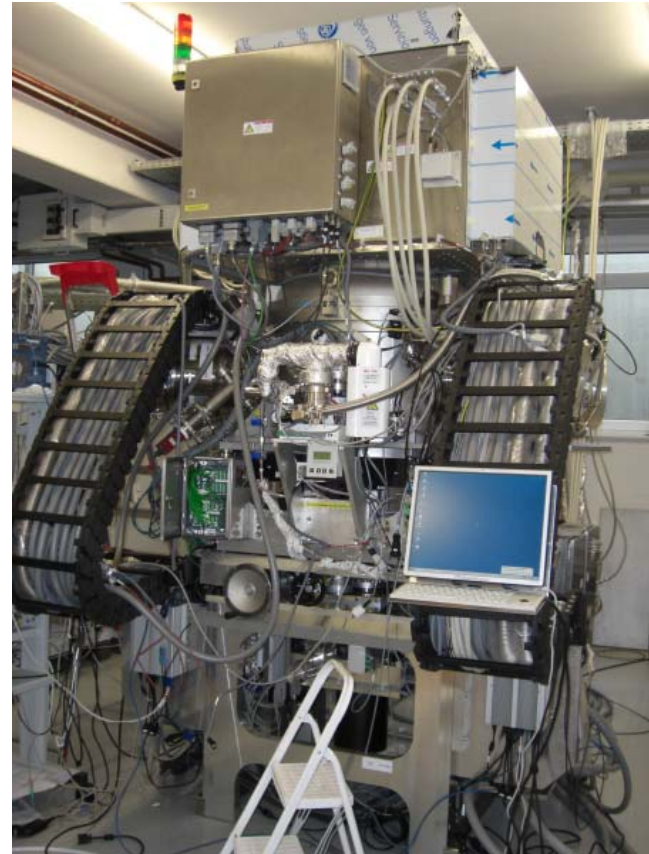


Progress on DPP source development towards HVM

Masaki Yoshioka
XTREME technologies GmbH

2007 International Symposium on
Extreme Ultraviolet Lithography
29-31 October 2007
Sapporo, Japan



XTS 13-150 IF

Outline

1. Progress on commercial Xe sources
2. HVM source development and Roadmap
3. Summary

XTREME leads installed EUV sources in the field

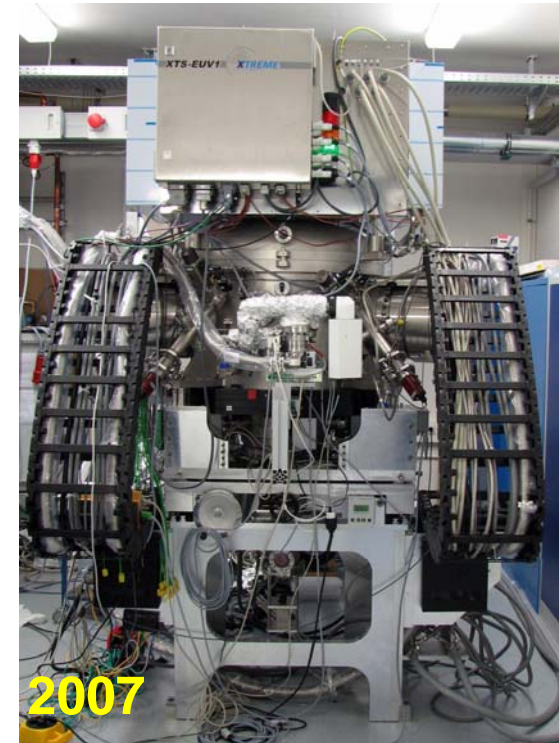
- 6 DPP sources in use for wafer exposures
- 10 DPP sources operated for EUV research
- XTS13-150 IF has been successfully integrated at customer side



XTS13-35



XTS13-75IF

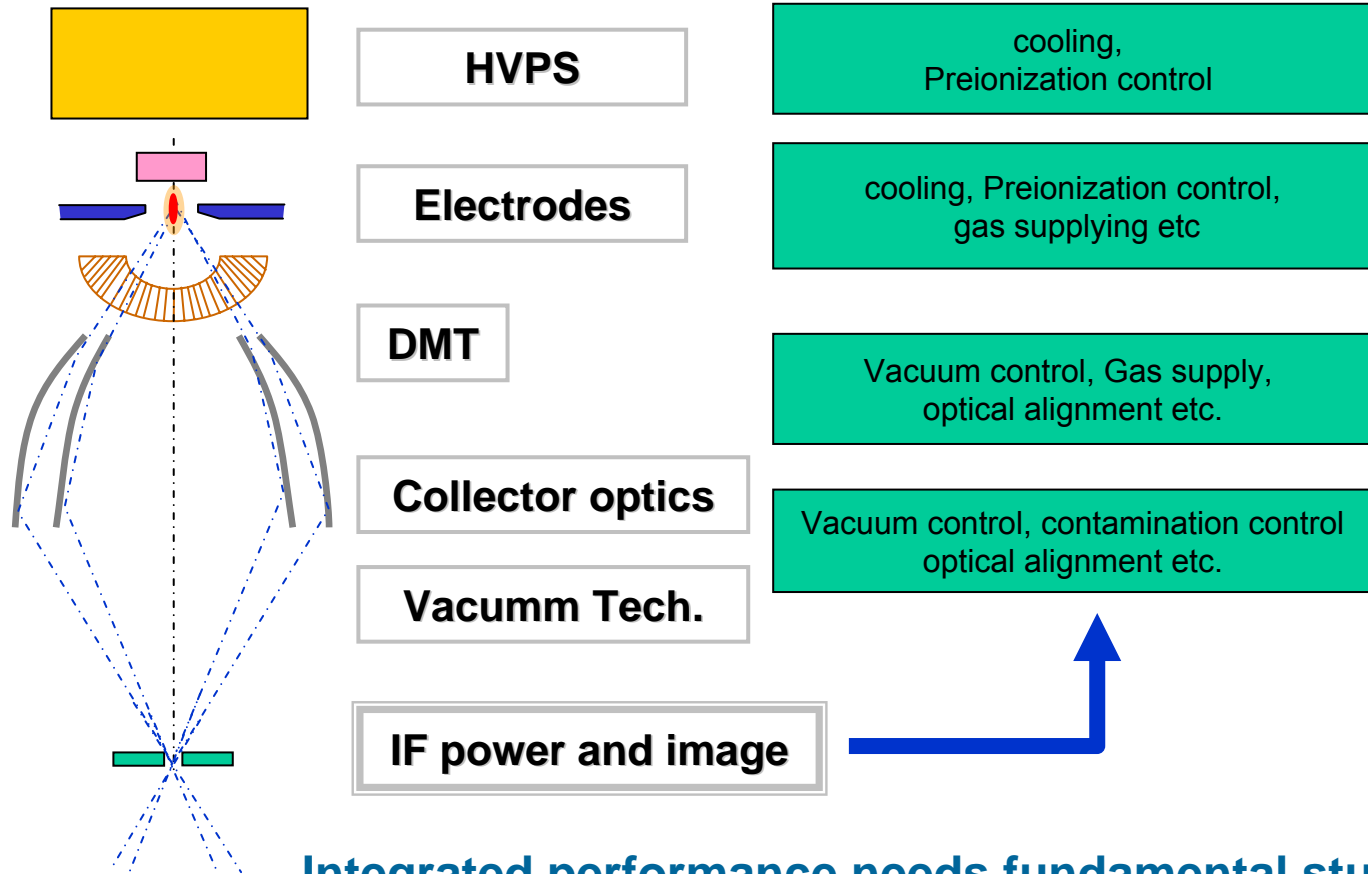


XTS13-150IF

- Integrated metrology tools provide for reliable operation with constant source characteristics
- Performance results and improvements benefit from partnering with key component suppliers and feedback received from customers

DPP source is an integration of crucial key components

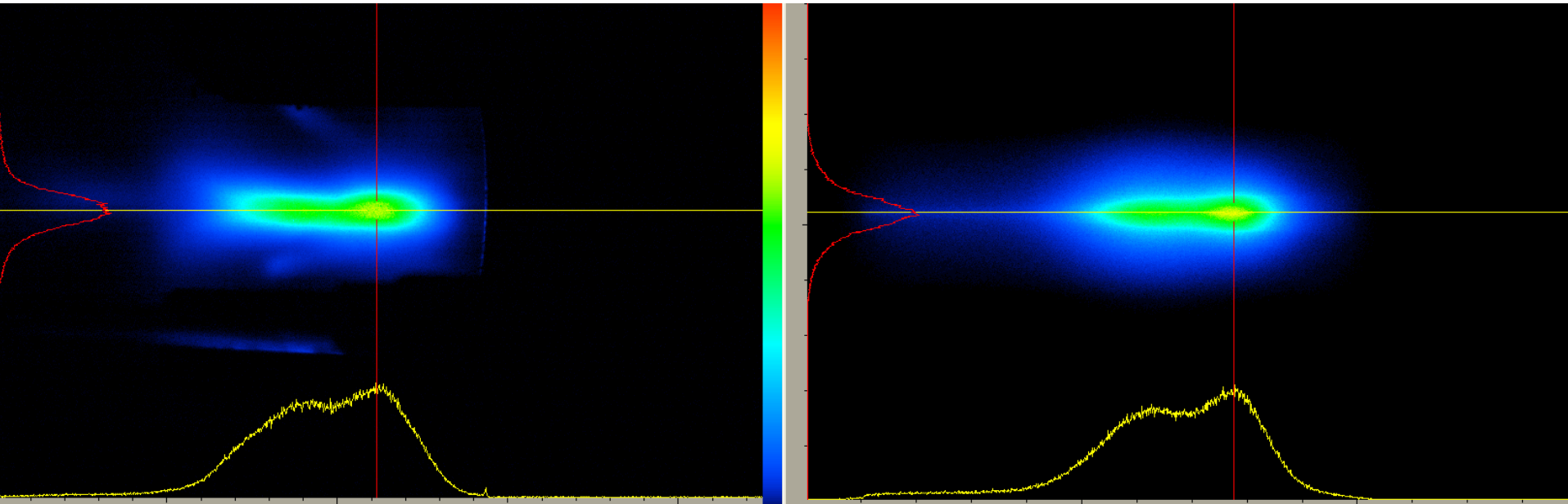
XTREME has provided integrated performance of SoCoMo



Integrated performance needs fundamental study and feedback received from customers

Source Model Enables Reliable Ray Tracing Simulations

Key objective: model to reproduce spatial plasma power distribution



Pinch, measured

Pinch, ZEMAX® model

(identical scale & total power)

Optical source model permits reliable calculations:

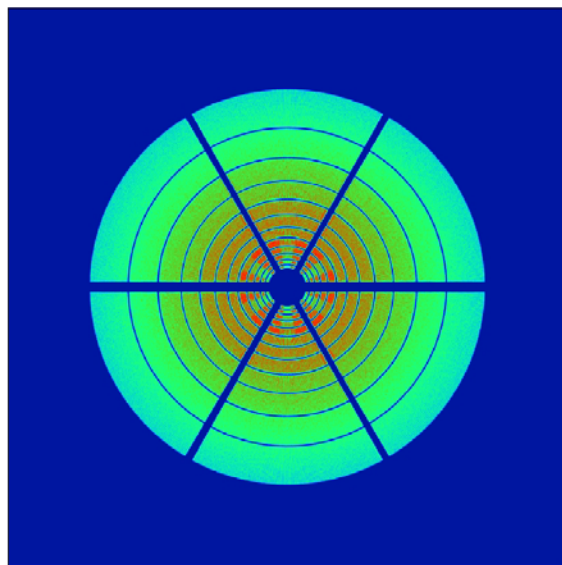
- Collection efficiency reproduced within 10%
- SoCoMo Far Field simulations

SoCoMo Ray Tracing Allows Far Field Predictions

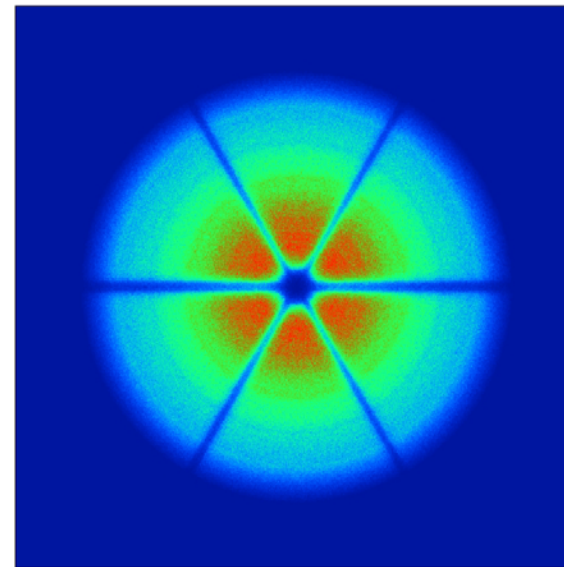
Effect of extended source vs. point like source:

- Collector efficiency drop 15.9% → 8.8%
- DMT transmission drop 87.8% → 83.2%

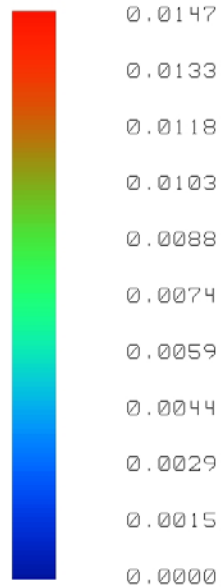
Extended source prediction confirmed by measurements



Point like source

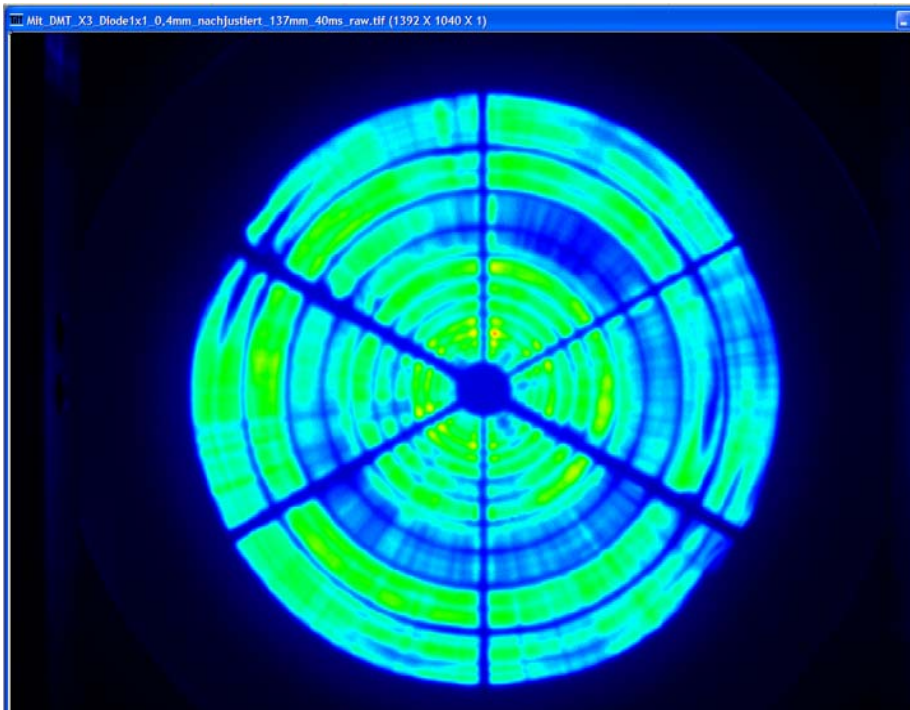


Extended source

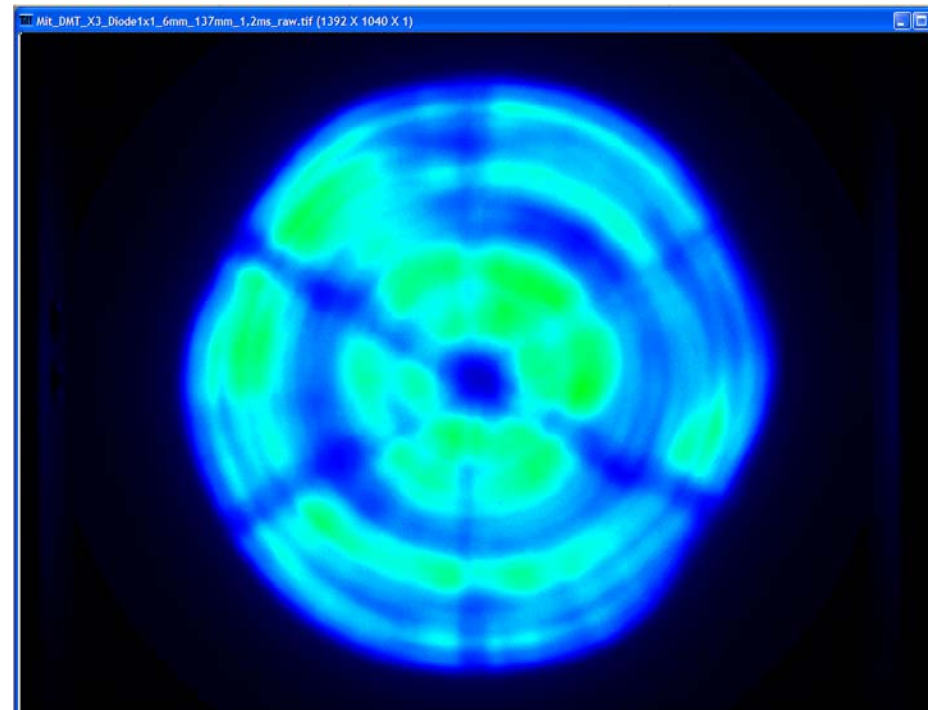


VIS Test Stand Strongly Supports Optical Performance Optimization

- Measurements with different source geometry
- Characterization of individual and convoluted contributions of collector and DMT to far field uniformity
- Efficiently used for optimization of far field imaging performance

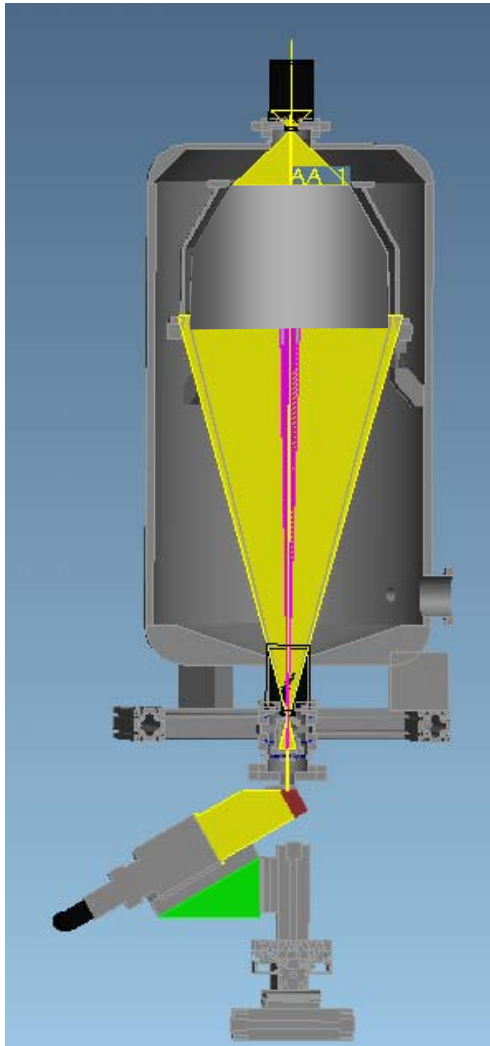


Point like source



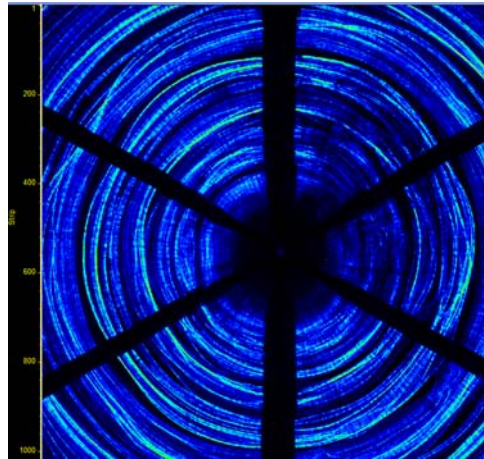
Extended pinch like source

Successful Introduction of New Basic EUV Metrology



EUV-reflectometer realized by LZH

- Full collector acceptance
- Collector reflectivity accuracy $< 2\%$
- Collector/DMT characterization capability
- Keying XTS 13-150 SoCoMo optical performance



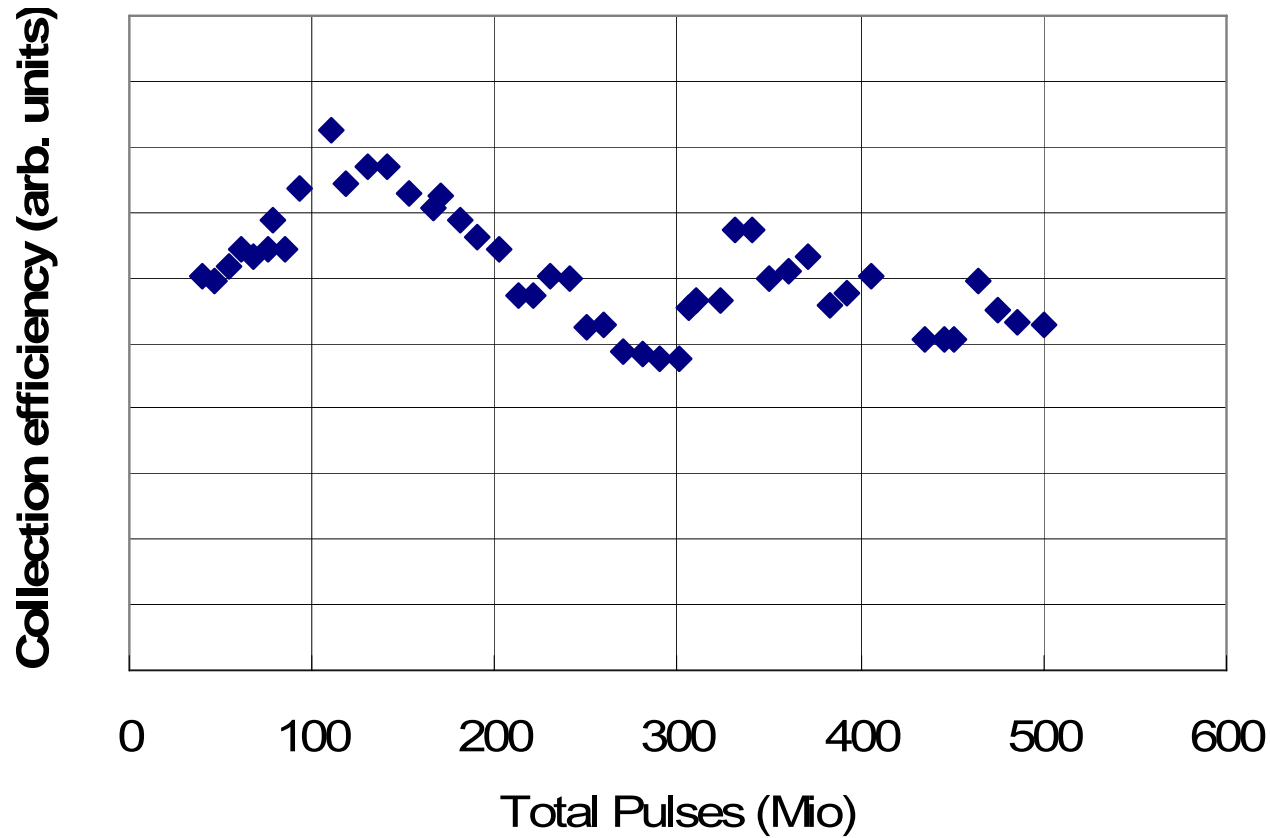
Intensity distribution of full collector behind source point



SO-05: U. Hintze et.al., EUV Source Collectors: Characterization of Performance and Lifetime using a Full Size EUV Collector Reflectometer

Electrode Lifetime Extension Improves Downtime and CoO

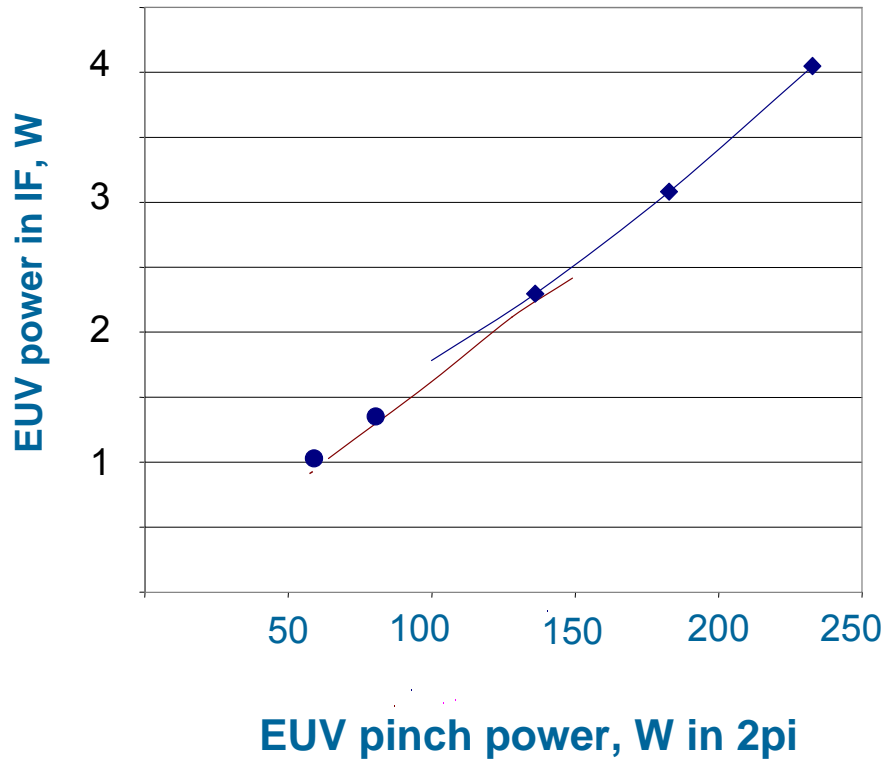
- Electrode lifetime extension achieved by design improvements
- Cathode lifetime 500M and anode lifetime >4B demonstrated
- CE fluctuations can be compensated by energy control



No power stabilization applied during test

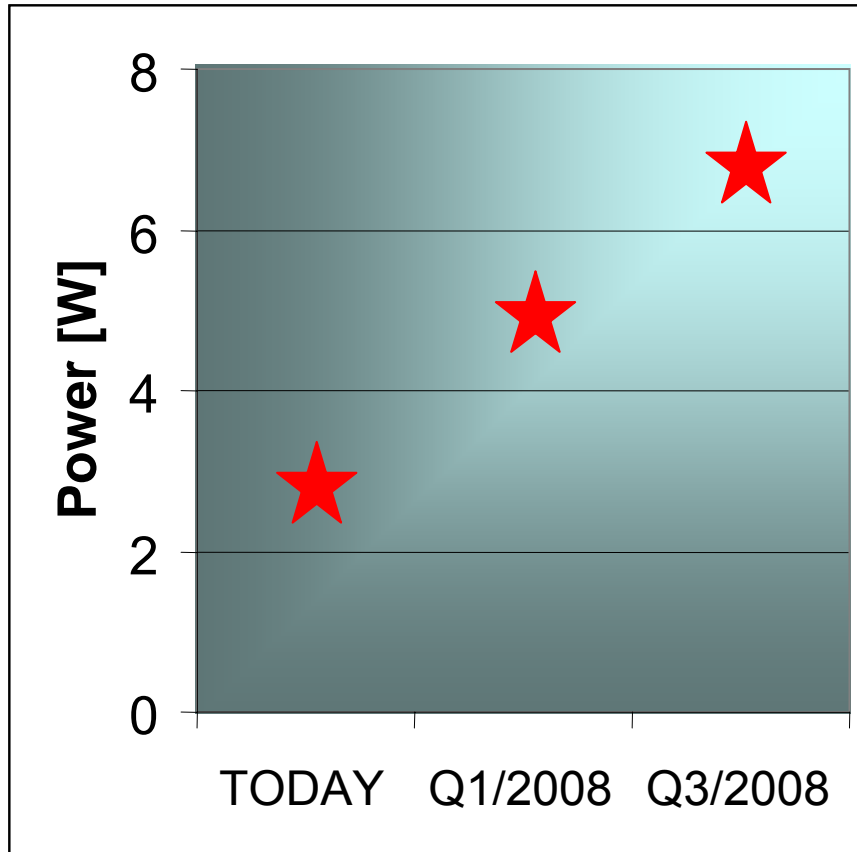
Taking light to new dimensions...

XTS 13-150 IF: EUV Power @IF vs. source power



- **These are real IF powers, which have been measured and NOT scaled!**
- Up to 4W achieved in 100% duty cycle operation
- Collection efficiency almost independent on source parameters (e.g. repetition rate, buffer gas flow)

XTS 13-150 IF Power Status and Roadmap



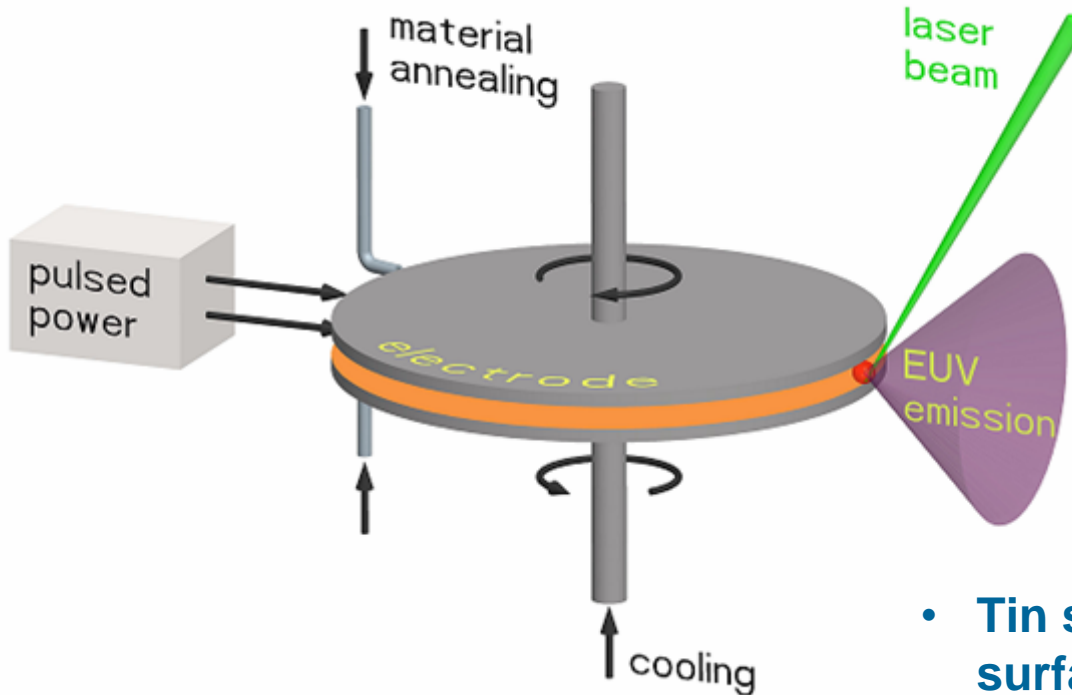
- Current Output power @ IF (3 W level) is limited by component lifetime considerations
- Experimental results on improved components evidence output power capability of 7W @IF
- Output power improvement to 4-5W expected in December 2007
- 7W evidence until Q2/2008

Outline

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XTREME Develops LA RDE as Promising Technology

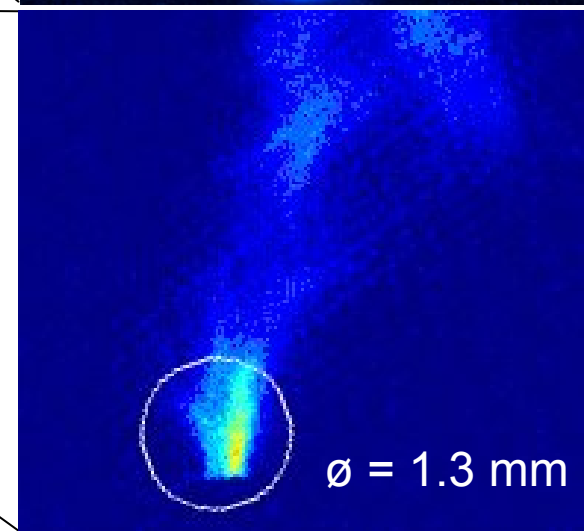
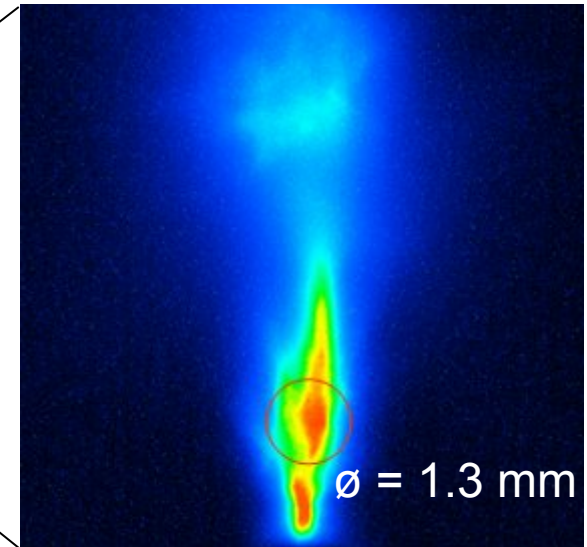
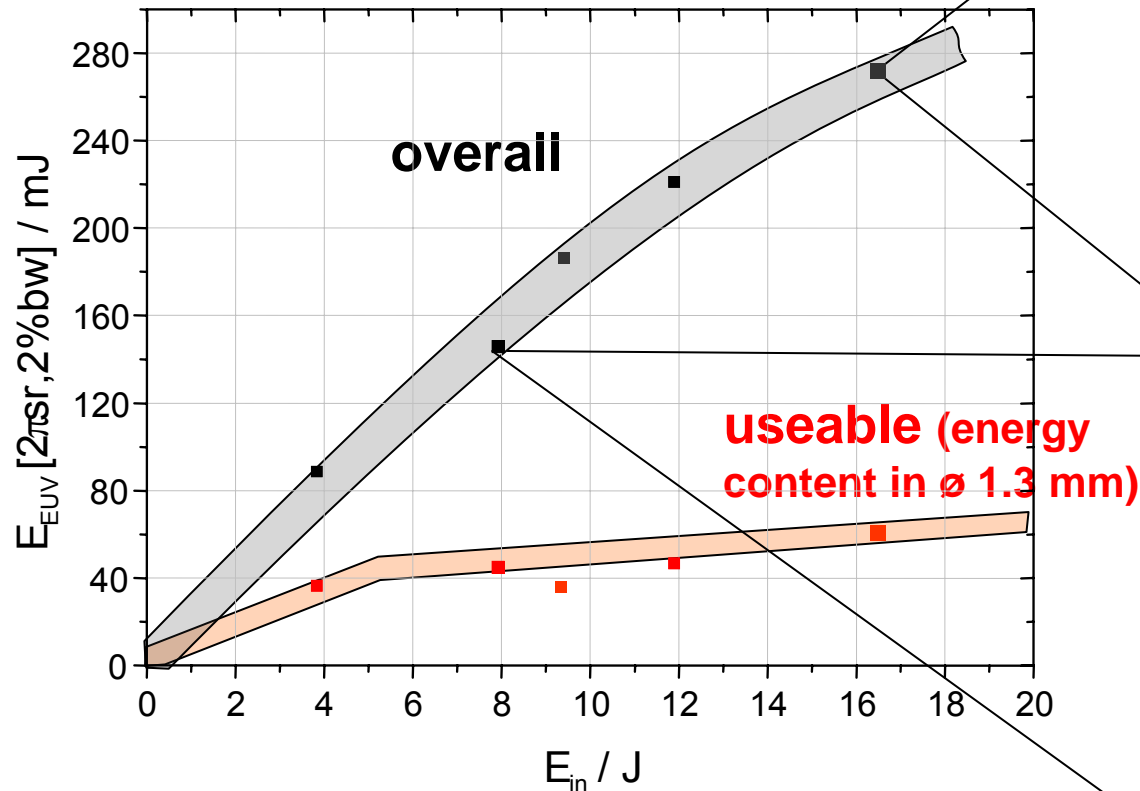
Laser Assisted DPP source with Rotating Disk Electrodes (RDE)



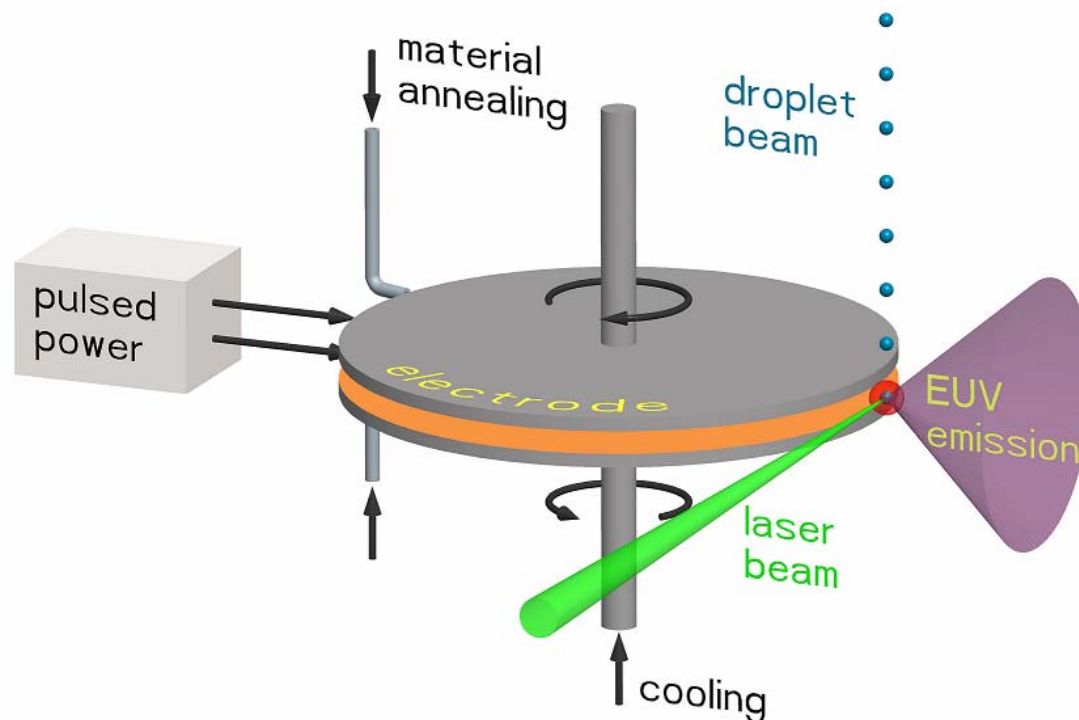
- Tin supply regenerates electrode surface and serves as fuel
- increases effective electrode area
- reduces heat load per area
- increases electrode lifetime

LA RDE Exhibits Scaling Issues with surface evaporation

Usable energy saturates
at input energies of about 8J



Adding Tin Droplet to LA RDE Solves Saturation Issue

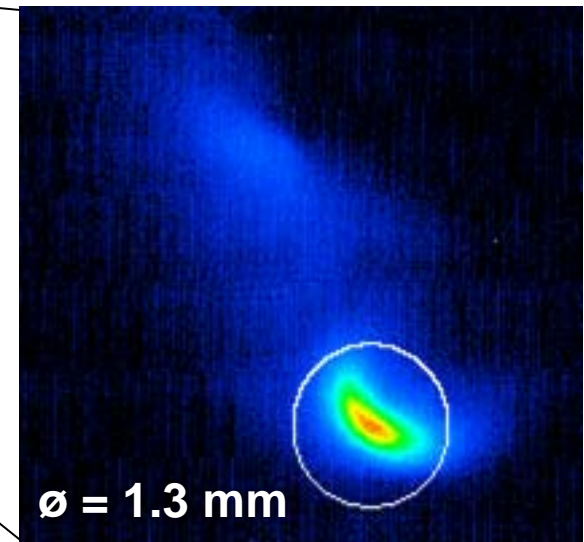
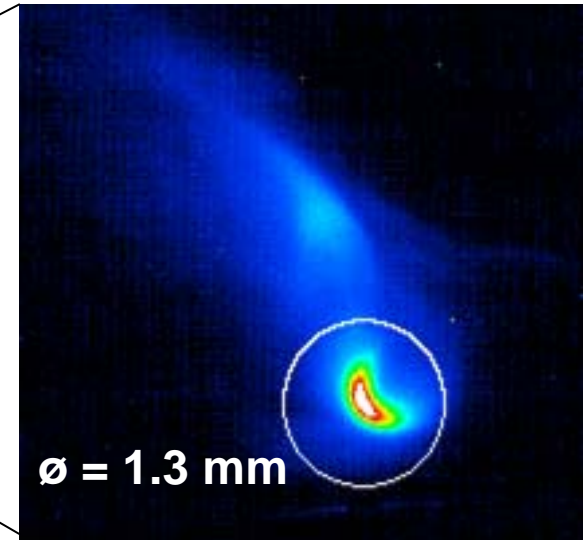
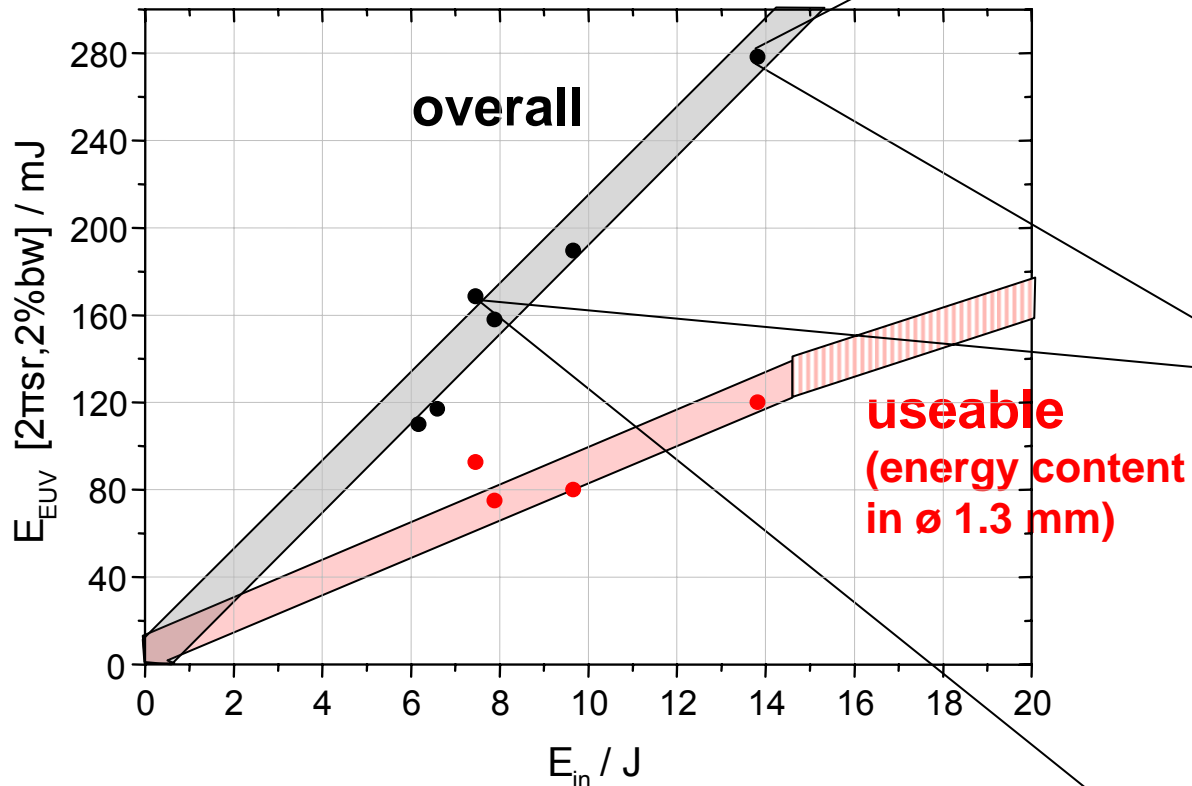


- Laser assisted droplet RDE design provides;**
- higher brightness plasma
 - mass limited tin fuel supply independent of electrode material and electrode surface regeneration
 - superior scaling possibilities
 - large collecting angles feasible

Droplet Technology brings Advantage over Surface Evaporation

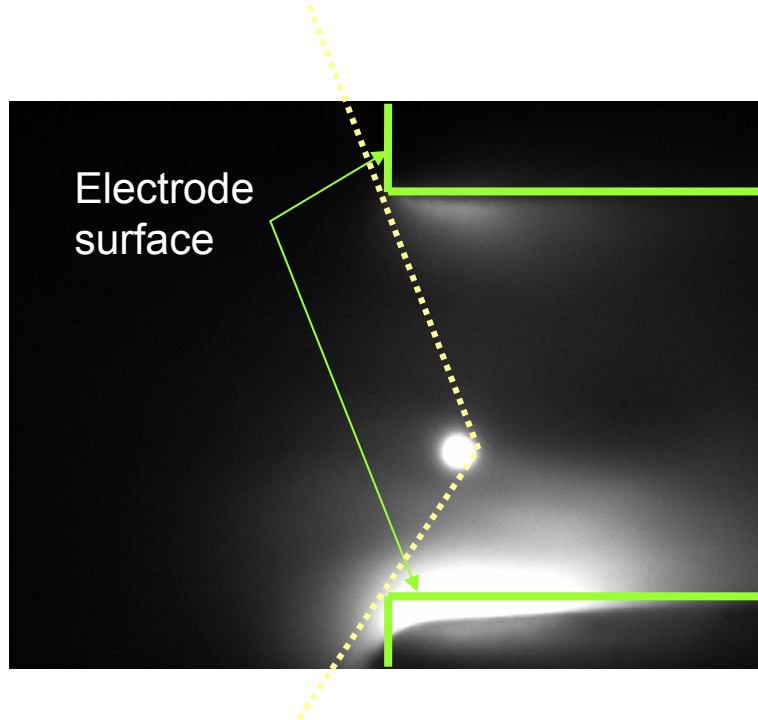
LA Droplet RDE Source provides High Power for HVM

High pulse energy while maintaining a small emitting volume – the key to scalable of high power

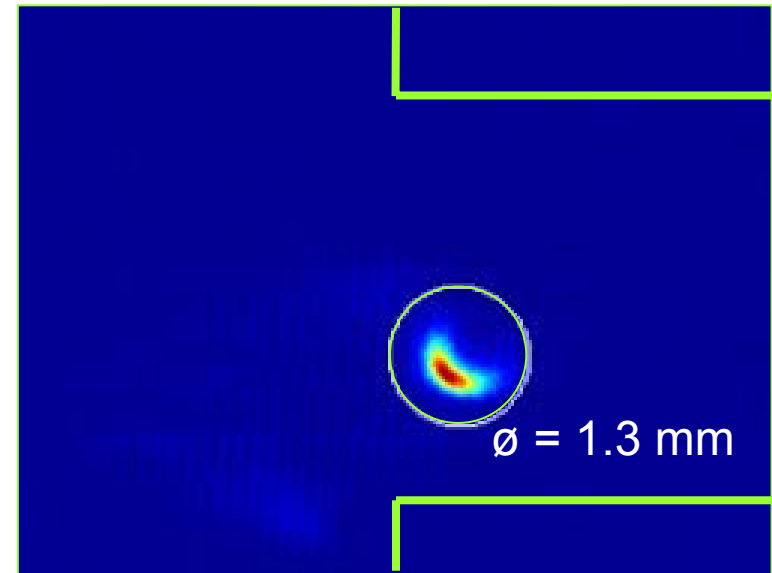


No saturation of usable energy detected for up to 14J

LA Droplet RDE Source allows for Large Collection Angle

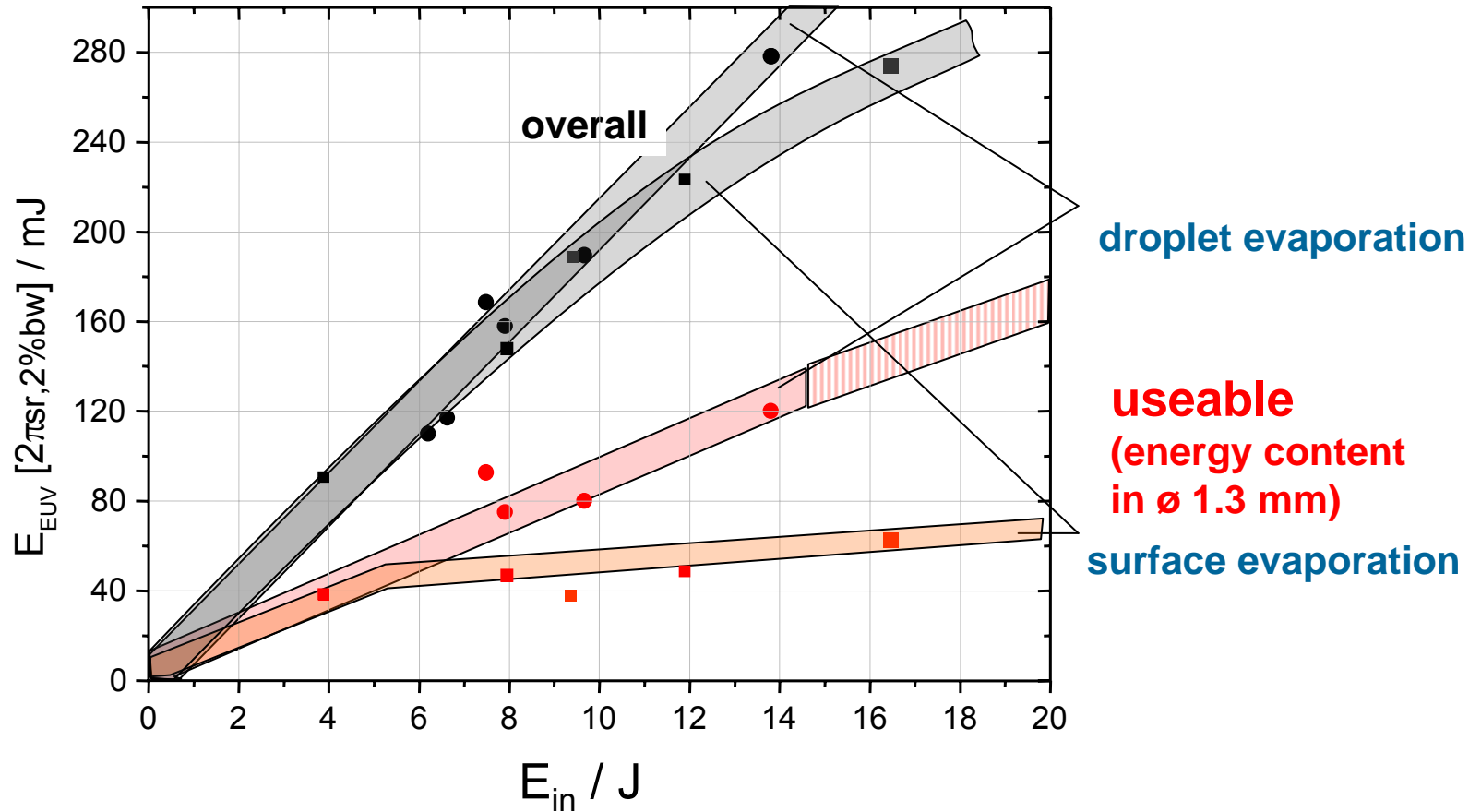


Visible image of the plasma showing a potentially large opening angle of the electrode arrangement



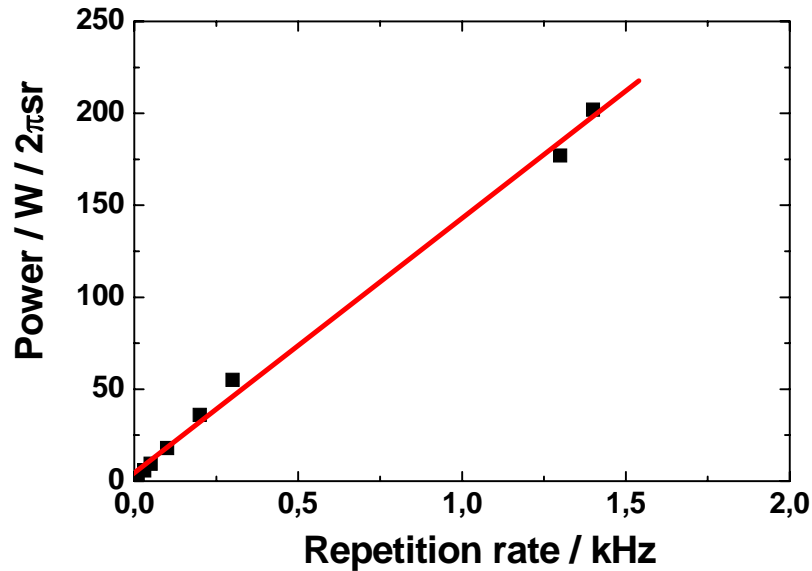
EUV in-band picture of the same pulse

Comparison between surface evaporation and droplet injection



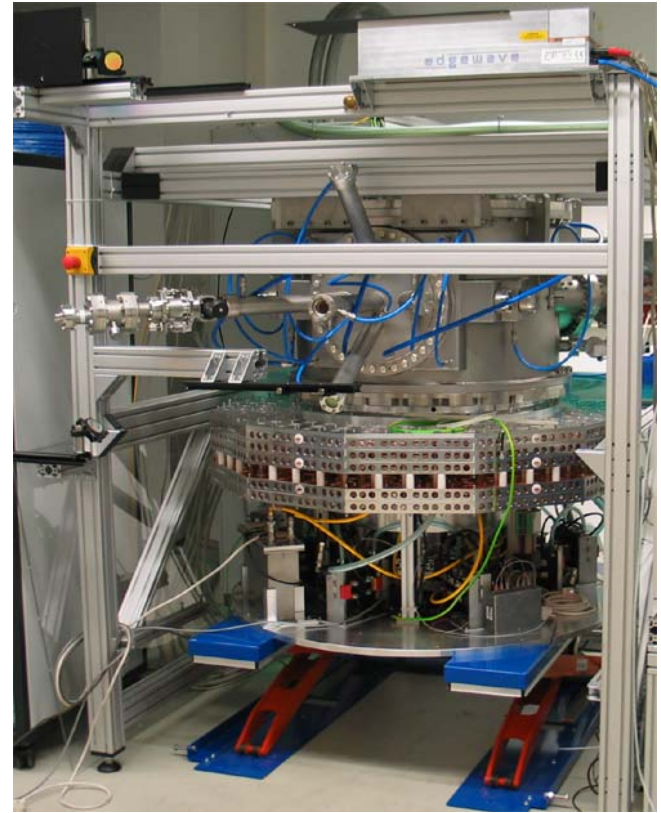
LA RDE with Tin Droplets makes available LPP scaling advantages on robust and proven DPP Technology

Outlook and EUV power demonstration



Output power: 200 W/ 2π sr at 1.4 kHz
Constant conversion efficiency

Experimental result strongly support scalability.
600W in source power @5kHz will be demonstrated
by end of December 2007



Experimental installation

Key components development for HVM DPP

- Droplet system is fundamentally established and continuously improved for practical use
- Adding new functions onto similar DMT concept of Xe DPP source
- Scaling for higher power metrology tools

DPP EUV sources: Power status and HVM power roadmap

	Currently Status 10/2007	1st generation HVM	2nd generation HVM	3rd generation HVM
Electrical input energy into plasma (J)	10	10	15	20
Repetition frequency (kHz)	1.5	7	10	10
Intermediate focus power (W)	6.4 ⁽¹⁾	62.5	178.5	238

(1) calculated for existing collector mirror

Summary

Commercial Xe sources

- Output power @ IF currently 3 W level
- Improvement to 7 W level ongoing according to our roadmap

HVM source development

- The new concept of laser assisted droplet RDE source has demonstrated its intrinsic performance
- Thermal management of RDE combined with droplet target supply strongly supports the path to HVM
- Demonstration of 600 W power in 2π sr by end of 2007 will enable XTREME technologies to commit for a Beta Level SoCoMo with 50 W IF power in 2008 according to our HVM power roadmap

DPP source provides a cost effective solution for HVM!

Acknowledgements

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 - Laser Laboratorium Göttingen, Germany
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 - JENOPTIK, Jena, Germany
 - USHIO, Tokyo, Japan