EUV Source Optics with 100% OOB Exclusion

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**Zero-OOB Collector**

A phase-Fresnel grating can separate long-wave radiation out of the EUV light path for OOB exclusion, effectively operating the collector as a grating monochromator:

Illustrative design configuration:
- Plasma-to-IF distance: 1.5 meter
- Mirror-to-plasma: 199 mm
- Collection angle at plasma: 81.5°
- Collection angle at IF: 11.6° (NA = 0.2)
- Maximum incidence angle: 35.0°
- Plasma clearance diameter: 500 µm
- 0-to-1st-order separation angle: 2.6 mrad
- Minimum grating period: 5.2 µm
- IF aperture diameter: 4.4 mm

**Efficiency Simulation**

RCWA simulation:
- Orders included: -100...+101
- Depth stratification: 0.2 nm
- Mo/Si layers (no capping/barrier layers)
- Layer edge distortion included in model.

Grating’s relative efficiency (vs flat Mo/Si mirror): 98%

**Dual-Function 10-sr Collector**

The grating can also merge zero-order laser light into the EUV light path for wide-angle plasma irradiation:

Illustrative design configuration:
- Plasma-to-IF distance: 1.5 meter
- Mirror-to-plasma: 199 mm
- Collection angle at plasma: 131.6° (>10 sr)
- Collection angle at IF: 11.6° (NA = 0.2)
- Incidence angles on primary, maximum: 35.5°
- Incidence angles on secondary, minimum: 55.6°
- Plasma clearance diameter: 500 µm
- 0-to-1st-order separation angle: 1.2-4.7 mrad
- Minimum grating period: 2.8 µm
- IF aperture diameter: 12.0 mm
- IF annular mirror outer diameter: 38.7 mm

**Conformal-Multilayer Grating Structure**

Illustrative design configuration:
- Normal incidence
- Grating period: 5 µm
- 40 bilayers, 4.19 nm Si \ 2.71 nm Mo
- (276-nm stack depth)
- Substrate pattern depth: 6.9 nm
- Mo/Si layers distorted by edge discontinuity (conformal deposition)

**Grating Manufacture**

Process:
1. Form a precision-machined, super-polished substrate base surface (either in Ni or a secondary substrate layer deposited on Ni).
2. Deposit a machinable, sacrificial layer on the substrate.
3. Cut a grating pattern in the sacrificial layer with a single-crystal diamond edge. The grating is much deeper than the target dimension (e.g. >100 nm).
4. Blanket-etch the structure to transfer the pattern into the substrate. The substrate etches much slower than the sacrificial layer, resulting in a shallow (7-10 nm), high-fidelity grating pattern.