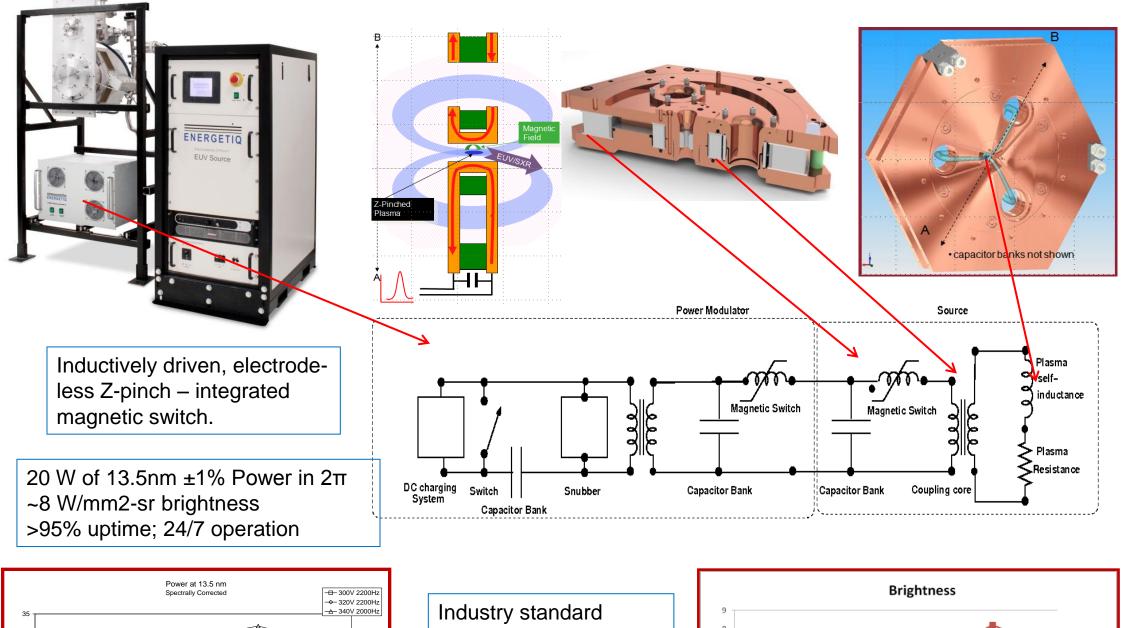


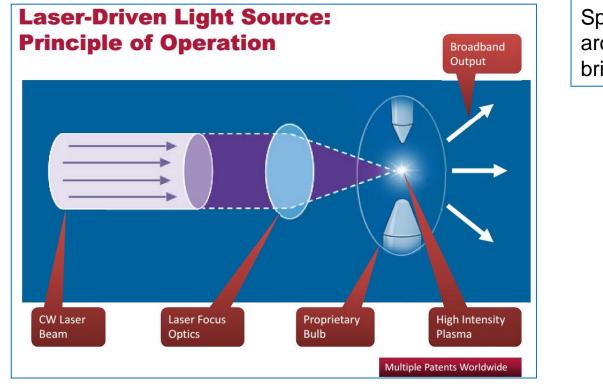
Light Source Development at Energetiq Stephen F. Horne, Donald K Smith, Matthew M Besen, Paul A Blackborow, Deborah S Gustafson, Matthew J. Partlow, Huiling Zhu Energetiq Technology, Inc.

Energetiq Technology Inc. produces a variety of light sources. This poster will review the physics of these products (and some proposed devices), with an emphasis on applications. The technology to be described includes the basic EQ-10 at 13 nm wavelength, and related devices including higher power, high pulse rate, and proposed high brightness concepts, and the 2.88 nm source for water window microscopy derived from the EQ-10. In addition, we will present a summary of the physics and applications of the family of products based on Energetiq's Laser Driven Light Source technology.

## Electrode-less Z-Pinch<sup>™</sup>



# Vis/UV Light Sources - LDLS<sup>™</sup>



Saha equilibrium

 $\frac{n_e n_i}{m_e} = 6 \times 10^{21} \frac{g_1}{T_e} T_e^{3/2} exp(-E_{iz}/T_e) \text{ cm}^{-3}$ 

Radiation scales as  $ne^2$ ,  $Te^{\frac{1}{2}}$ , and a

oltzmann-like exponential factor

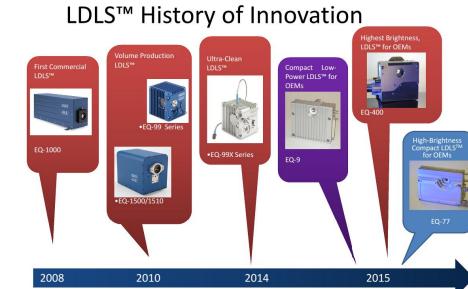
Basic physics of the model

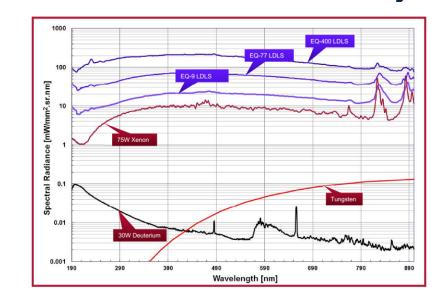
(YZ stade

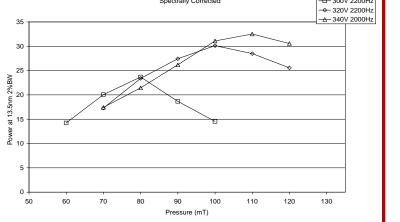
Microscope

orption scales as ne<sup>2</sup>

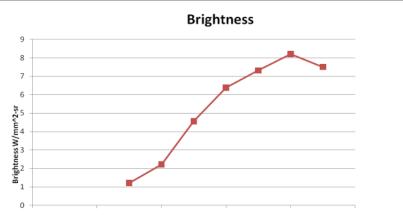
Spectral brightness scales with laser power (unlike arc lamp, where plasma increases in size, limiting brightness).







source for EUV infrastructure R&D, Inspection, Resist development, Outgassing, Mirror testing, &etc...



pressure (mT)

**CCD** camera

**EUV** light source



### Analytical Spectroscopy HPLC, AA, UV-Vis Materials Characterization **Environmental Analysis** Hyperspectral Imaging **Gas Phase Measurements** Advanced Microscopes Endoscopes...

**Application – UV Microscopy** 

250x improvement in exposure times compared to UV



LED illumination, 280

### **Applications and Installations** ~ 25 worldwide





Lasertec/EIDEC mask inspection tool [1]

tube

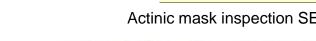
Heating chamber

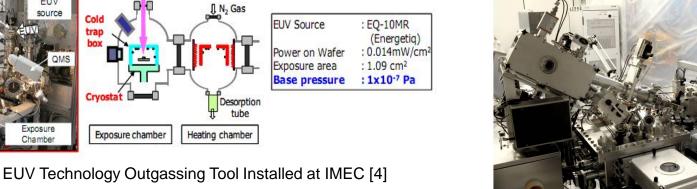
**Advanced Concepts**[8]

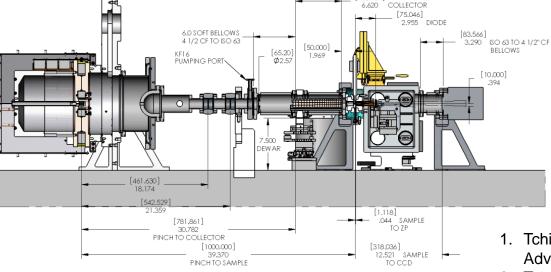
Exposure chamber



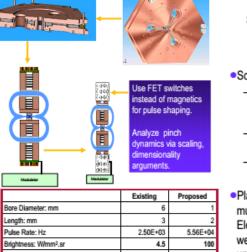
Flood Exposure system installed at Osaka University [3]







- Water Window microscope (2.88 nm) at Energetig[9]



mpression Ratio

Bennet current: A

Peak current: A

fotal Inductance: H

stance: Ω

apacitance: F

Voltage: V Power to Plasma: W

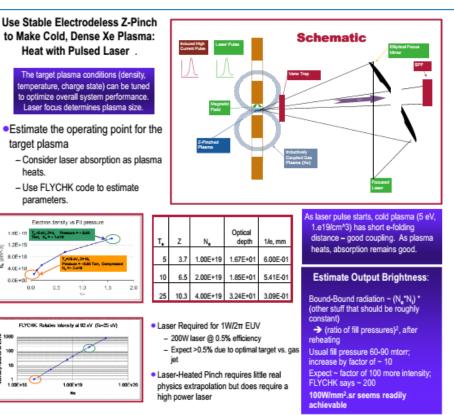
compressed ion Dens

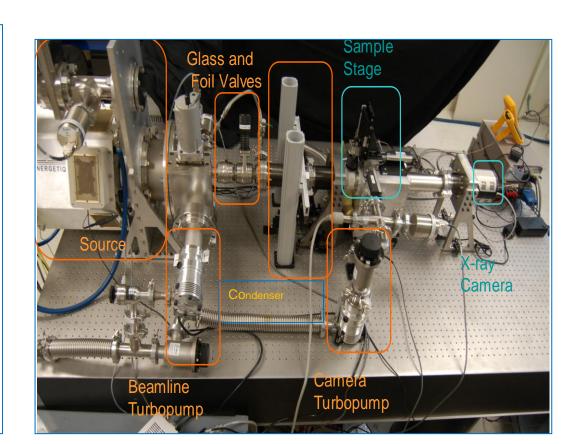
Modest length decrease. performance gives pulse rate

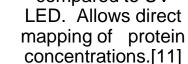
unchanged. (25 eV) 0.4 1.77E+21 3.53E+ 6.64E+03 1.56E+03 1.05 6.99E+03 1.65E+03 Time to Reach Peak Current: 2.51E-07 4.18E-08 1.90E-08 9.49E-0 9.87E-02 9.87E-0 - Current, dynamical timescales, inductance 2.38E-06 8.96E-08 determines voltage, power requirements.

4.21E+03

Modified Z-pinch: Scale frequency up, size, power down. Heat with Pulsed Laser Scale to a measured EQ-10 plasma Bore geometry: scaling: 1 mm bore diameter plus compression ratio meets plasma size goal. target plasma - Brightness legislated; scaling to EQ-10 heats - Plasma density: choose to double to ensure optical thickness. (Scaling implies 1.5x sufficient) parameters Plasma Conditions for Xenon: Charge state must be ~10 times ionized to radiate in EUV. Electron temperature - from charge state; weak density dependence. Assume 0.0 0.5 1.0 - Density, state, radial size give Bennet current. - In base plasma, current peaks above Bennet current. Use same scaling in proposed device. FLYCHK Relative intensity at 92 eV (Te-25 e - Dynamics scaled via argument due to Ryatov. - Inductance assumed reduced by reducing device

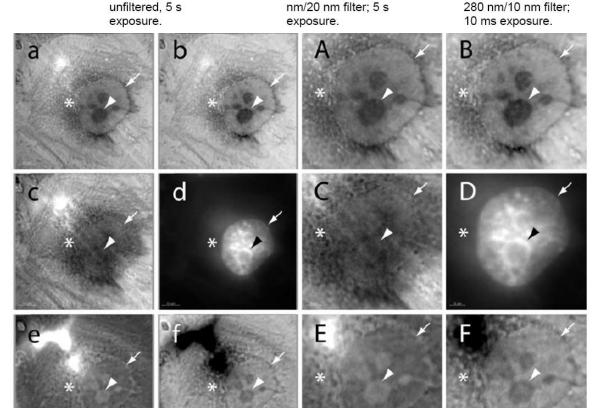






LED illumination unfiltered, 5 s

EQ-99 illumination 280 nm/10 nm filter;

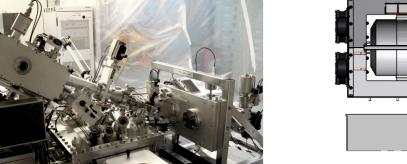


# References

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Actinic mask inspection SELETE [2]



**Vibration Isolator** 

- LithoTech Outgassing Tool installed at Selete [5]
- [1000.000] 39,370 PINCH TO SAMPL

Tip/Ti

Laser flux -- focusing.



0

XYZ stage

# chamber