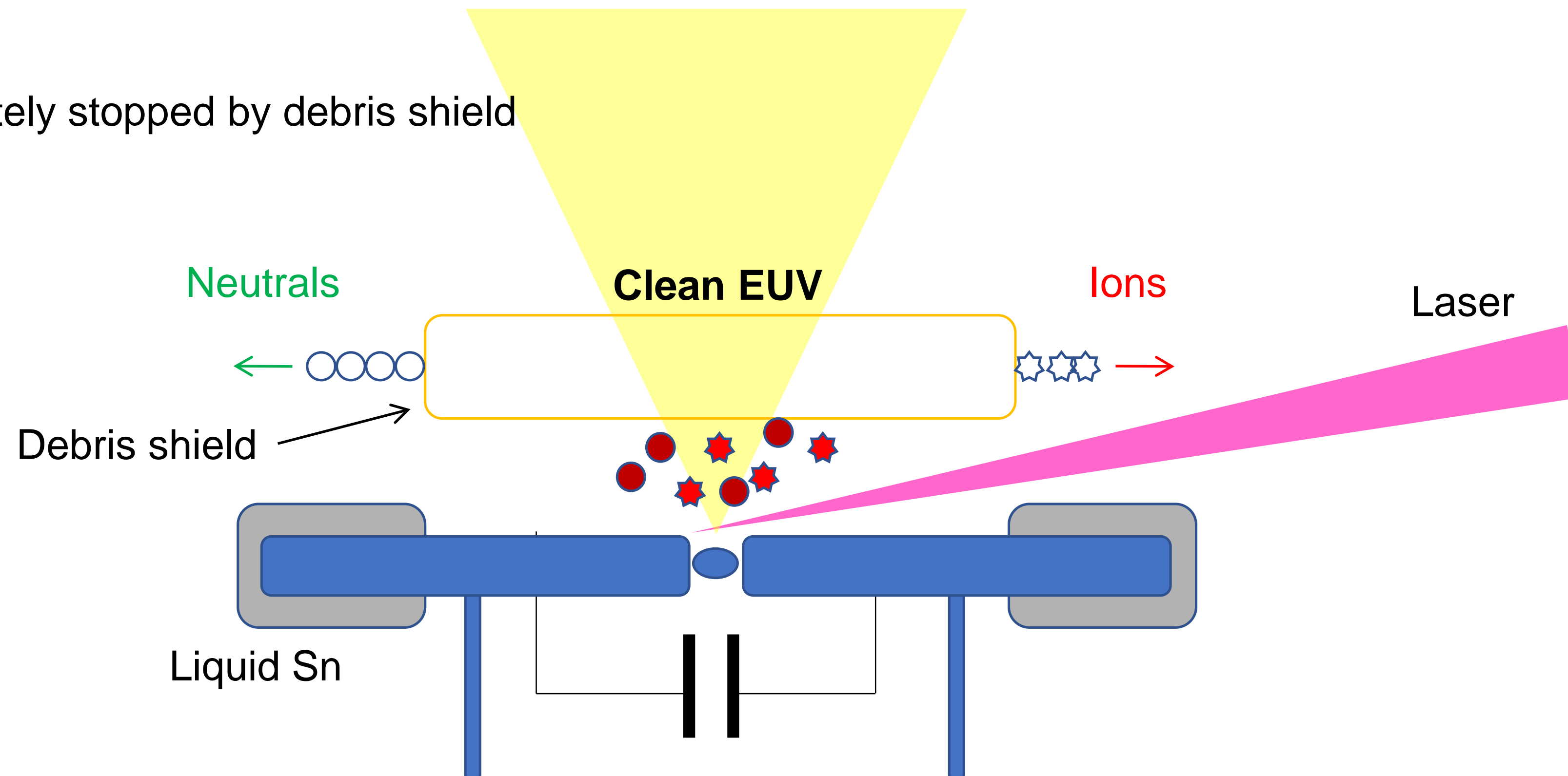
Fast ions
- Mostly stopped by debris shield
- Slow down in debris shield

Neutrals
- Completely stopped by debris shield



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LDP source S910 series: main cabinet

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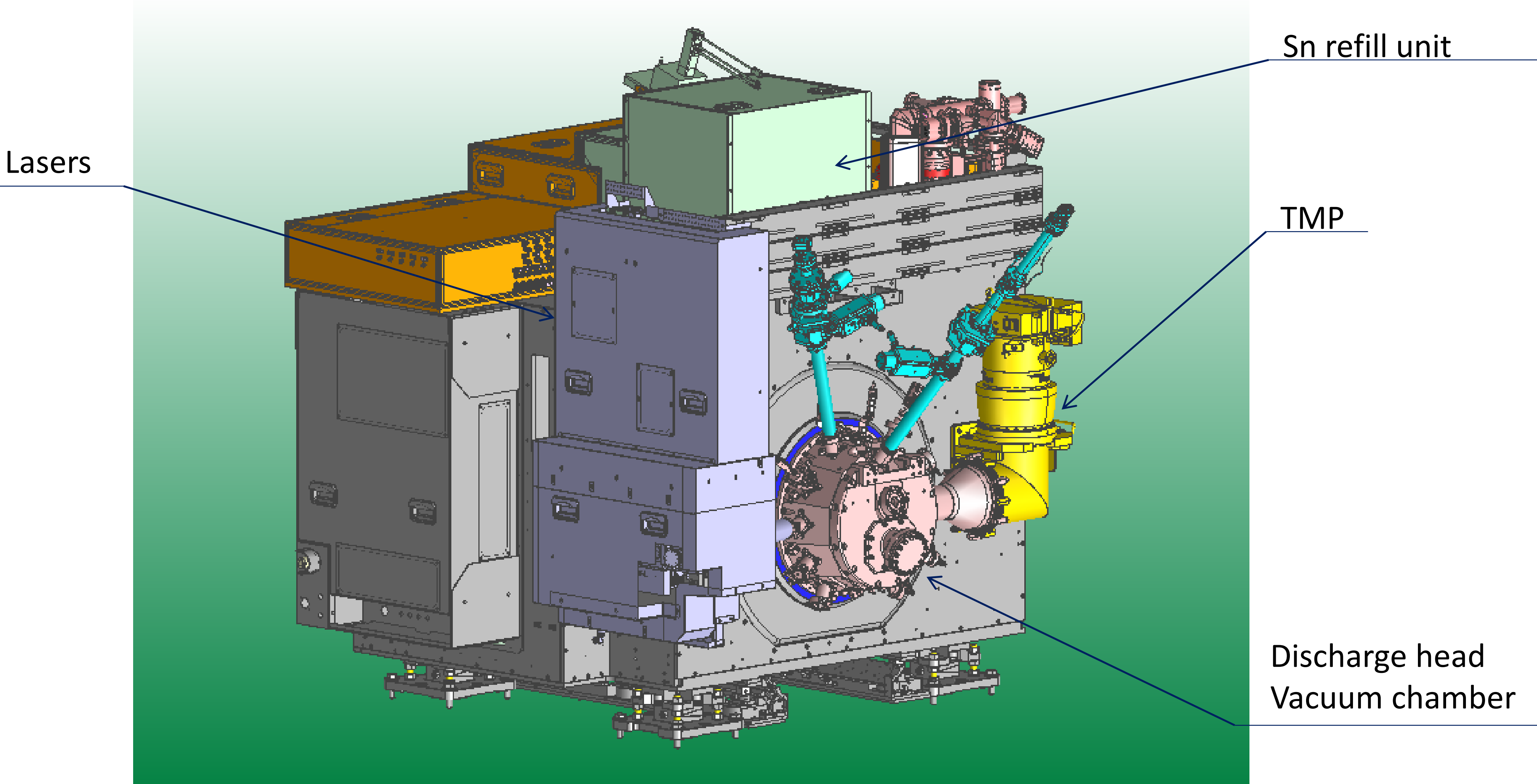

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Dynamics of EUV-emitting plasma

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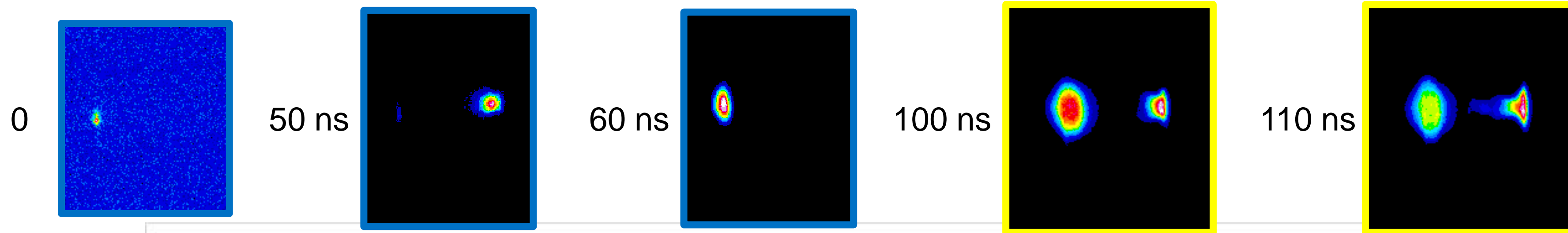
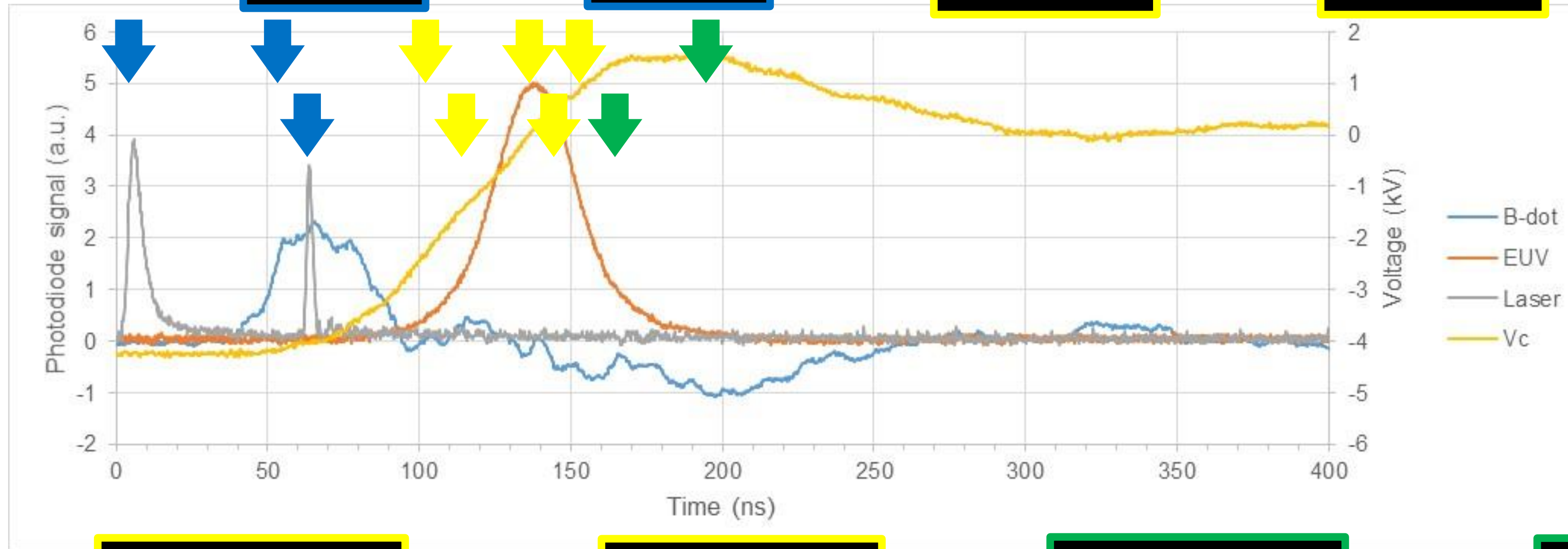
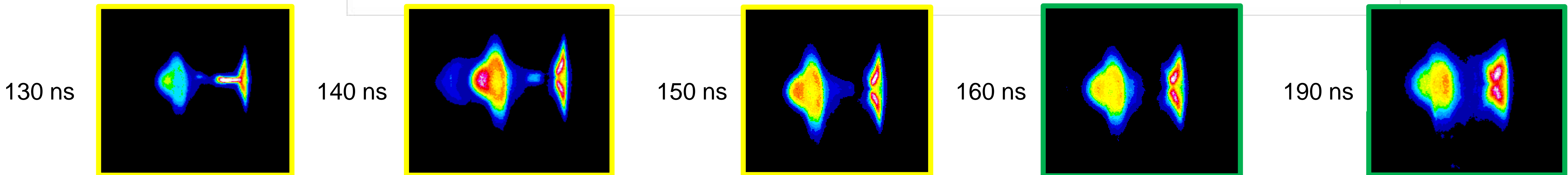


- Images obtained with a gated camera
- Visible light emission
- Exposure time 5 ns
- Observed perpendicular to the plasma





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Emission size and spectrum

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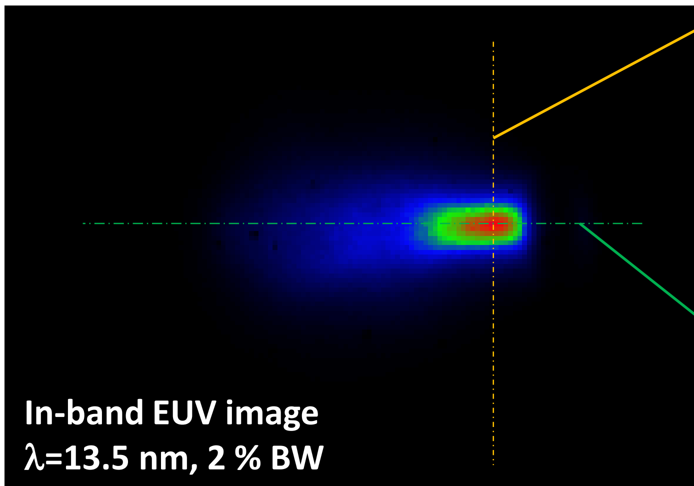
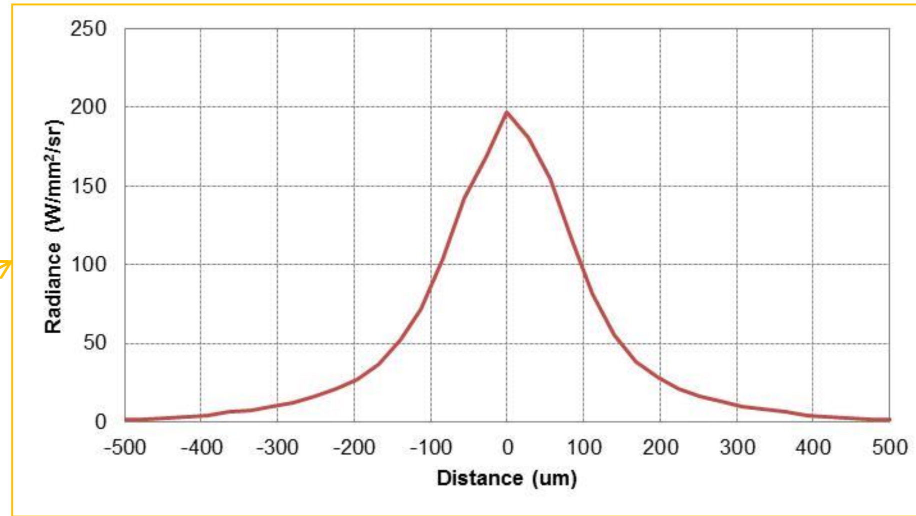
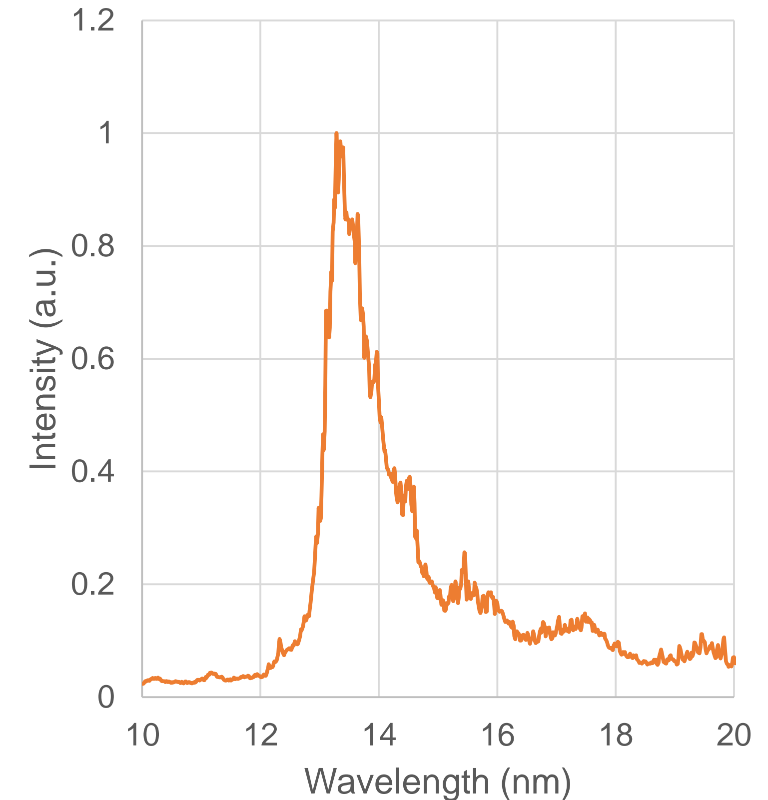
- High brightness
- Plasma size smaller than DPP, larger than LPP: good spatial stability







- Diameter: 200 μm (FWHM)
- Length: 450 μm (FWHM)

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Brightness vs frequency and long-term stability

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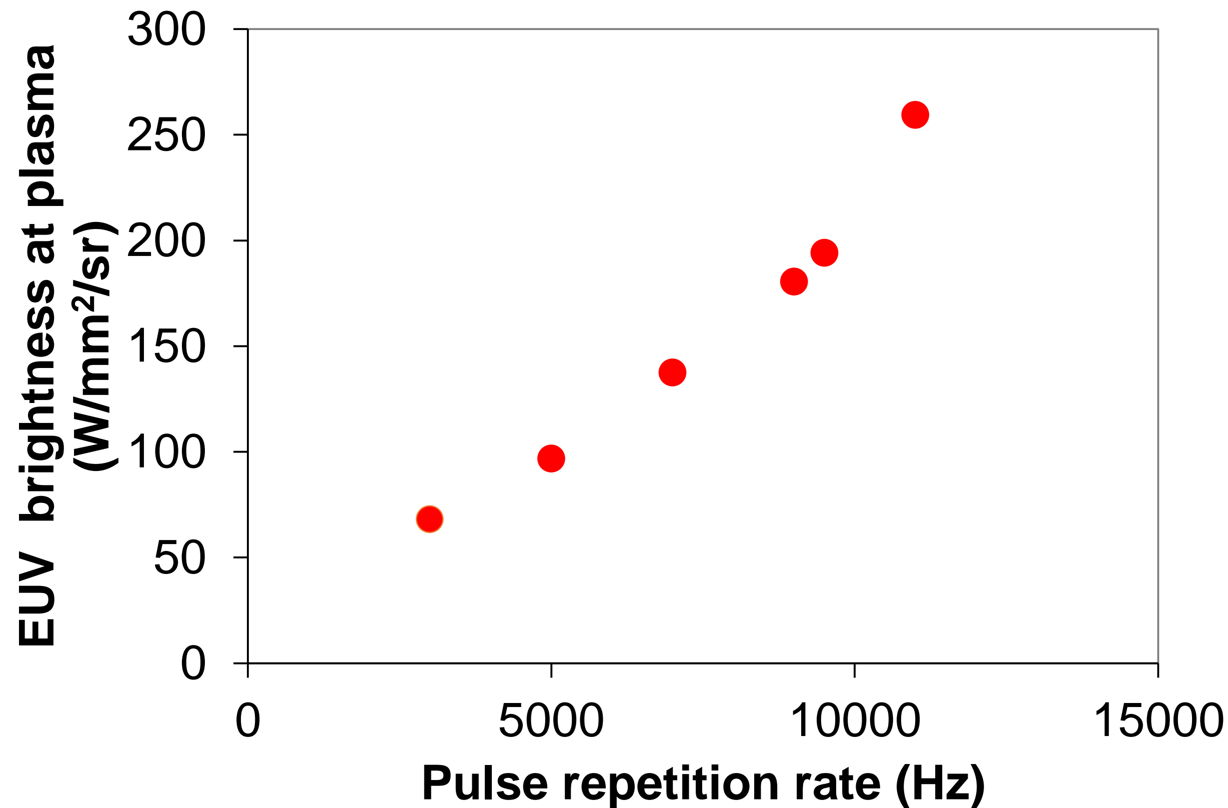
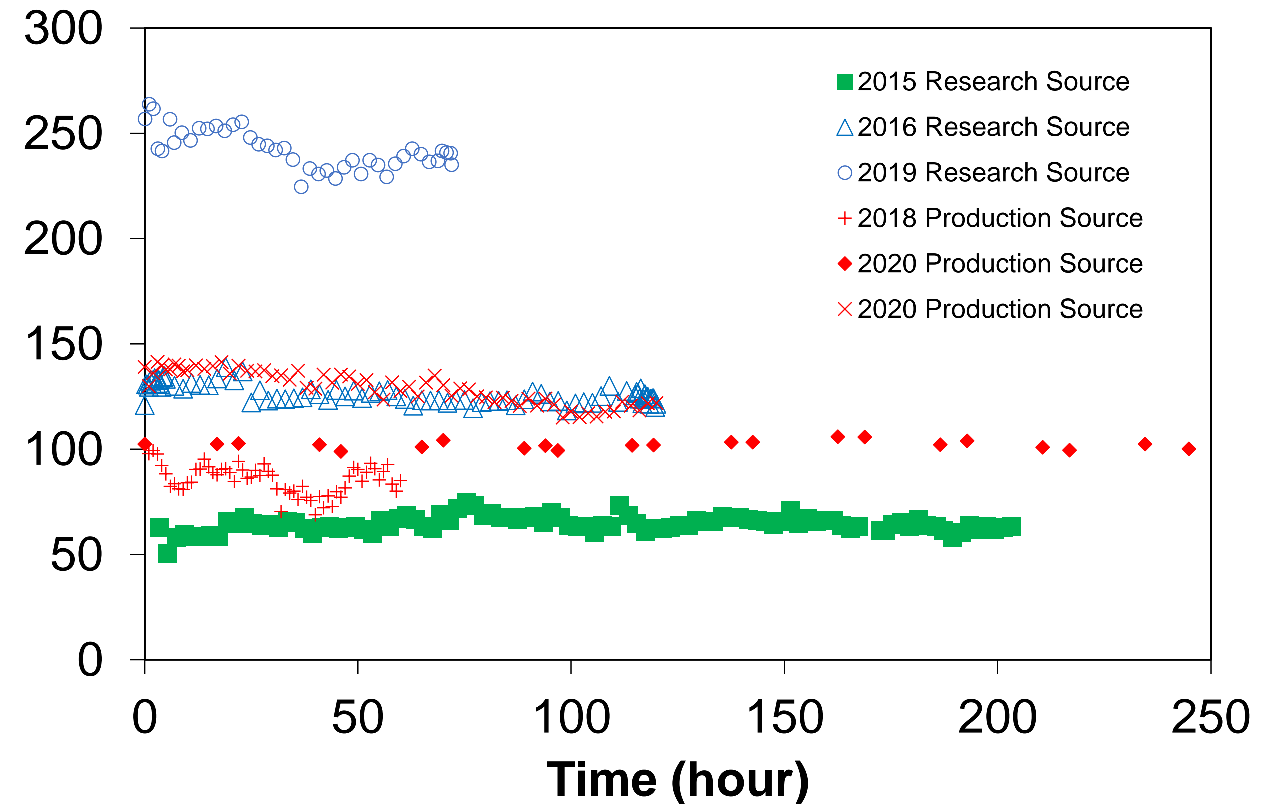
- Stable operation at up to 11 kHz
- >200 W/mm²/sr obtained at the source level



- Steady progress in the past years



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Brightness stability

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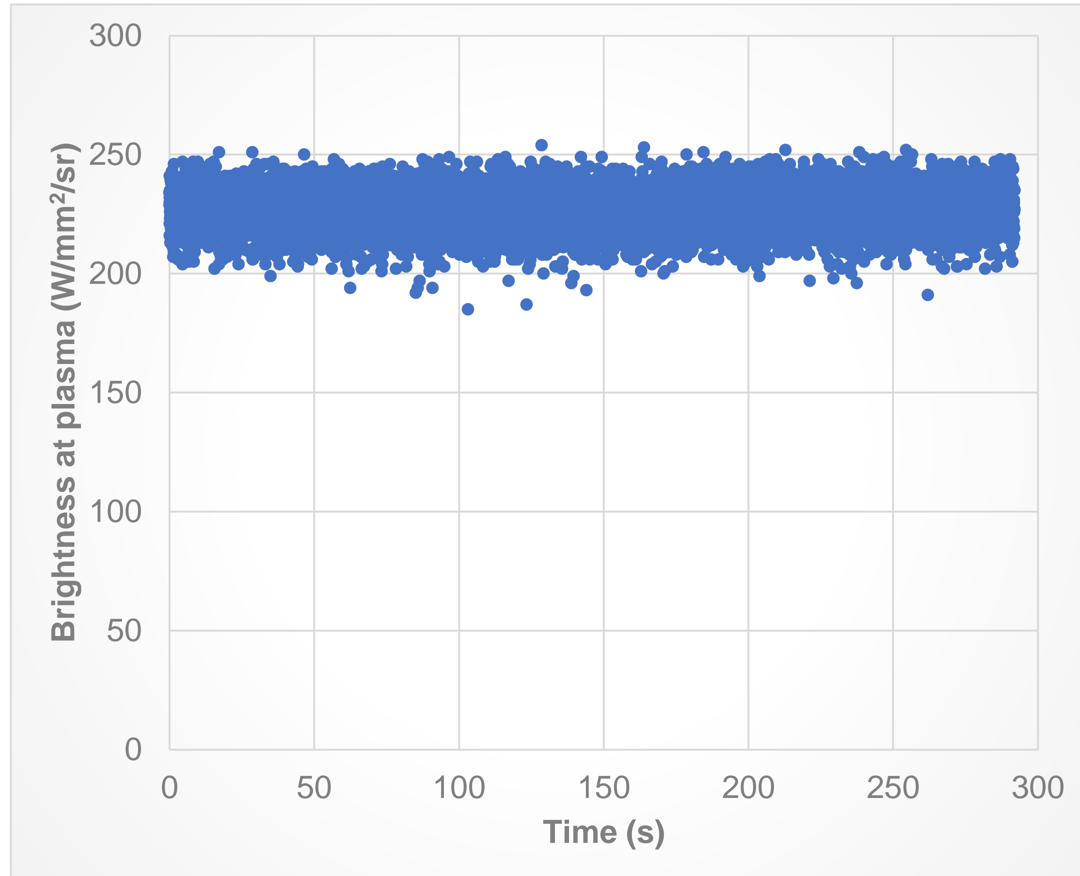
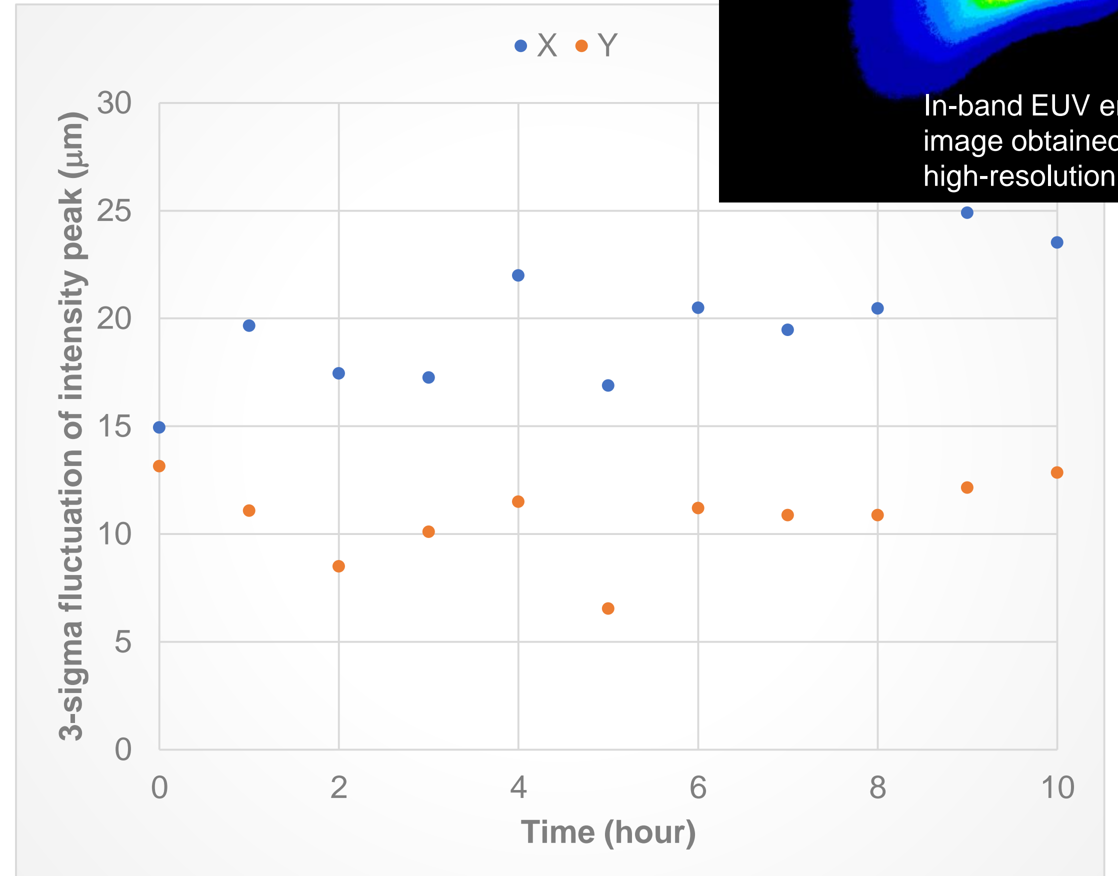
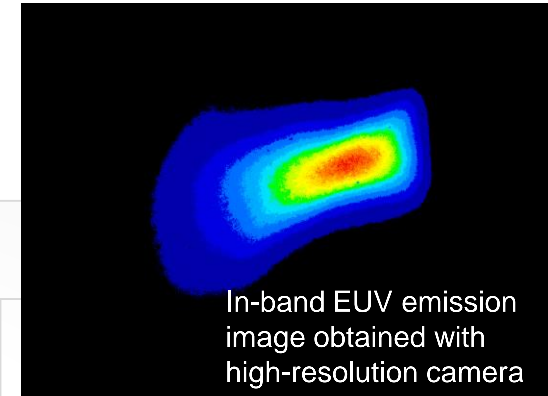
Brightness



Position





In-band EUV emission image obtained with high-resolution camera

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Availability of production source

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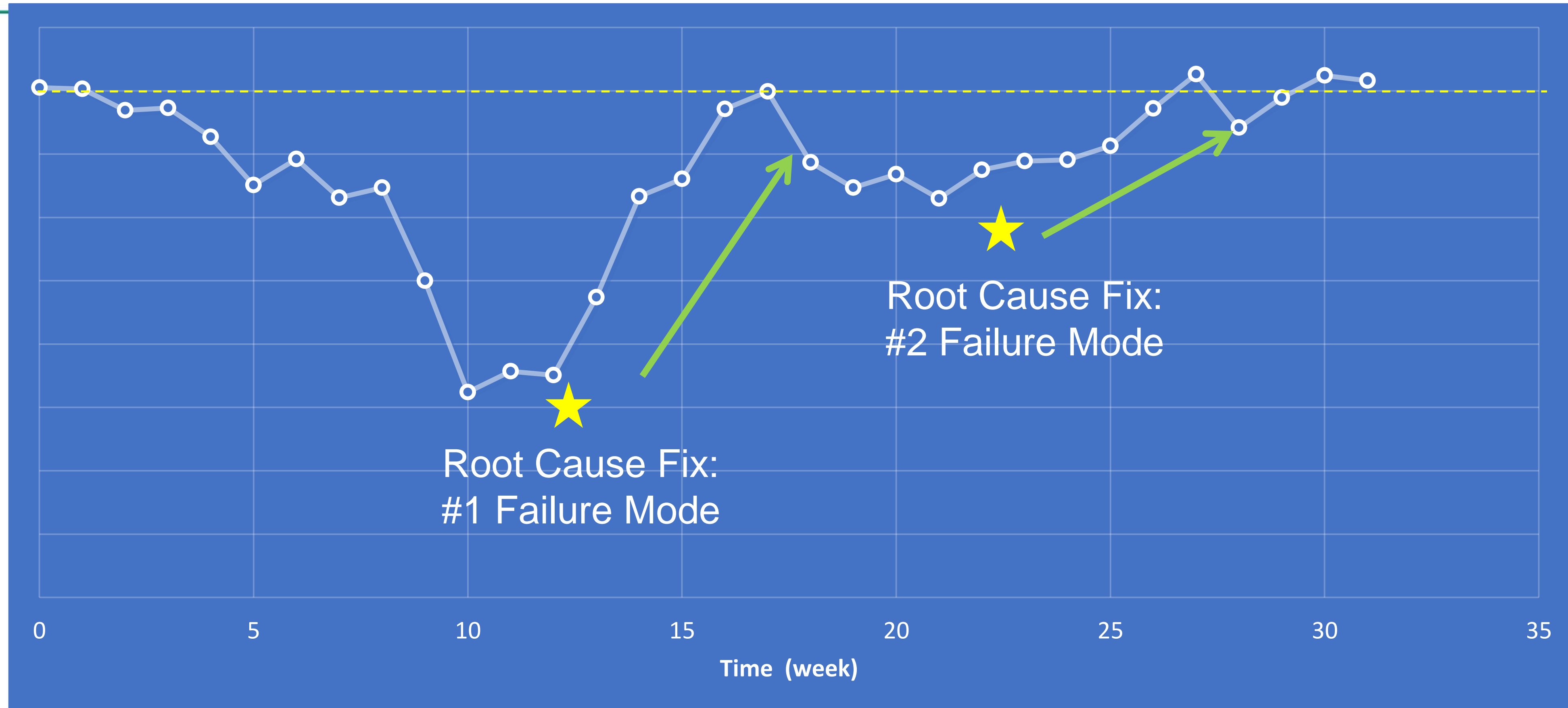

- ✓ Robust platform - Approaching to POR availability of optical platforms
- ✓ Two key failure modes are fixed in a relatively short period of time.
- ✓ Current focus is to further improve reliability and availability.

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APMI images

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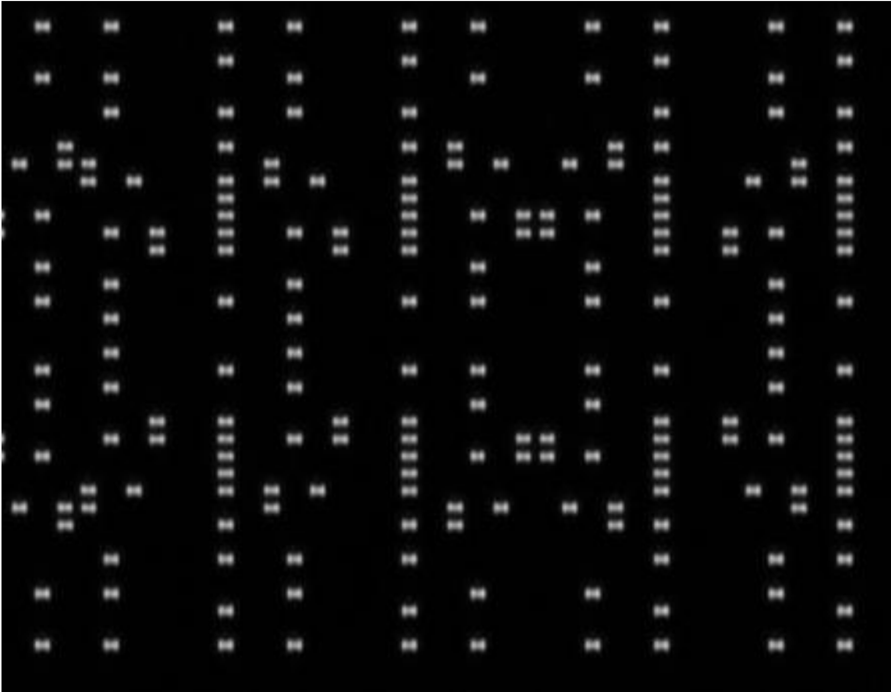

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Summary

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- S910 series LDP EUV sources are now used in APMI tools.
- Source performance fulfills the requirements for HVM use.
- Further development continues to improve the performance and availability.
- Further update is provided in the paper submitted to SPIE Advanced Lithography 2021, Safak Sayan (Intel Corporation).

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