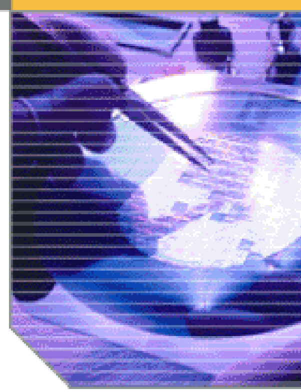
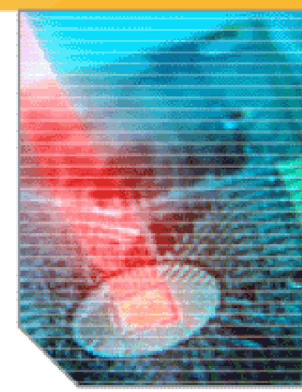
The Optimal Source Path to HVM





Dave Myers, Brian Klene, Igor Fomenkov, Björn Hansson,
Bruce Bolliger

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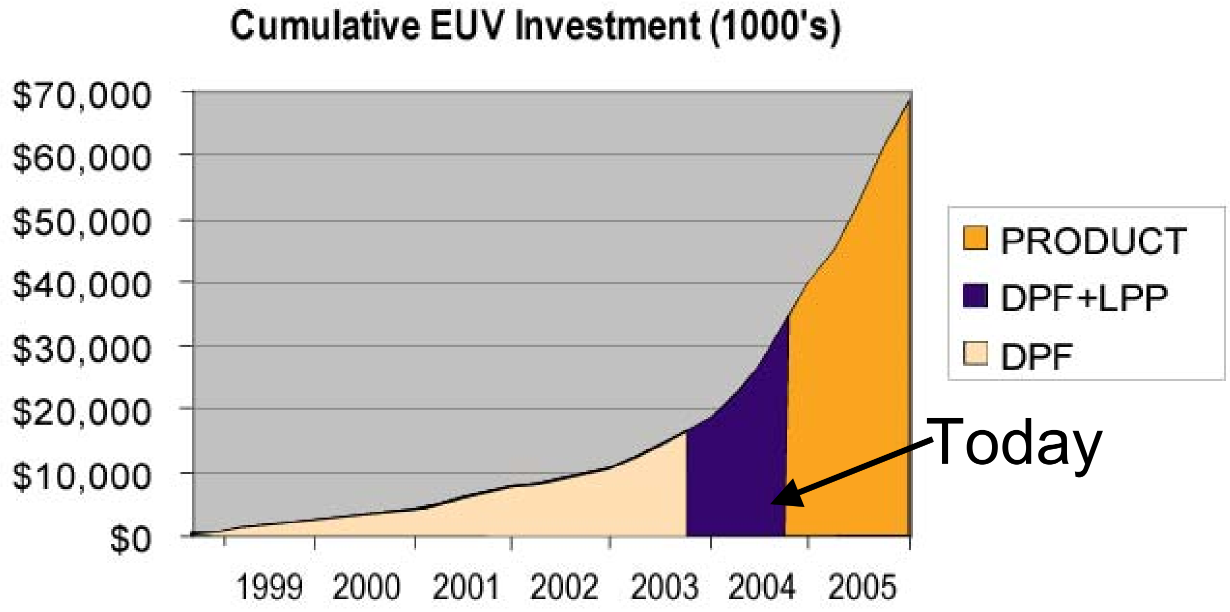
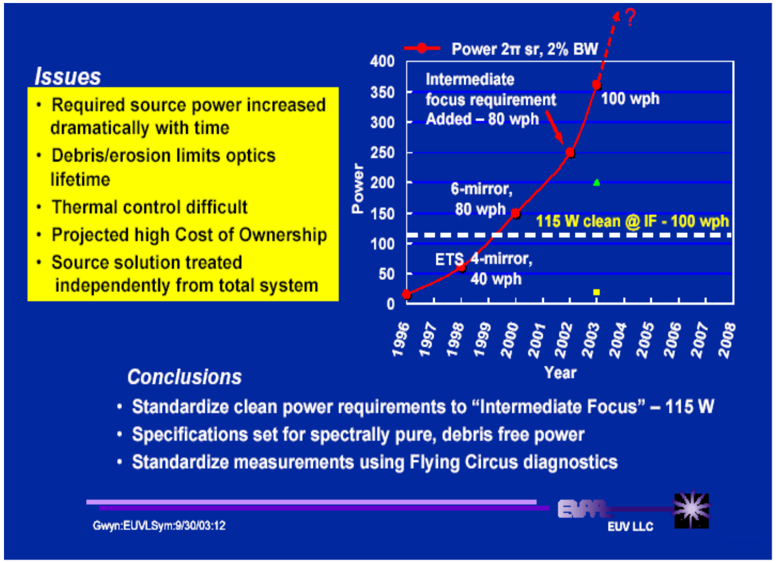
Cymer's Optimal Path to HVM EUV Source

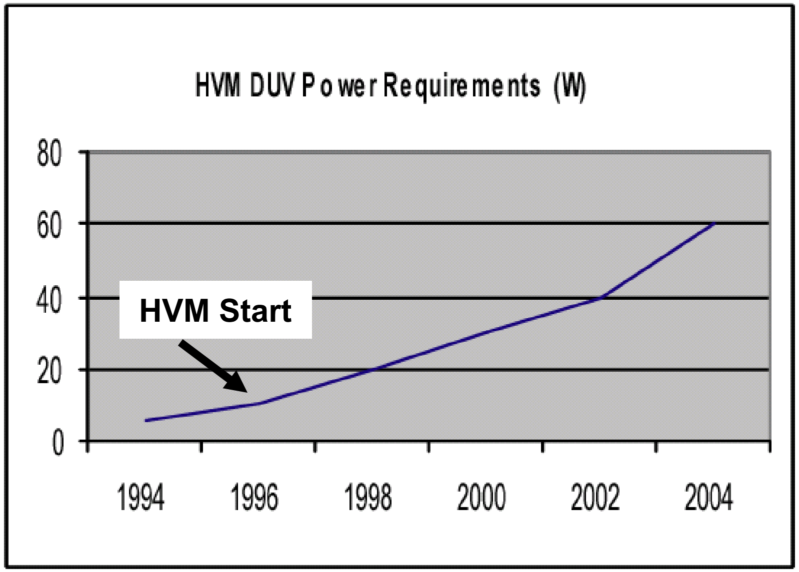
- Today Cymer presents its selected path to a HVM source
  - Selected path based on our research efforts over the last six years
  - Selected path validated by accelerated research in 2004
    - Will show results of research to date
    - Continue to validate with on-going development



Source Development Challenges

- Power requirements expected to increase in future
- Collector lifetime – 10k hours or inexpensive replacement
- Cost of operation (system cost, cost of consumables)

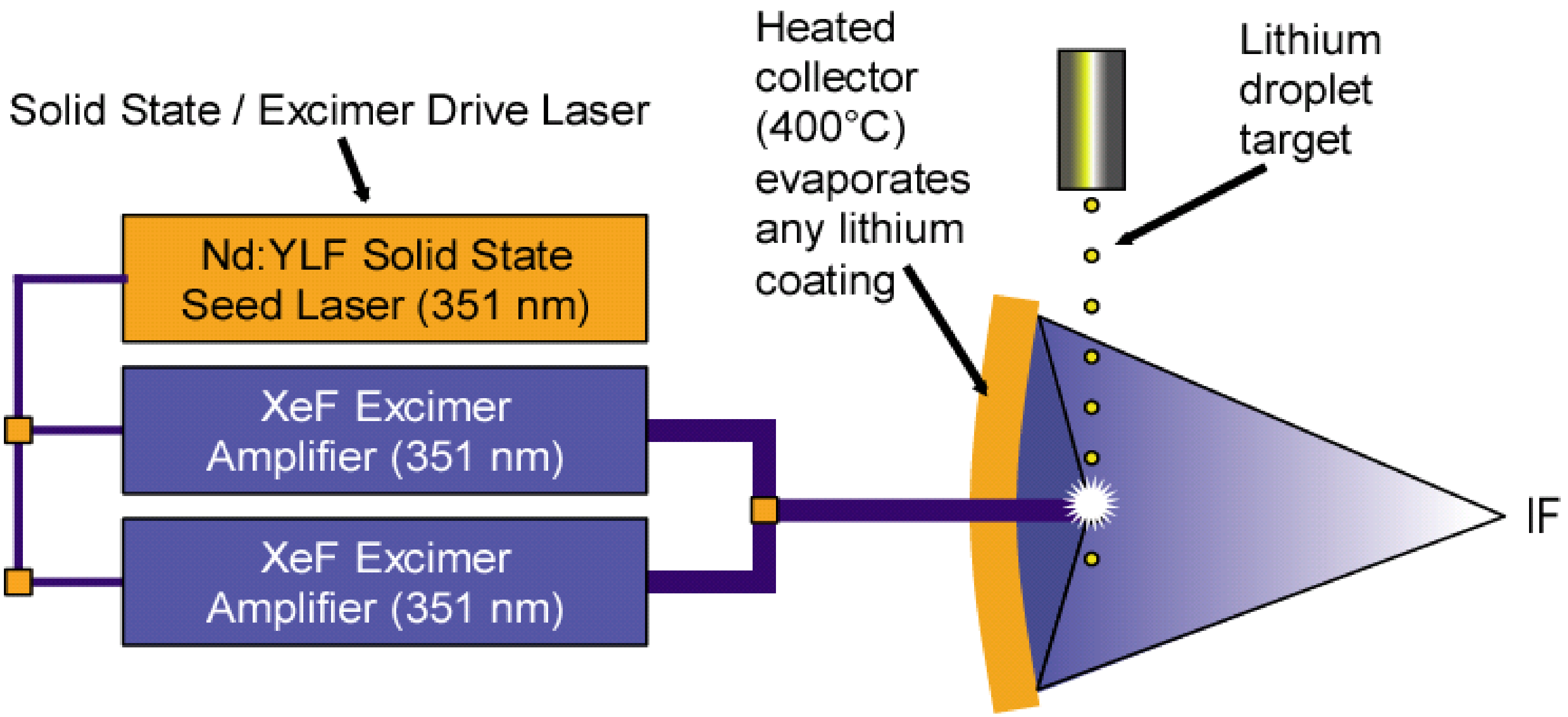




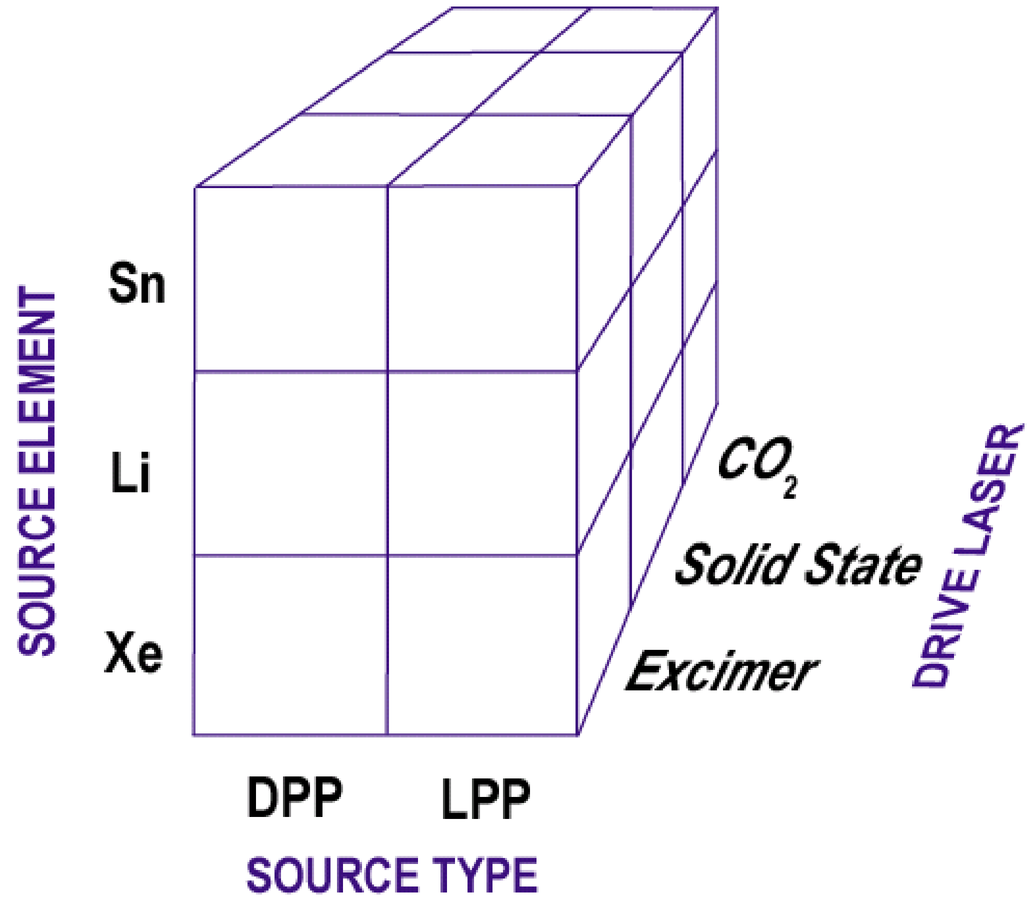
History Shows Power Requirements Increase Over Time

Optimal Path to HVM Source

Excimer Laser Combined with Lithium Droplets



Choices for EUV Source Technology



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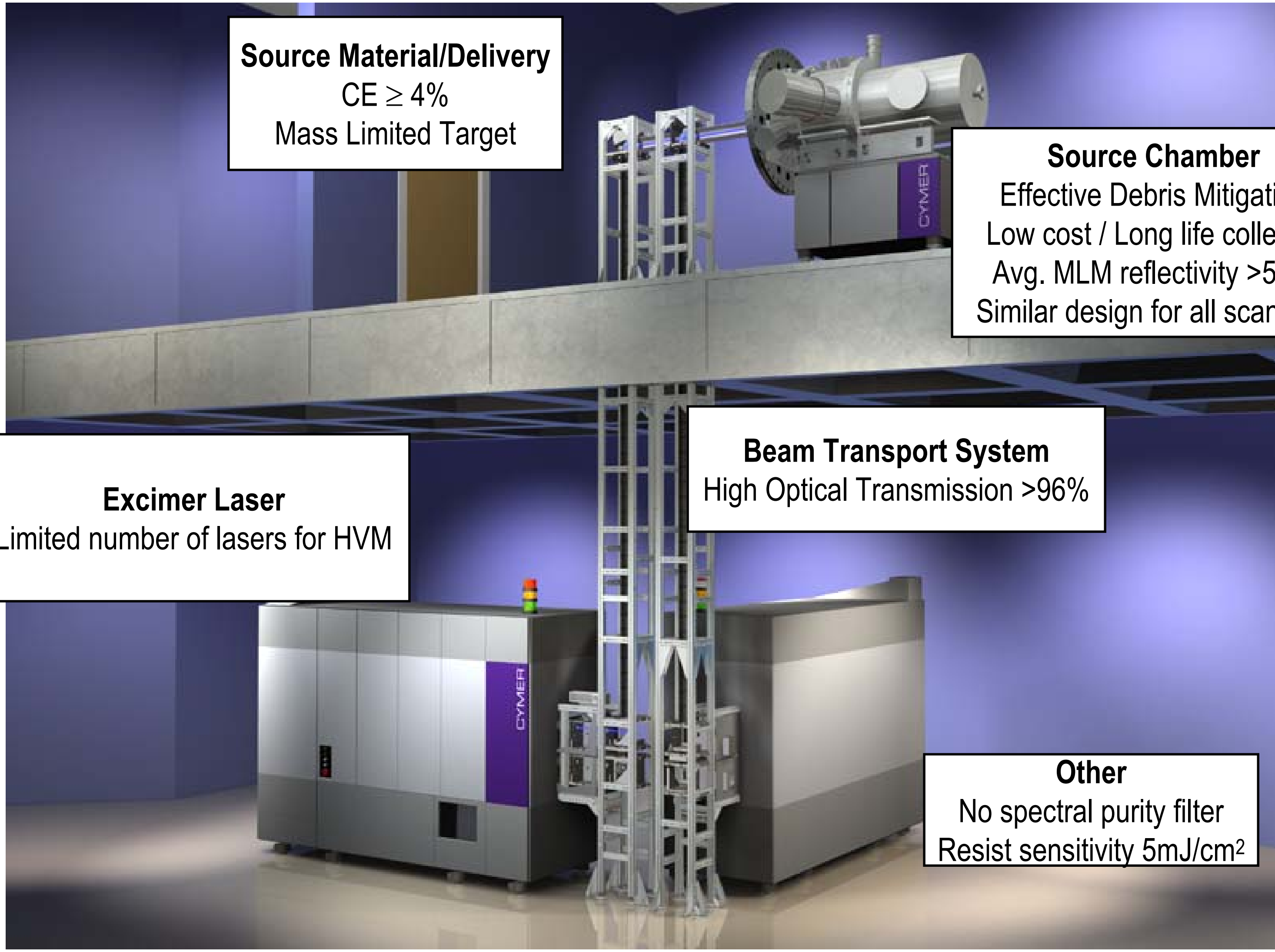
Our Discharge Produced Plasma Source Has Reached Its Limit

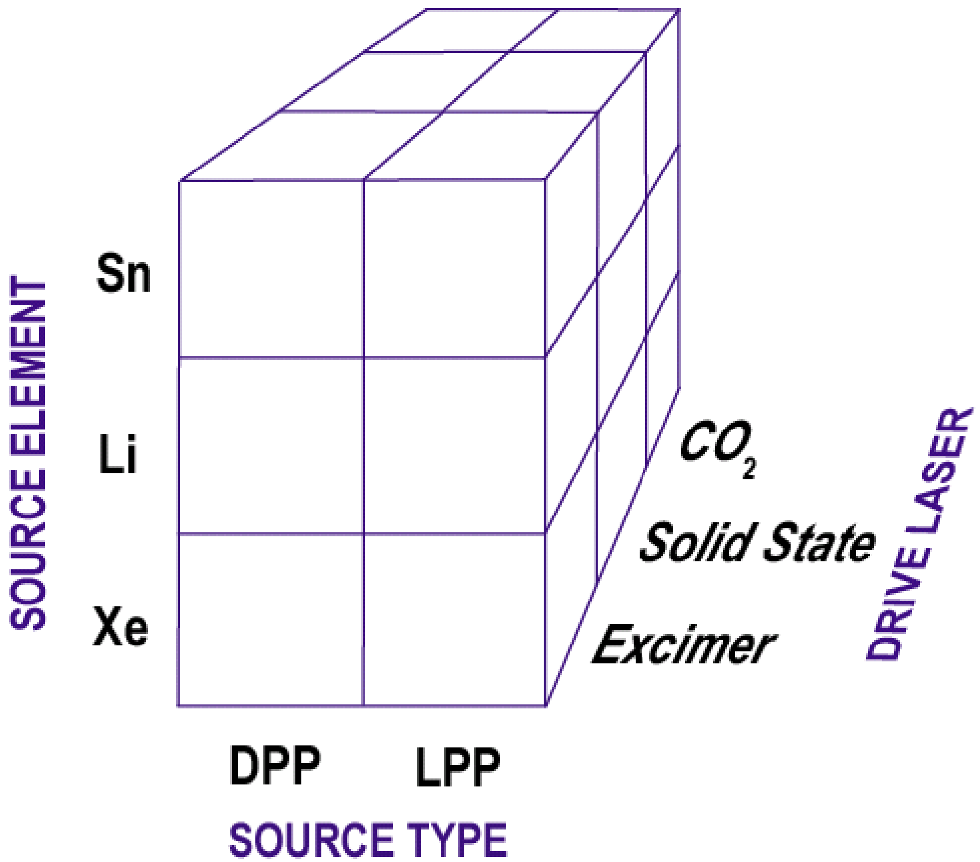
DPP Challenge	2003	Today (Xe)	Today (Sn)	Required
Steady State Mode				
Thermal Extraction Power (W)	21000	31000	31000	
Conversion Eff.	0.45%	0.45%	2.50%	
EUV Power (W), 2% bw,2π sr	95	140	775	762
Rep Rate kHz (Peak/Cont)	5 / 2	5 / 2.5	5 / 2.5	
Geometric Collection Efficiency	20%	20%	20%	30%
Collected EUV (W)	19	28	155	229
Transmission to IF	50%	50%	50%	56%
EUV at Interm. Focus (W)	8.6	12.7	69.8	115.0
Electrode Lifetime (shots)	10M	10 - 35M	10 - 35M?	10B
Source Size (mm)	0.4 x 3.0	0.4 x 3.0	0.4 x 3.0	0.4 x 1.0

Source Type	Source Size	Power Scaling	Debris Generation	Debris Mitigation	System Cost	System CoC
DPP	☹	😐	☹	☹	☺	😐
LPP	☺	☺	☹	☺	☹	😐

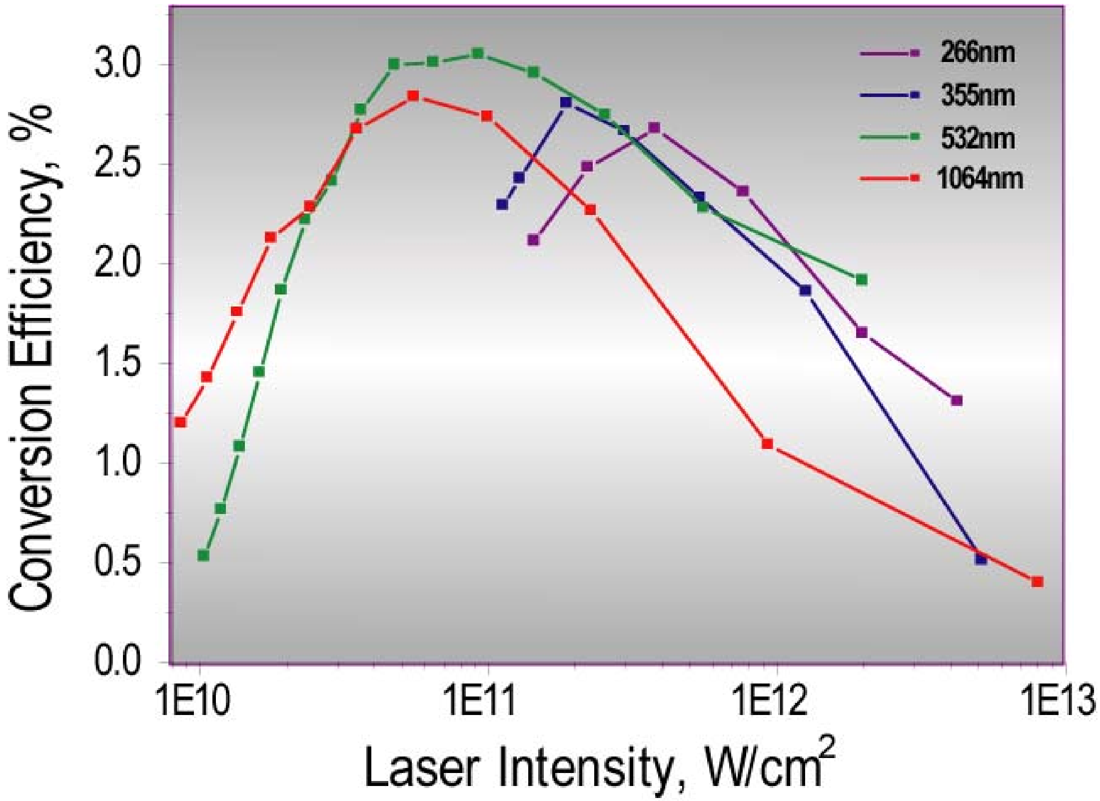
EUV Source System Affordability Requirements



The Optimal Path to HVM is LPP



Lithium Source Material
High Conversion Efficiency at 13.5nm



- Li CE > 2.5% (as good as Sn)
- Xe CE is less than 1%
- Li offers broad choice of drive-laser wavelengths

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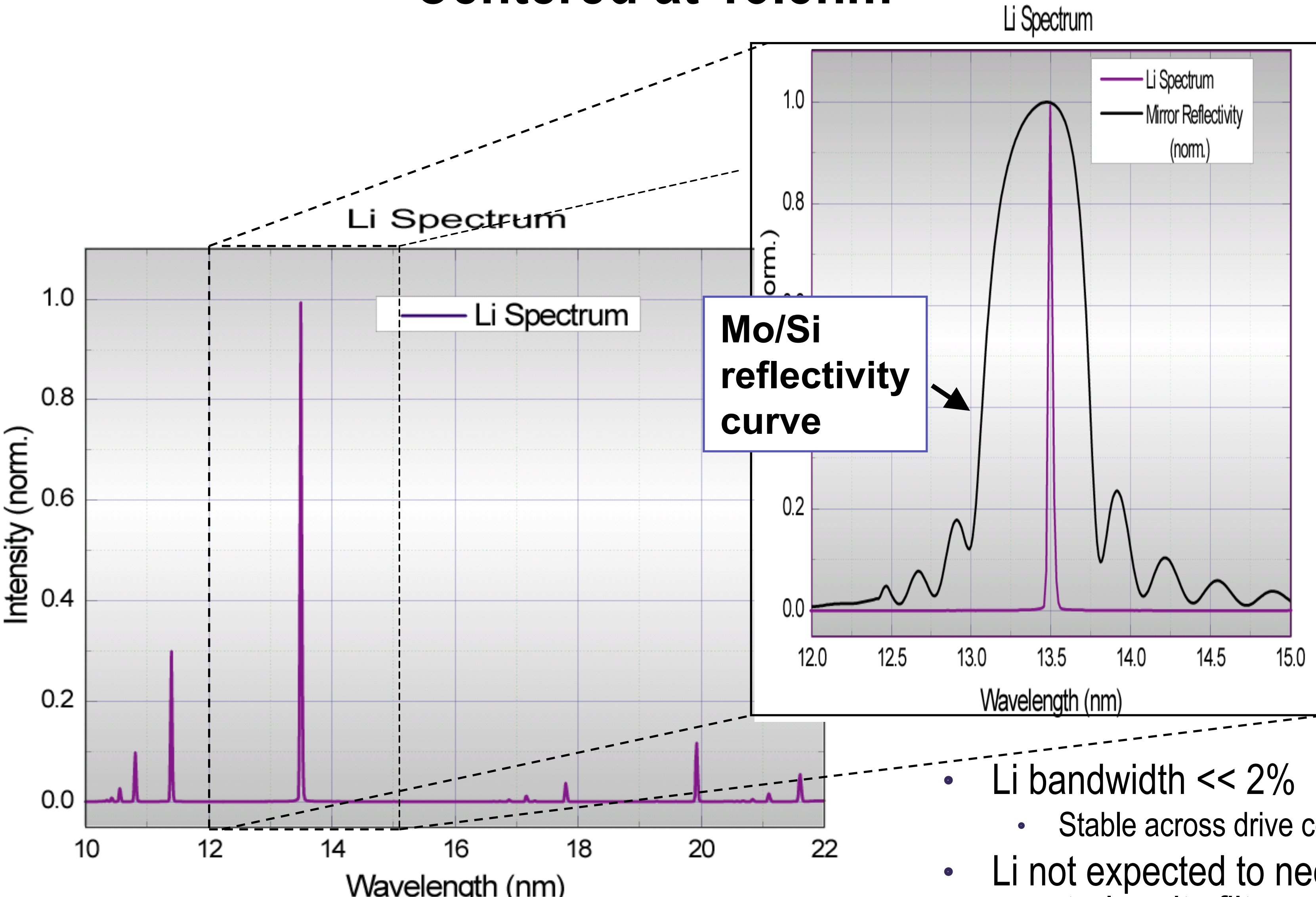
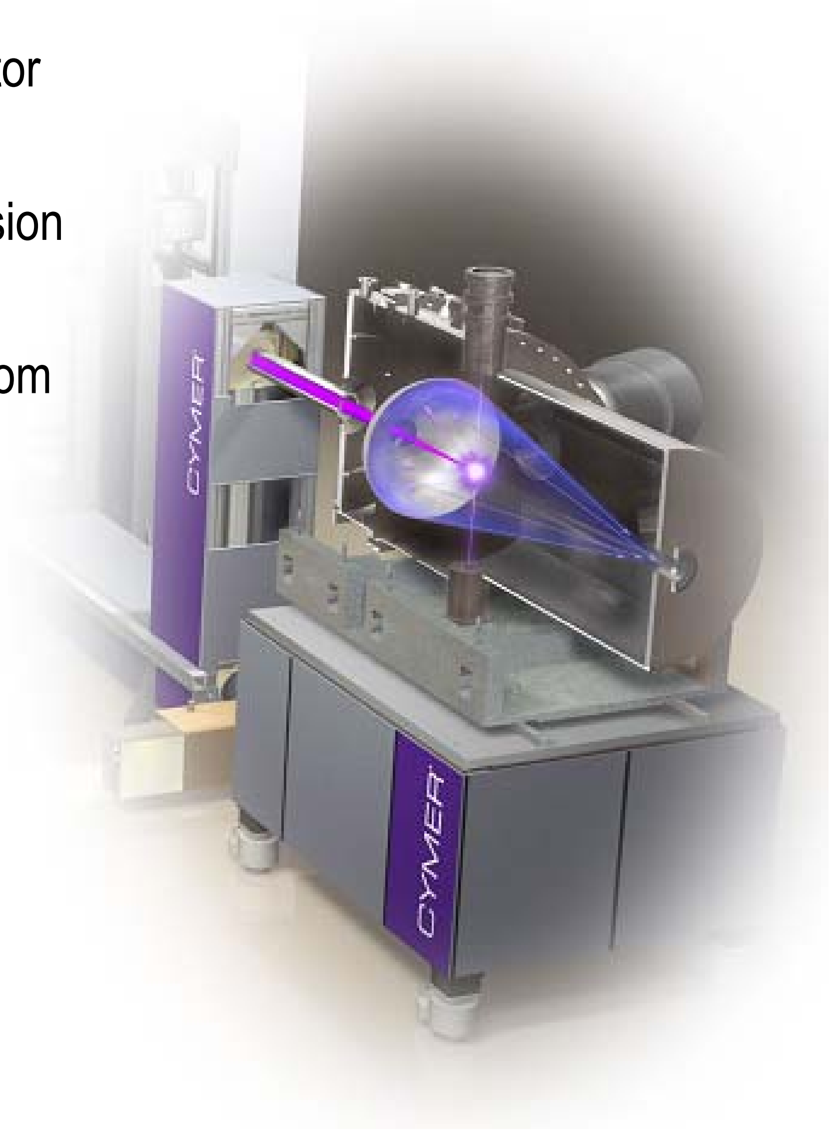
Lithium Source Material has a Narrow Spectrum Centered at 13.5nm



- Li bandwidth << 2%
  - Stable across drive conditions
- Li not expected to need spectral purity filter

Collector Lifetime Challenges

- Source material buildup on Collector
- Sputtering of MLM
- Source material implantation/diffusion into MLM
- Deposition of material sputtered from source hardware
- Deposition of source material contaminants
- EUV induced carbon growth and oxidation
- Thermal stability of MLM



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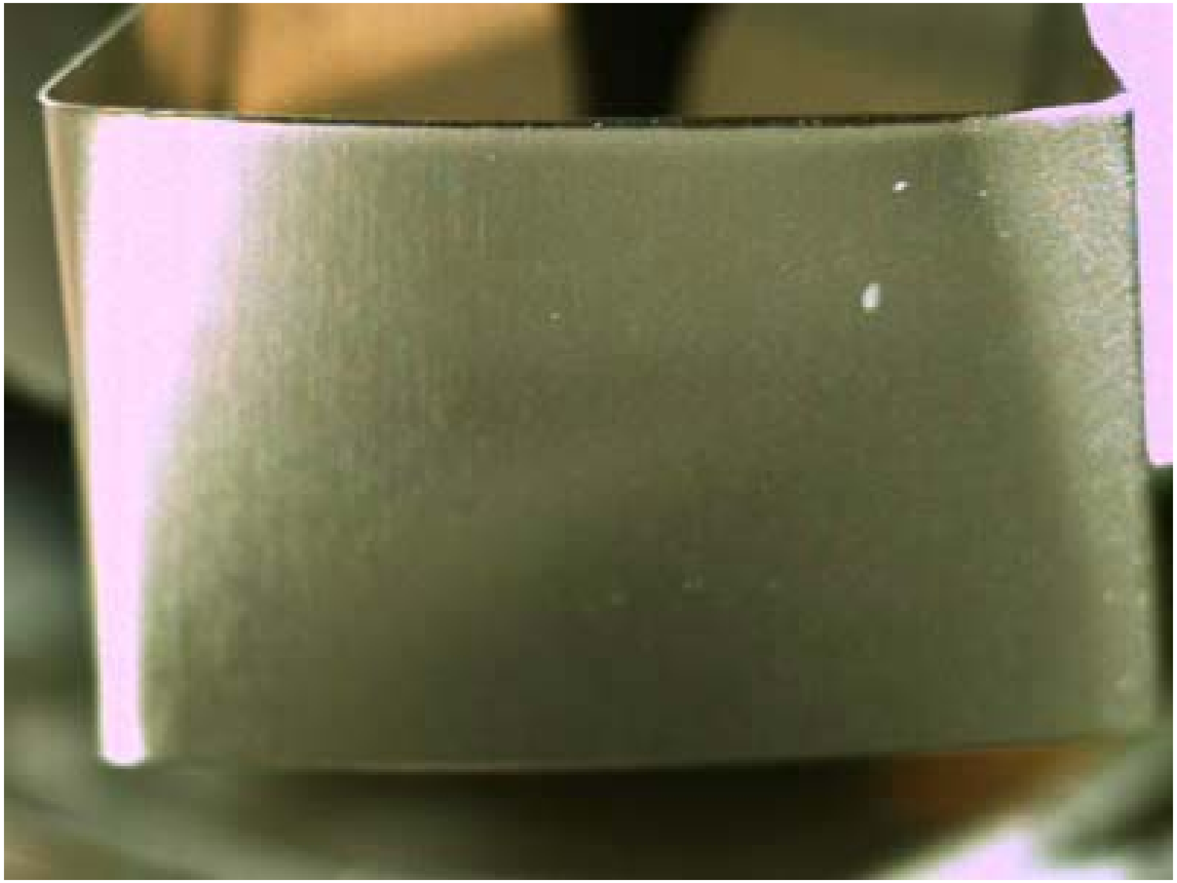
Lithium Can Be Removed from the Collector Surface

- With appropriate capping layer and heating, Li can be evaporated before significant diffusion occurs



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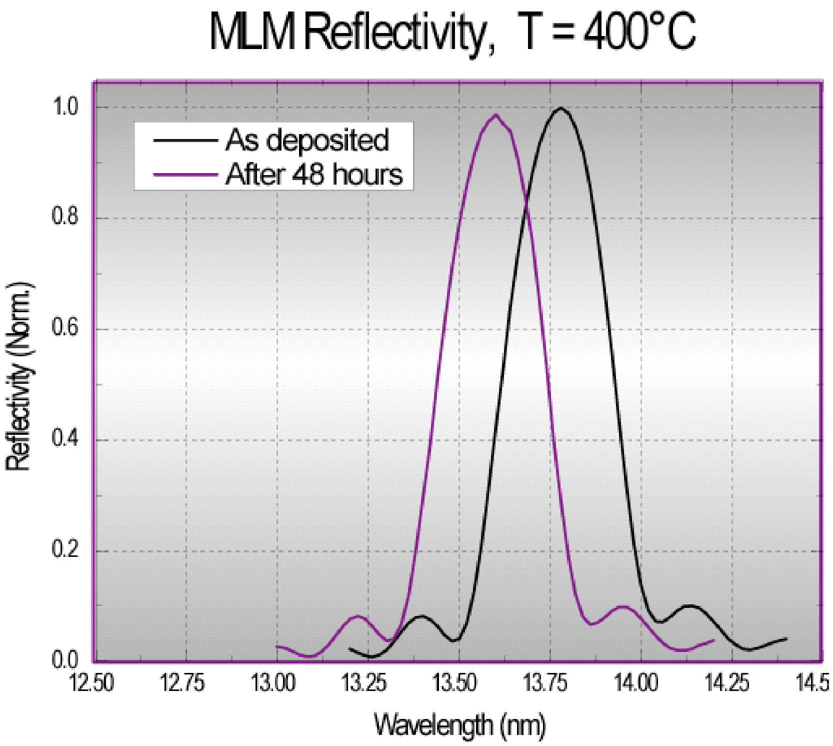
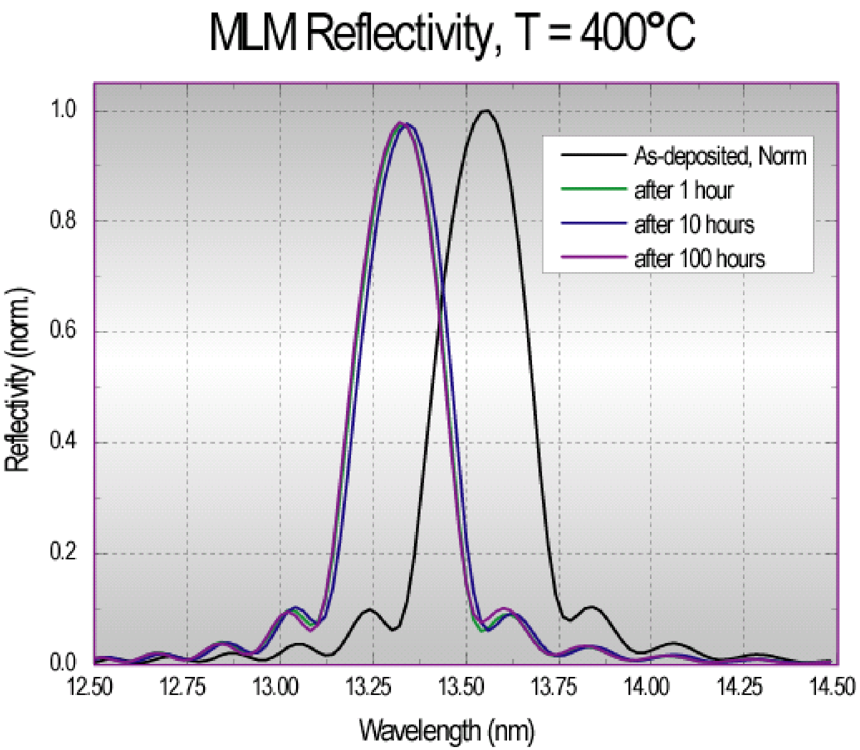
High Temperature MLM Coatings have been Developed

- High-temperature capable MLM developed through research at LLNL and Fraunhofer IOF





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Ion Energy Reduction is the Key to Extending Collector Lifetime

- Sn and Xe ions have significantly higher energies
- Li sputtering of collector is more than an order of magnitude less than Sn and Xe

Data from litterature:
Innolite presentation
EUVL Source Workshop,
Feb. 2003, Santa Clara

Source Target Element	Source Element Mass, AMU	Maximum Ion Energy, eV	Peak Ion Energy, eV	Relative Sputter Rate of MLM *
Xe, 1064nm	131	20,000	10,000	140%
Sn, 1064nm	119	6,500	2,450	100%
Sn, 355nm	119	5,600	1,550	84%
Li, 1064nm	7	1,200	550	9.3%
Li, 355 nm	7	1,100	500	7.8%

Data from Cymer experiments at identical conditions

* Calculated using TRIM code

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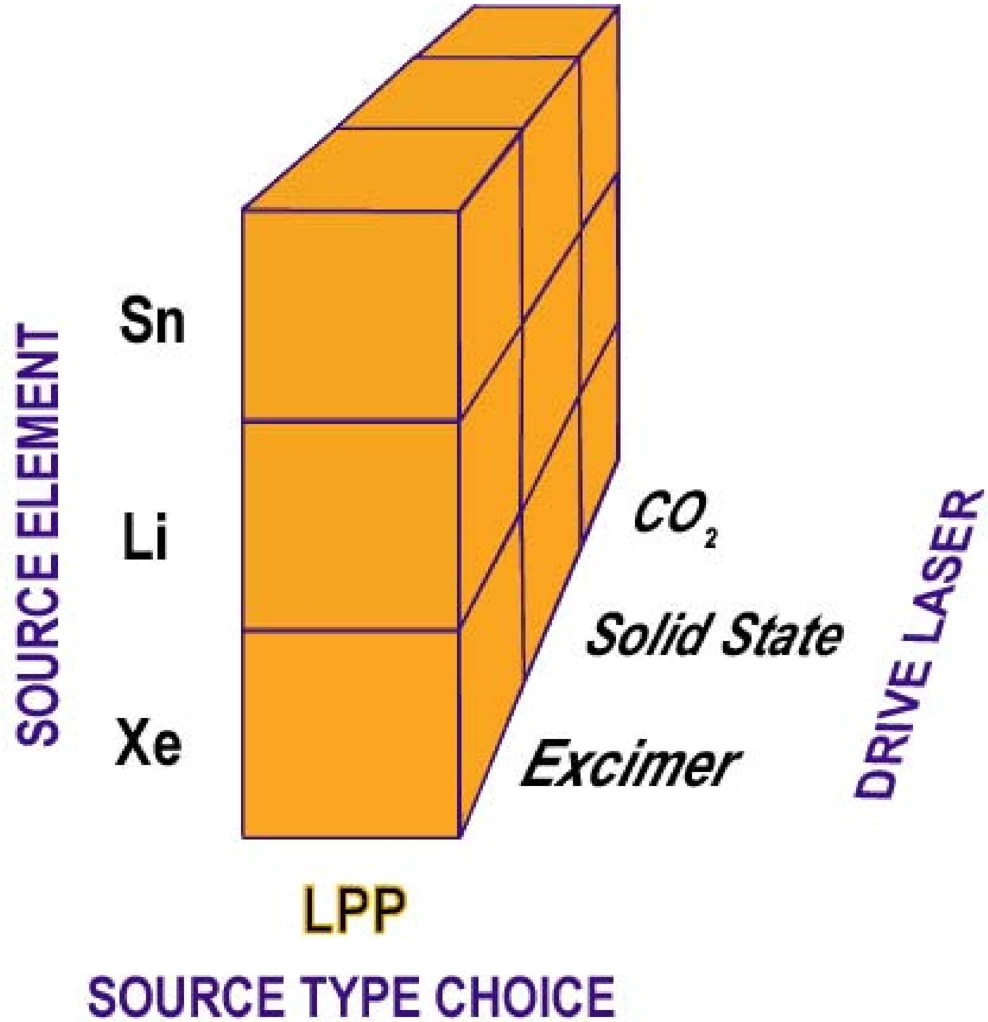
The Optimal Source Element for HVM is Lithium



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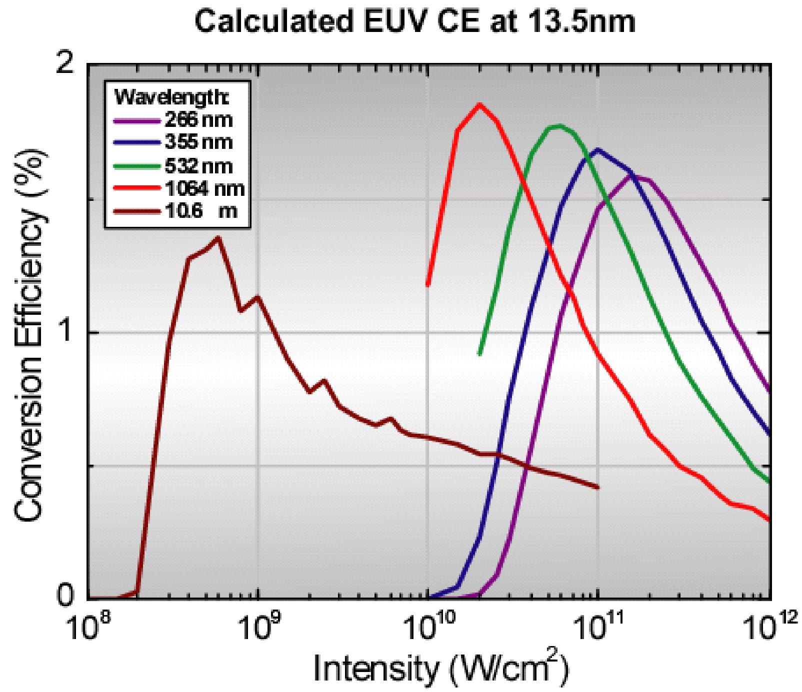
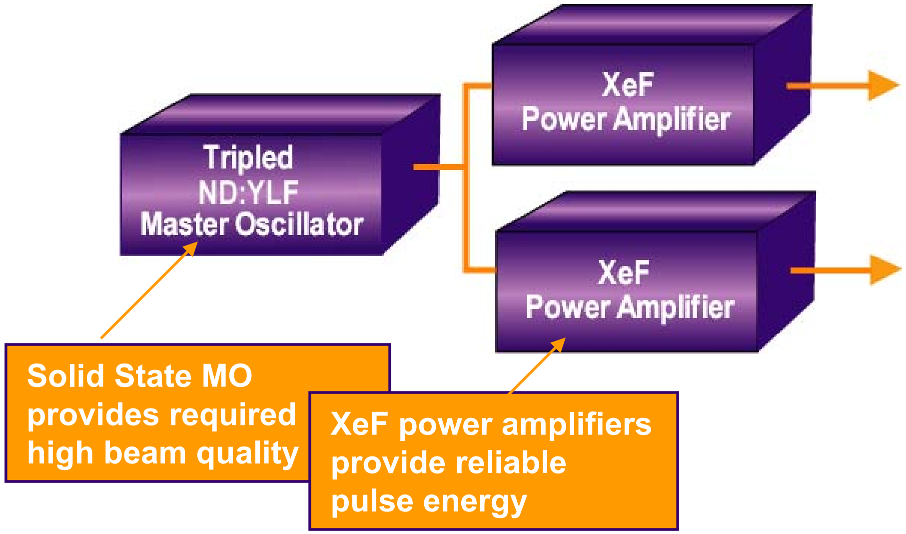
Which Drive Laser Technology?
(Excimer vs. Solid State vs. CO_2)

- Lithium provides a broad laser wavelength choice
  - CE generally constant vs. wavelength
  - CE at Xe Excimer wavelength is high
- XeF Excimer
  - Leverages our MOPA DUV experience
  - Provides low risk path to meet HVM requirements



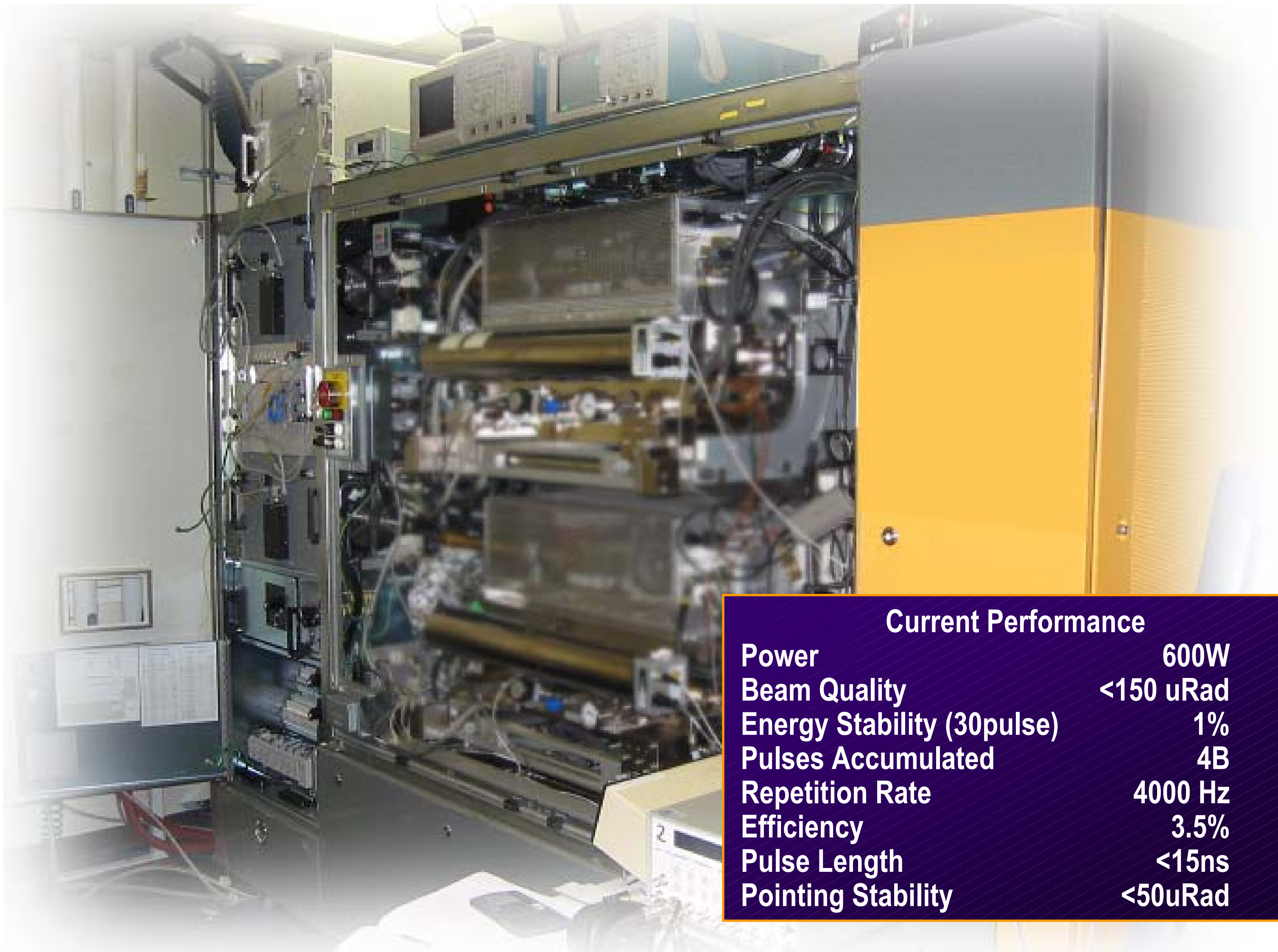
Laser Type	λ (nm)	Power & effcy	Beam Quality	Optical Matls	Polar-zation	Pulse width	Fab Exp.	System Cost	CoO	Resist sens.
KrF	248	😐	☹	☹	🙂	☹	🙂	😐	😐	☹
XeF	351	😐	🙂	😐	🙂	🙂	😐	😐	😐	🙂
DPSS	1064	🙂	🙂	😐	🙂	🙂	☹	☹	☹	🙂
CO_2	10.6 µm	🙂	😐	😐	🙂	☹	☹	😐	🙂	🙂

Excimer Drive Laser as a Path to HVM



Drive Laser Development Roadmap				
	2004	2005	2006	2007
Number of laser frames	1	1	2	2
Power amplifiers per frame	2	2	2	2
Rep rate per amplifier (kHz)	4	6	6	8
Drive laser rep rate (kHz)	8	12	12	16
Total rep rate (kHz)	8	12	24	32
Pulse energy (mJ)	100	190	210	220
Drive laser power (W)	**800**	**2280**	**5040**	**7040**

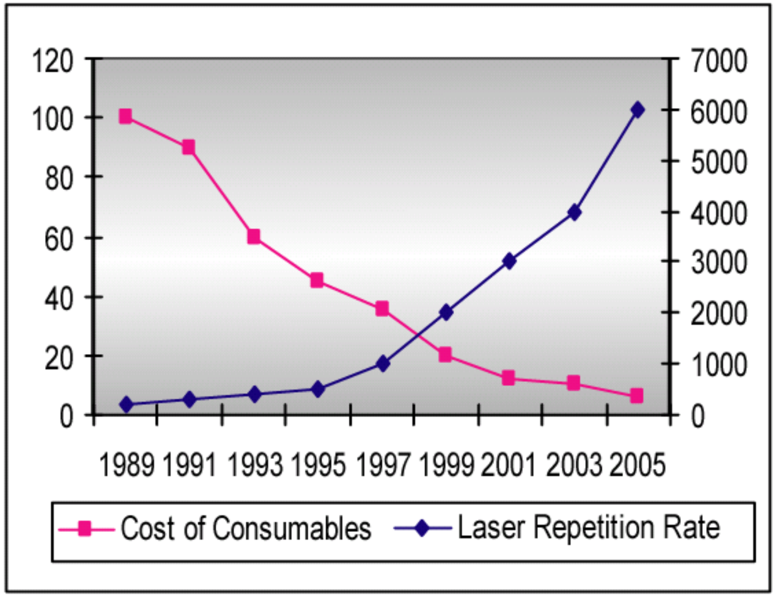
Operational 600W, 4kHz XeF Excimer Laser

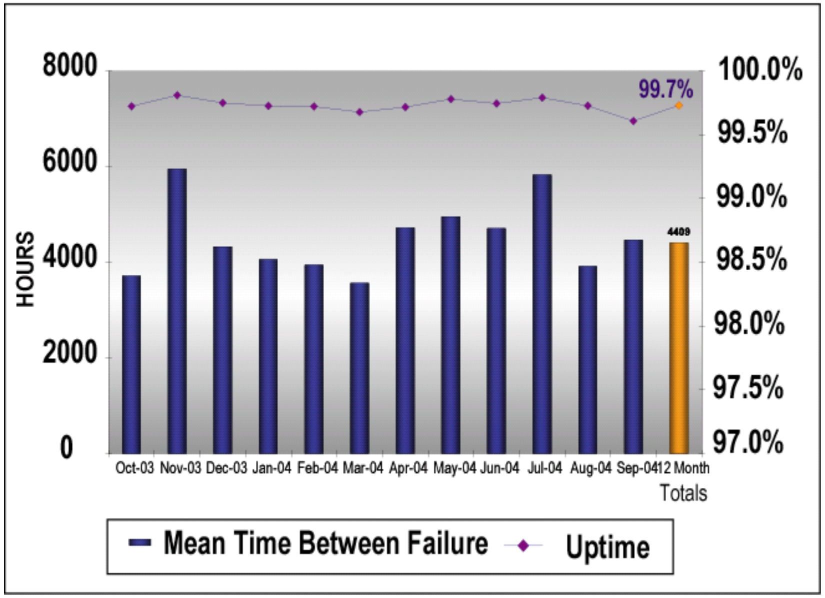


Current Performance	
Power	600W
Beam Quality	<150 uRad
Energy Stability (30pulse)	1%
Pulses Accumulated	4B
Repetition Rate	4000 Hz
Efficiency	3.5%
Pulse Length	<15ns
Pointing Stability	<50uRad

Cymer Excimers: Fab-Proven Reliability

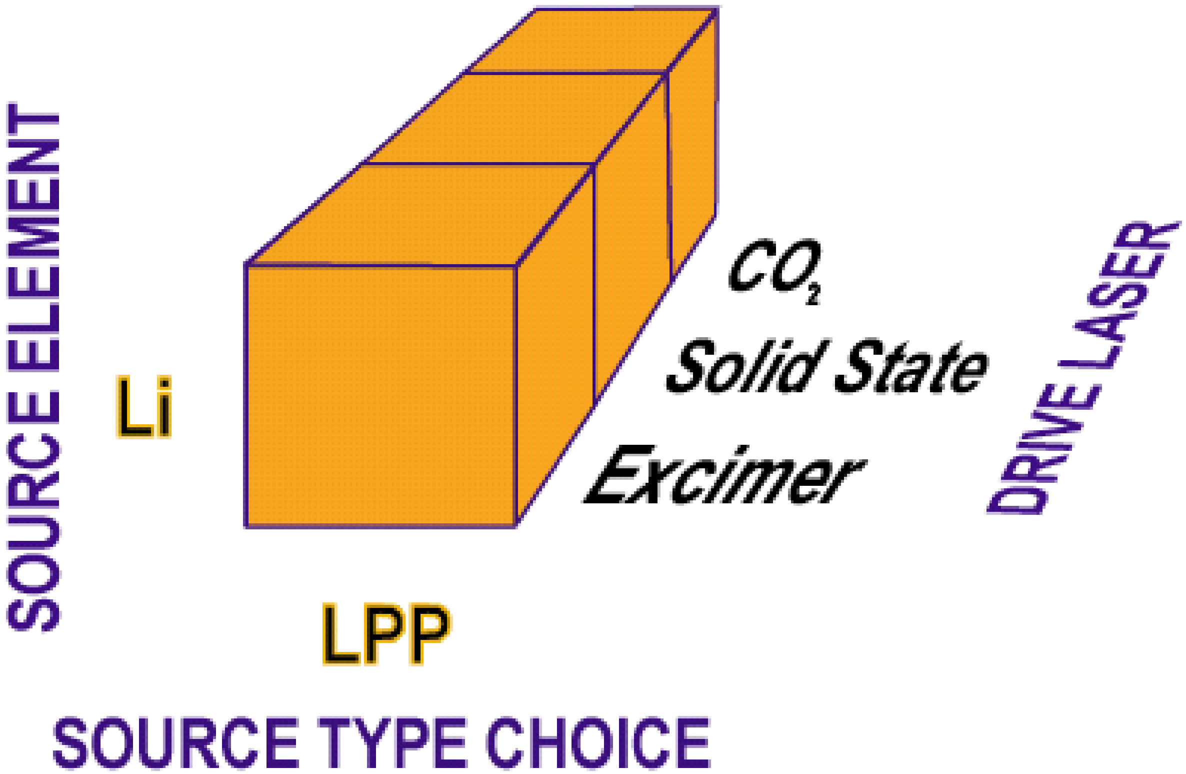
- Using today's technology, demonstrated billions of pulses at 600W
- Worldwide installed base of 2431 (Q3/04) light sources





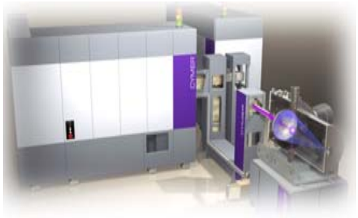
Cymer's Track Record Predicts the Future

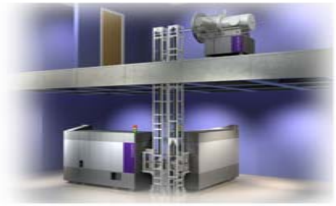
The Optimal Path to HVM is an LPP Using Li as the Source Element Driven by an Excimer Laser



Roadmap for Cymer EUV Source Development

LPP Source Roadmap				
	2004	**2005**	**2006**	**2007**
Number of laser frames	1	1	2	2
Power amplifiers per frame	2	2	2	2
Rep rate per amplifier (kHz)	4	6	6	8
Drive laser rep rate (kHz)	8	12	12	16
Total rep rate (kHz)	8	12	24	32
Pulse energy (mJ)	100	190	210	220
Drive laser power (W)	**800**	**2280**	**5040**	**7040**
Transmission BTS	96%	96%	96%	96%
In-band CE	2.5%	2.5%	3.2%	4.0%
Geometric collection efficiency (sr)	5	5	5	5.5
Collector obscurations	6%	6%	4%	4%
Collector average reflectivity	35%	41%	48%	50%
Collector Lifetime (k hrs)	0.0	1	5	10
Buffer gas transmission	90%	90%	90%	90%
Total power at IF (W)	**4.52**	**15.10**	**51.10**	**102.23**





EUV Animation

Optimal Path to HVM Source

Lithium Droplets Combined with Excimer Laser

- Only LPP can meet anticipated HVM requirements
- Li maximizes in-band CE with manageable debris mitigation
- Excimer laser technology today's best drive-laser solution
  - Excimer technology scales to high power through higher rep rates
  - Excimer track record indicates capability to provide high reliability at affordable cost of operation

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  - Dave Patterson, Cynthia Hanson, Donald Mullin
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- Lawrence Livermore National Laboratory
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- Prism Computational Sciences
  - Joseph J. MacFarlane
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  - Eric Gullikson

Cymer EUV Team

Cymer Poster Presentations:

- "Progress in Development of a High Power Source for EUV Lithography based on DPF and LPP"
  - B.A.M. Hansson, I.V. Fomenkov, W. N. Partlo, N. R. Böwering, A. I. Ershov, S. T. Melnychuk, O.V. Khodykin, J. R. Hoffman, V. B. Fleurov, J. M. Algots, J. W. Viatella, O. Hemberg, A. N. Bykanov, E. A. Lopez, P.C. Oh, T. D. Steiger
- "Modeling MHD, Radiation Transfer, and Photonics in DPP and LPP EUVL Light Sources"
  - C. Rettig, I.V. Fomenkon, J. J. MacFarlane (Prism Computational)

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