EUV Source Development at Energetiq Technology

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Abstract
The EQ-10 is a commercially available, medium-power (10 W / 2π, 13.5 nm ± 1%, bandwidth). It does not provide perfect measurement device possible. Must always infer P based on installed sources.

15 Watt Development
Must address thermal, reliability issues. Thermal modeling and temperature measurements imply cooling is adequate.

Current applications -- installed sources
- Open frame exposure (both inband and broadband)
- Resist sensitivity measurements
- Resist development (chemistry)
- Resist outgassing
- Qualification of resists for alpha tools
- Mirror contamination
- Mirror characterization
- Reflectivity, bandwidth

Metrology
- Basic measurement: Watts in 2π at 13.5 nm ± 1% bandwidth.
- No "perfect" measurement device possible. Must always infer P based on imperfect measurements.
- Approach - definitions: (all in Amperes/Watt)
- Instrument Responsivity: Amperes/Watt (assuming line source, standard mirror/mode curve, NIST traceable)
- Peak Responsivity: Above value, at peak of response.
- Spectral Responsivity: Assume power distributed according to some measured spectrum, with normalization set to yield 1 watt inband. Calculate expected current.

Define Spectral Correction = Instrument responsivity / Spectral responsivity

Initial testing -- 2 hrs operation @ 15W

Power Metrology setup
- Glass window to verify foil integrity, measure instrumental offsets (all valves inserted)
- Aperture and diode
- Diode output to scope or ammeter
- Pressure measurement
- Beamline aperture
- Turbopumped beamline

Power scales with pulse rate
Customer requirements drive source development
- Stability
- Position
- Size
- Power per pulse
- Average beam size
- Time lag
- Flexibility
- Power size
- Brightness

Programs under way to raise output energy
- Soft X-rays of biological interest – X-ray microscopy, Microbeams
- Operation at 430 eV demonstrated (He-like N): 11 eV, 3 kV to be attempted (Ne, Ar)
- NIH funded - R44RR022488-02, R44RR023753-01

Experienced Semiconductor Product Developers
A track record of bringing high power plasma devices into production.

Customer requirements drive source development

Stability
- Position
- Power per pulse
- Average beam size
- Time lag

Flexibility
- Power
- Size
- Brightness

Size...

Unique inductive design eliminates electrodes and electrode current
- No electrodes – no electrode debris
- Plasma is magnetically confined away from source components
- Electrode debris allows higher power operation
- Lower cost and complexity
- Six patent applications filed

Pulse-to-pulse stability
20,000 continuous pulses – digitized, each pulse integrated...

Spectral correction of power data
- Narrow band mirror (LBL) Calibration (NIST)
- Spectral correction for 13.5 nm ± 1% nearly unity.
- Broadband mirror (LBL) Calibration (Scientec)
- Spectral correction for 13.5 nm ± 1% = 0.393

Various measures of stability...
- Position

48 hrs continuous operation
- One image every 30 minutes
- Camera pixel size (referred to source) ~ 20 microns
- Observed variation in near measurement resolution limit

Electroless 2-pinch source developed to enable EUV lithography for semiconductor fabrication:
- 10 watts/2π, 13.5 nm ± 1%, 1 bandwith.
- Xenon plasma.

One image every 30 minutes
- Camera pixel size (referred to source) ~ 20 microns
- Observed variation in near measurement resolution limit

Power vs pressure, pulse rate

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Steady Dev. 2.7% Statistics near Gaussian...

References