Compact Optical Undulator Technology for a High Brightness EUV Lithography Source

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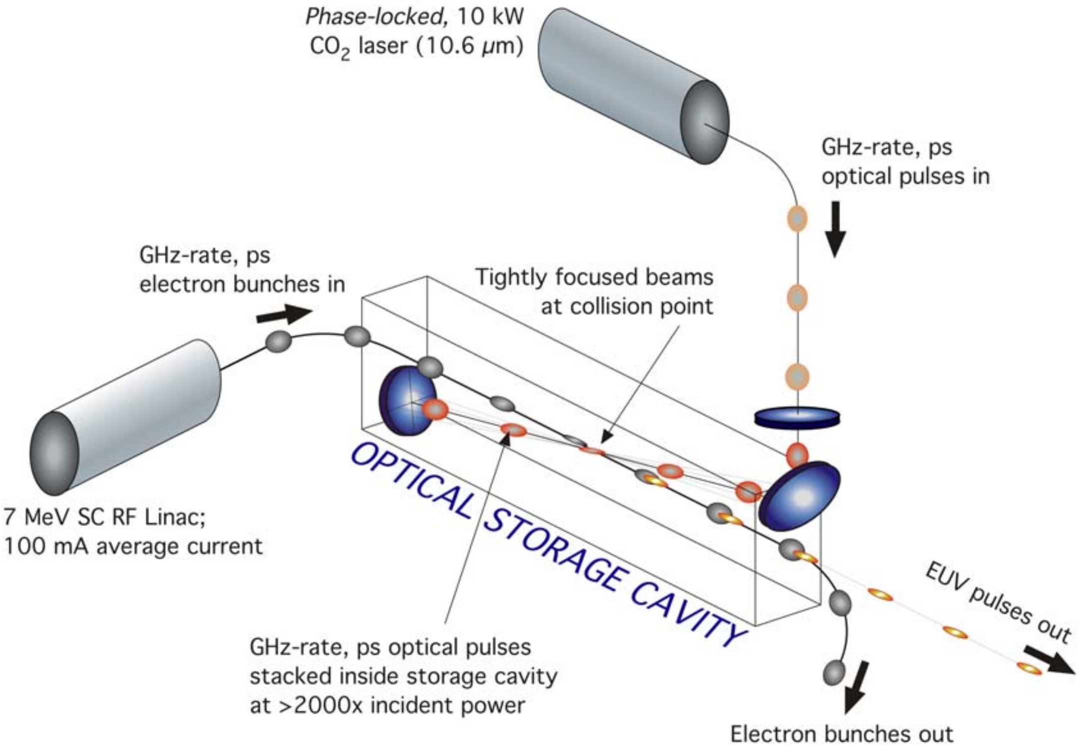
Elements of a Compact, High Brightness EUV Lithography Source

(Physical principles described by the authors at the 2008 EUV Lithography Workshop)



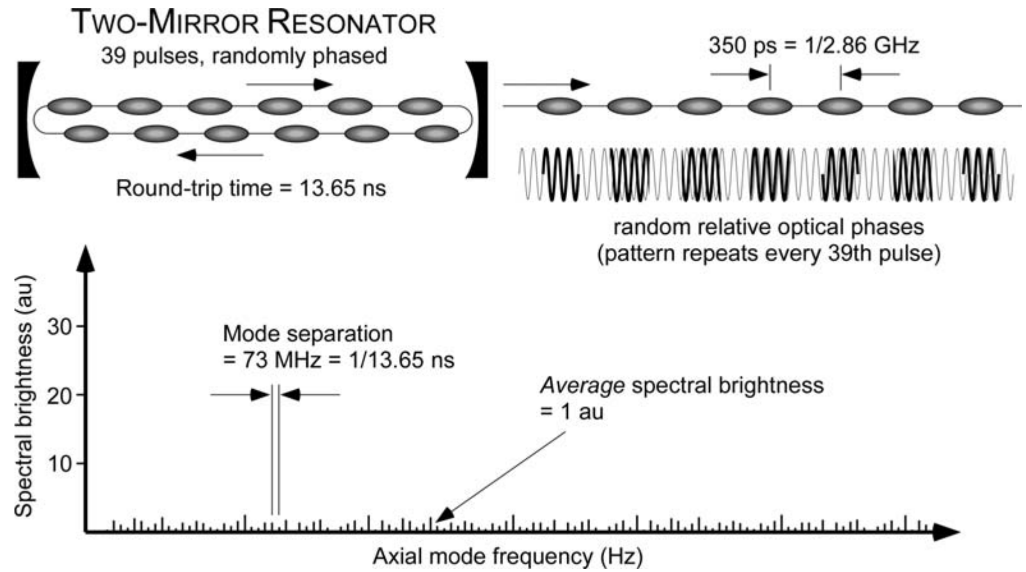
Component subsystems to be developed:

1) 100 mA, low energy, superconducting S-band gun & linac
2) Phase locked, CO_2 laser source
3) Optical storage cavity

Phase-Locked Laser Technology for Harmonically Mode Locked Lasers

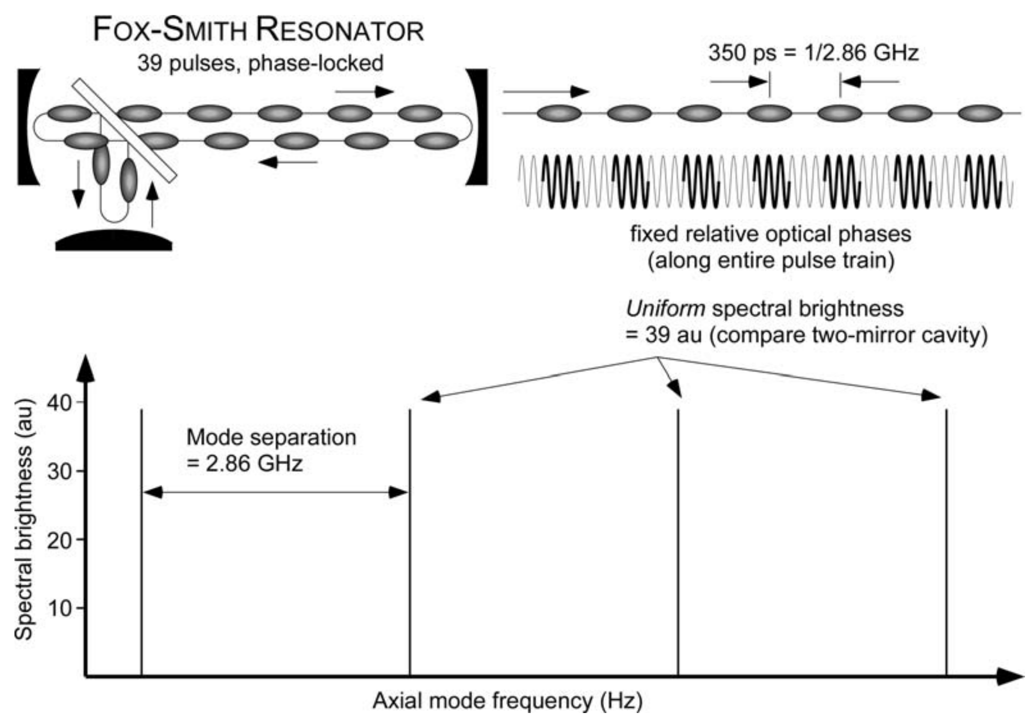
In conventional two-mirror laser resonator, multiple circulating laser pulses build up with random optical phases.

When incident on optical storage cavity, successive pulses undergo destructive interference and do not build up power in the cavity.

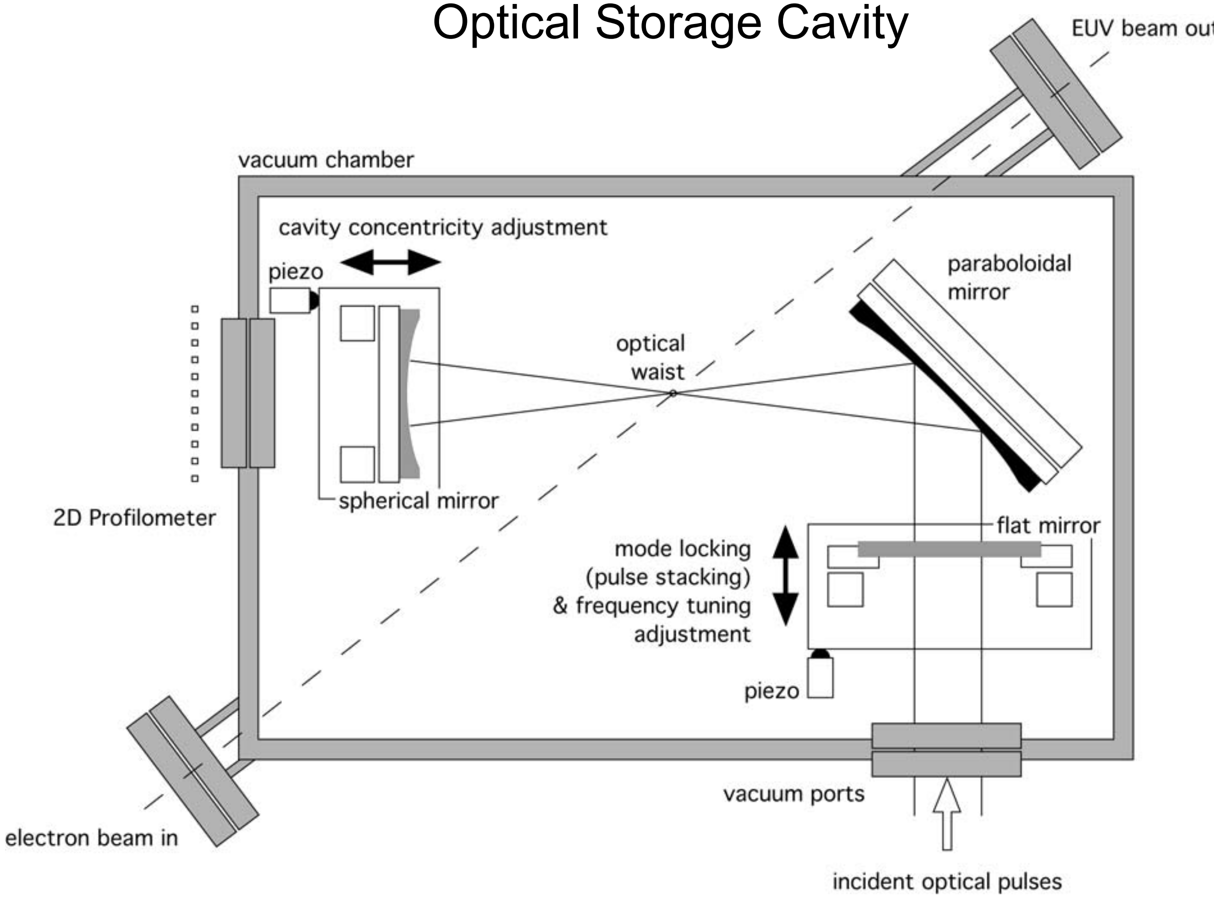


Most straightforward solution is to use an *intracavity interferometer* to optically couple successive pulses in the laser, which are then forced to build up *in phase with each other*.

When incident on optical storage cavity, successive pulses all contribute to constructive interference for optimum power growth in the cavity.



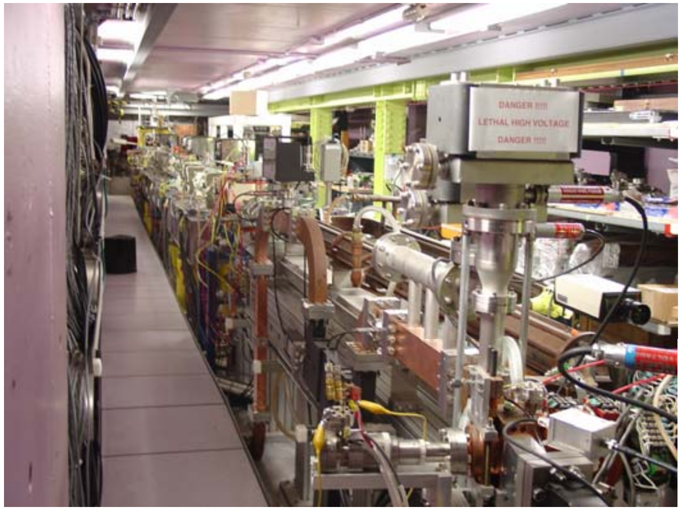
Optical Storage Cavity

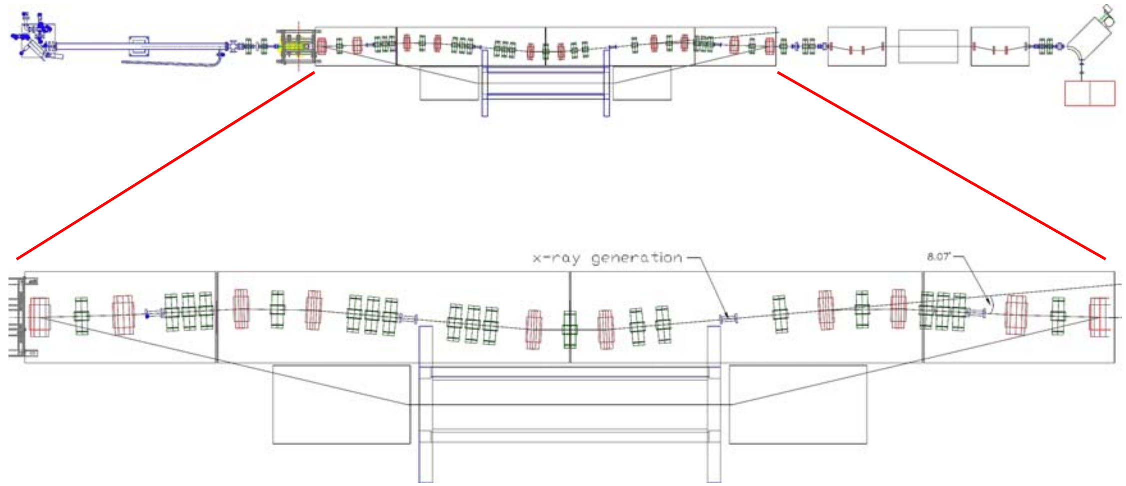


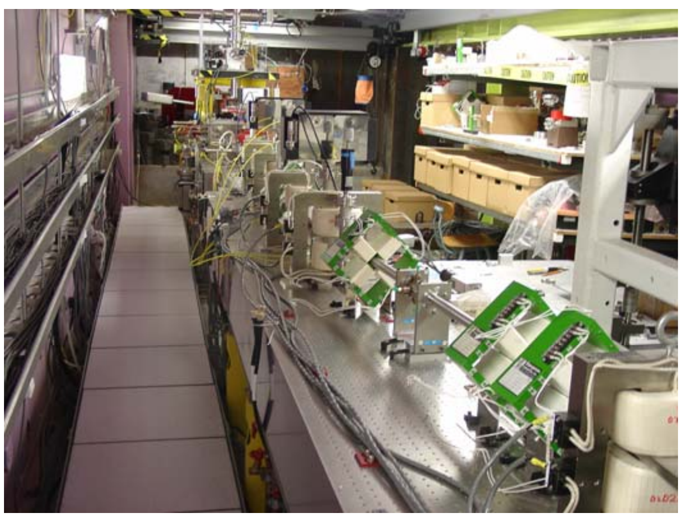
Design criteria:

1) Independent cavity-concentricity and pulse stacking capabilities
2) Nearly head-on collision (crossing angle ~ 5° , greatly exaggerated above)
3) Relatively modest finesse (~ 4000), with >2000× power enhancement
4) Actively stabilized for mode size, mode position, and frequency matching
5) Stored pulses yield ~ optimized optical undulator at waist, with beam fluence less than damage threshold at mirrors

Facilities at the University of Hawai‘i







Accelerator facilities include:

1) Thermionic microwave gun
   (rep rate = 2.86 GHz, 200 mA ave. current)
2) 45 MeV linear accelerator
3) Fully instrumented diagnostic chicane
4) MkIII infrared free-electron laser
5) Insertion space for storage cavity and
   extraction of hard x-rays

EUV Source with CW S-band Superconducting Linac and 10 kW, 2.86 GHz, Phase-Locked CO_2 Laser

Projected Operating Parameters

Laser pump	Wavelength	10.6 μm
	Peak power	1.4 MW
	Pulsewidth	2.5 ps (10 atm pressure-broadened)
Electron beam	Energy	6.6 MeV
	Emittance	1.4π mmmrad
	Average current	100 mA
	Beam radius at focus	14 μm
Storage Cavity	Cavity coupling	0.12%
	Cavity losses	0.15%
	Beam radius at focus	45 μm
	CW circulating power	3.0 GW
	Peak vector potential	0.062
EUV Beam	Wavelength	13.5 nm
	Bandwidth	2%
	Half-divergence	10 mrad
	Brightness	10 kW/mm^2/sr (7.2$\times$10^{14} photons/s/mm^2/mrad^2)

References

Optical undulator technology

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High Power CO_2 Laser Technology

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