High Power Lasers for EUV Sources

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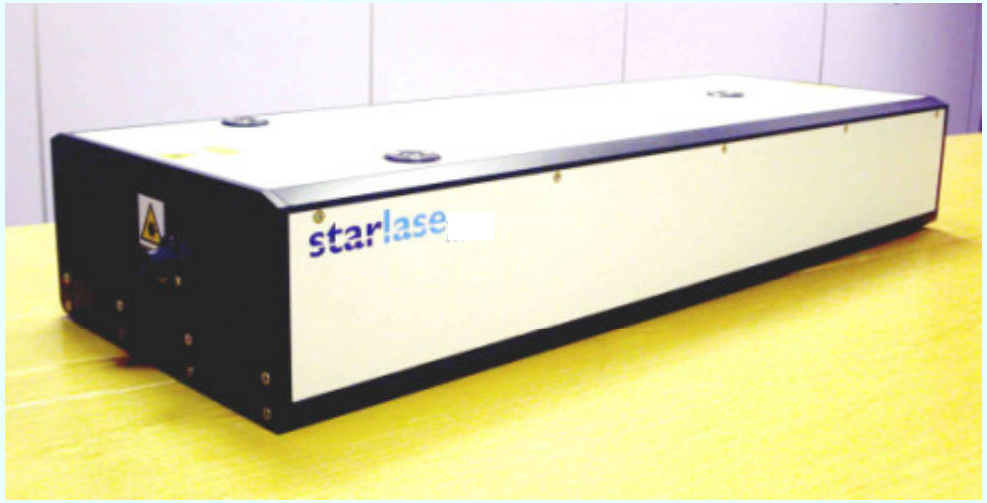
Laser technologies for EUV sources

- **The business objective of Powerlase is to provide laser systems for both EUV source approaches**
  - DPP sources- Powerlase has already provided a laser for DPP research and development
  - LPP sources- Powerlase has established a collaborative programme with University of Central Florida (UCF).
- **The lasers used for both EUV source approaches have similar properties with the pulse duration tuned to suit either source.**
- **100's of Powerlase laser systems have been installed worldwide for use in many types of applications such as HVM of flat panel display (FPD).**
- **Up to 8 laser systems have been multiplexed in high demand industries and used in one single processing machine - 6 to 8kW of processing power is used.**
- **The lasers have been running for more than 10,000 hours.**

Starlase short pulse laser technology

1kW class Starlase laser system released Q3 2005 for HVM 24/7 Flat Panel Display industry



Dimensions (LxWxH)1250x420x235mm

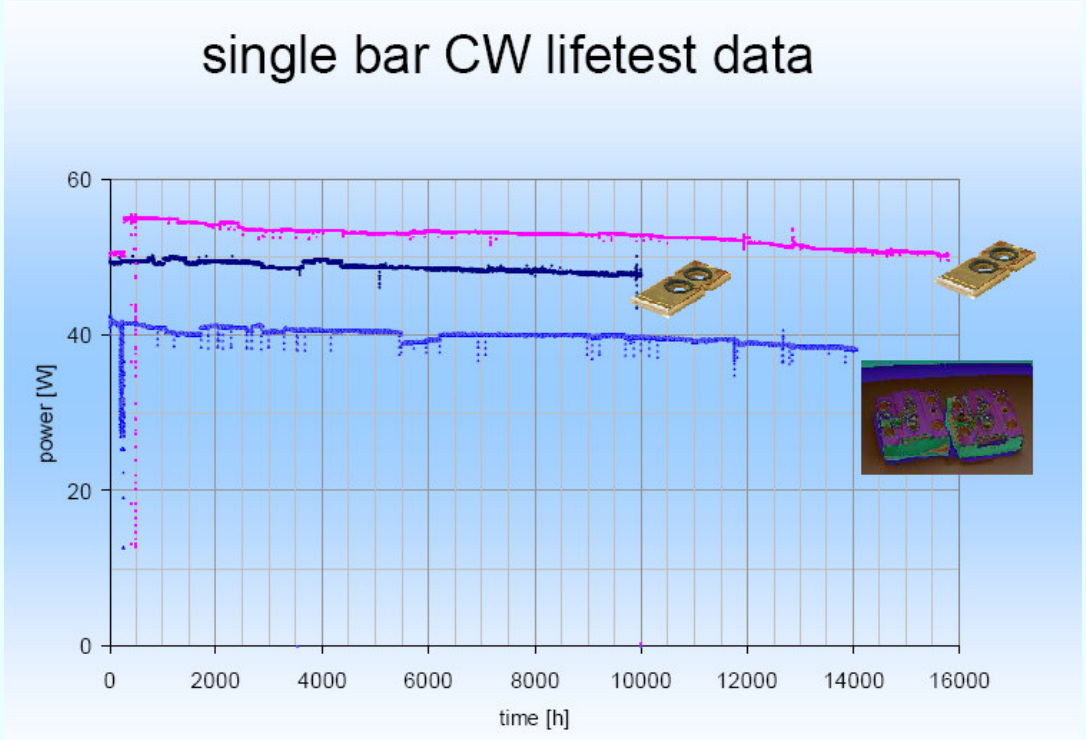
Key features and characteristics

- Average power 800W to1kW
- Dimensions (L, W,H) (1250mm, 420mm, 235mm)
- Repetition rate range 3kHz to 20kHz
- Pulse energy varies with the rep rate (up to 160mJ per pulse)

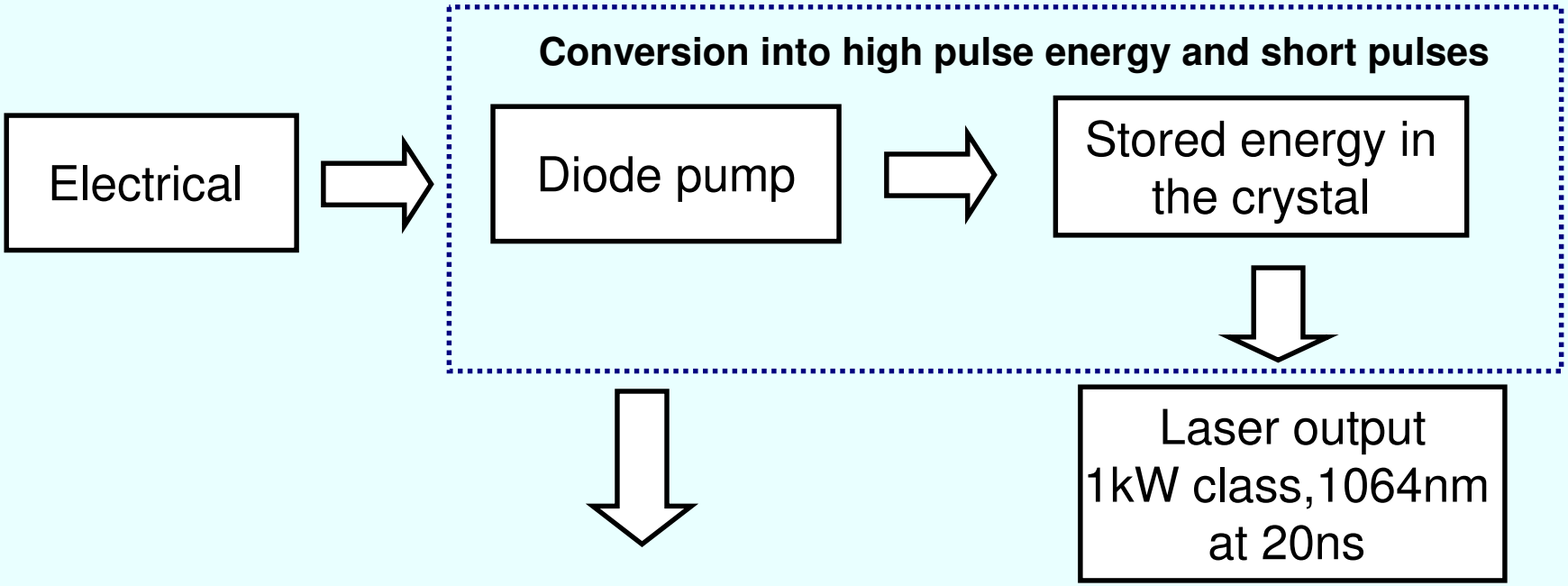
Laser lifetime

- 100's of Starlase lasers have been running for 10,000 hours in a high volume manufacturing environment (24/7)
- Diode suppliers have provided lifetime data with an excess of 16,000 hours continuous operation

Long MTBF



Laser efficiency and cost effectiveness

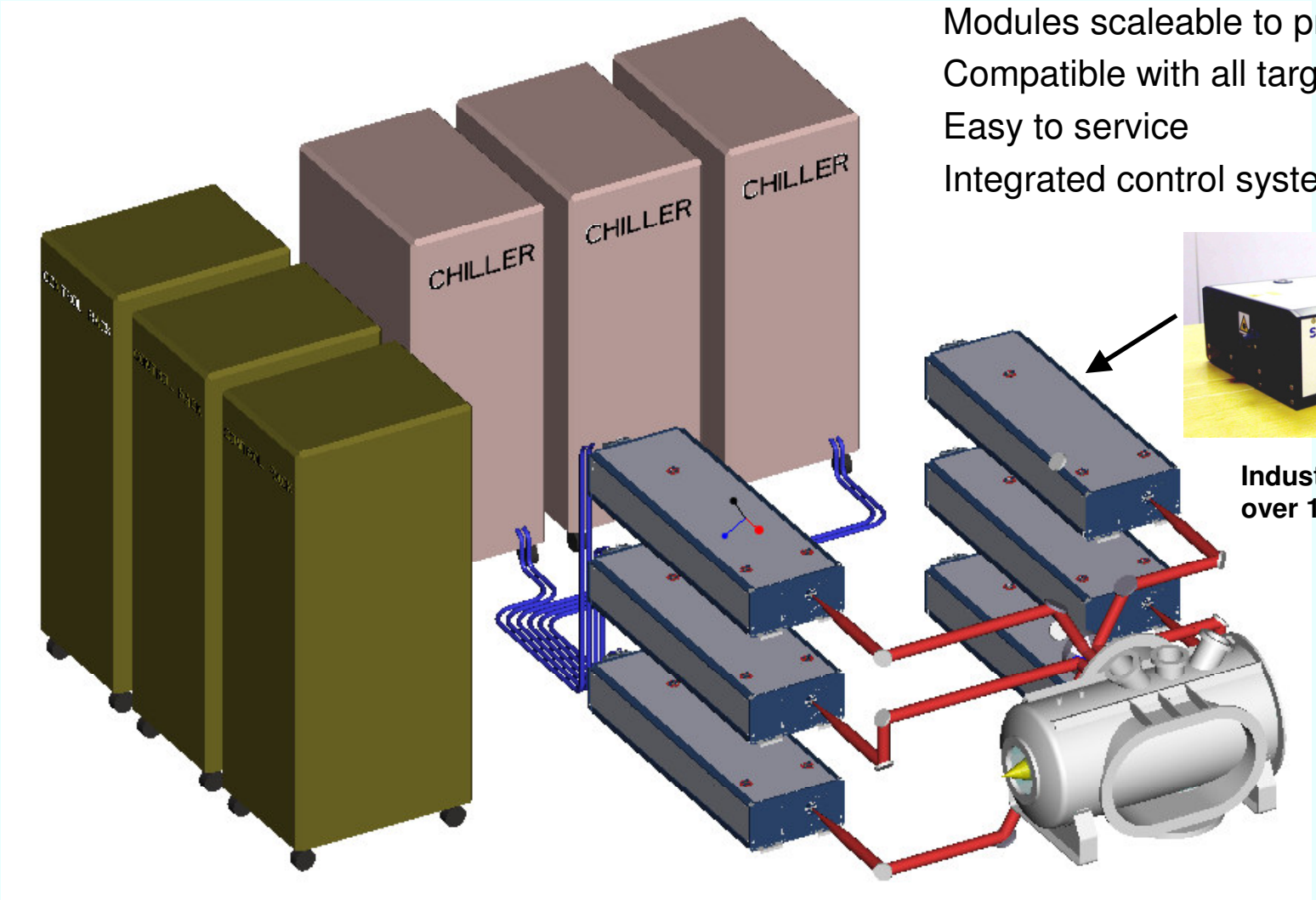


Achievements:

- Excellent coupling efficiency between the diode and the crystal- Wall plug efficiency-11%
- Cost reduction by increasing performance
- Unique laser cavity design

Starlase multiplexed laser products

Features of LPP EUV source using spatial and temporal multiplexing



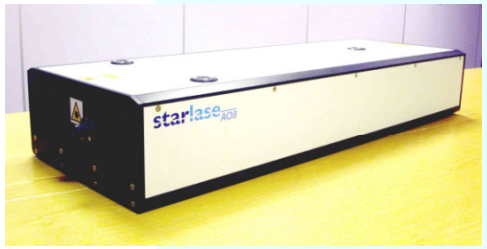
Key features

Modules scaleable to production level

Compatible with all targets

Easy to service

Integrated control system



Industry proven laser has over 10,000 hours runtime

LPP demo system- collaborative work programme with UCF

Objectives/milestones of the collaborative work between UCF and Powerlase

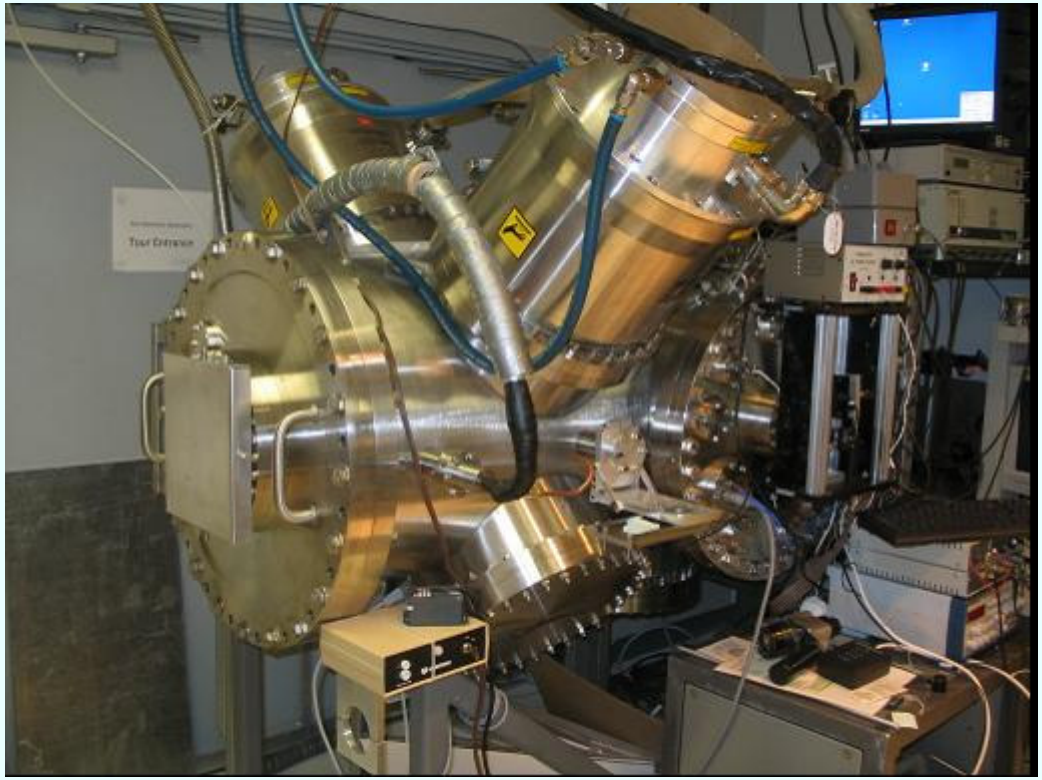
- Demonstrate the use of high average power diode pumped solid state laser for generating high EUV CE.
  - 1kW class laser has already been installed in UCF's facility

- Generate clean photons using tin mass limited target at the intermediate focus (IF) for Q4-06 the target is 5W at IF. Clear strategy for debris confinement /mitigation and tin consumption.

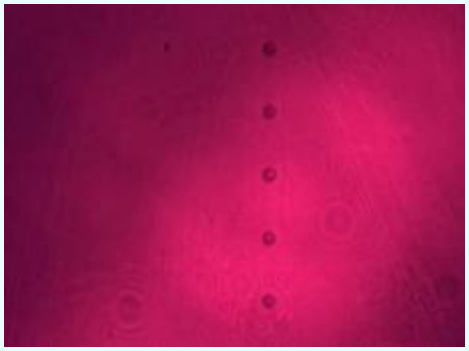
- We are in the process of partnering with a collector supplier. The aim is to demonstrate a high power EUV source with10W at IF, by Q2- 07, collected by a normal incidence collector.
  - Another 1kW class laser will be installed in UCF's facility in Q1 2007
  - 2 lasers will be spatially or temporally multiplexed to irradiate the EUV target

- High power demo system for HVM could be available for the market early 2008.

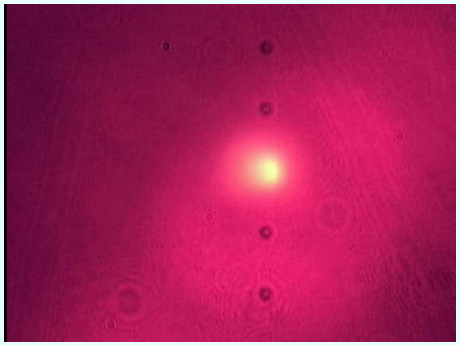
High rep rate Starlase laser irradiating UCF's tin mass limited target



EUV source

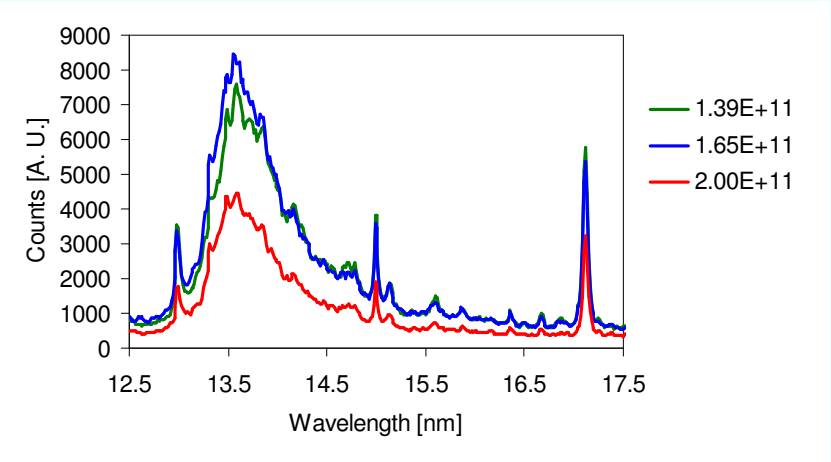


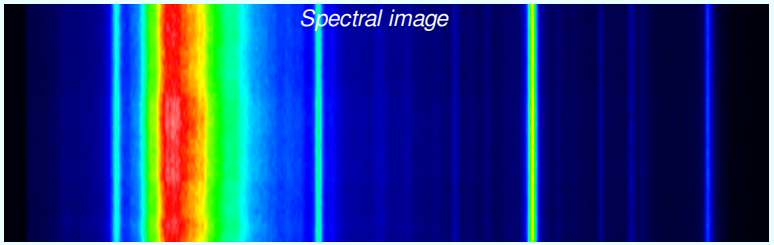
Target before illumination
The target is tin which is extremely stable and well suited to the spatial & temporal multiplexing approach



Target after illumination, high CE has been achieved -1.8%.Translates to 10W into 2π

UCF's tin mass limited target spectra using Starlase laser





Spectrograph is cross-calibrated against Flying Circus

Even higher peak power can be achieved using the method of spatial multiplexing to generate higher EUV CE.

Scale up strategy & cost of 10kW system

10 x 1 kW lasers can be multiplexed to 50 μm focal spot

Total laser power 10 kW

2.5% CE is the aim to achieve using tin target

Assume 45% collection efficiency including mitigation

Gives ~250 W into 2π and **~110 W at IF**

- Laser efficiency is 10% which translates to electrical power of 100kW if 10 kW of laser power is used.
- The cost of 10kW of laser power is $3m to $4m

Acknowledgements

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Powerlase's team

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UCF