Multi-Diagnostic Transverse Profile Monitor Chamber for Extreme Ultraviolet Lithography

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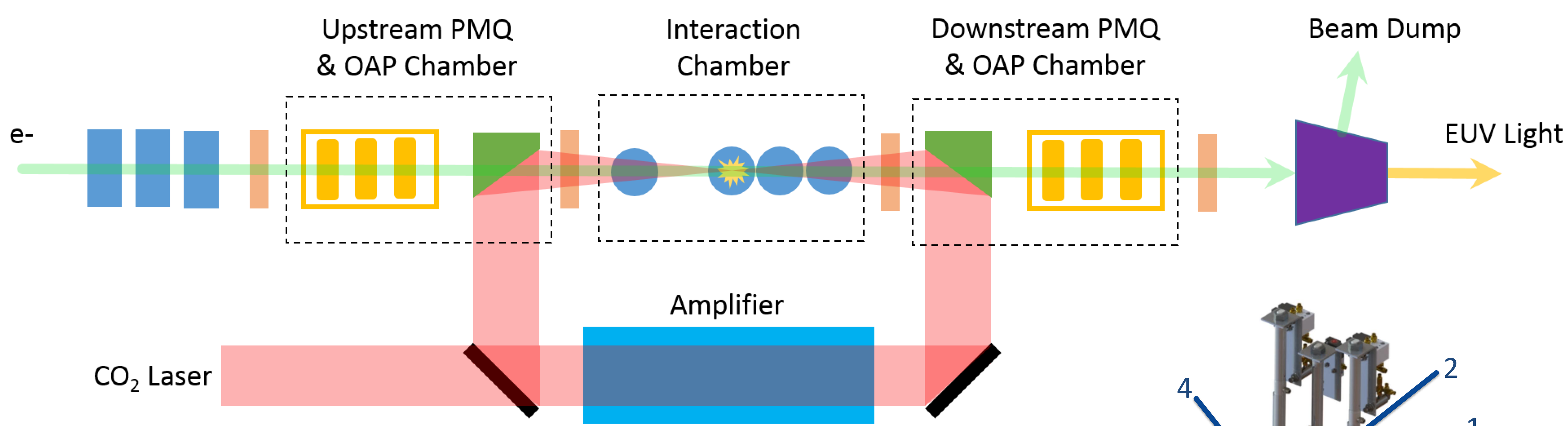
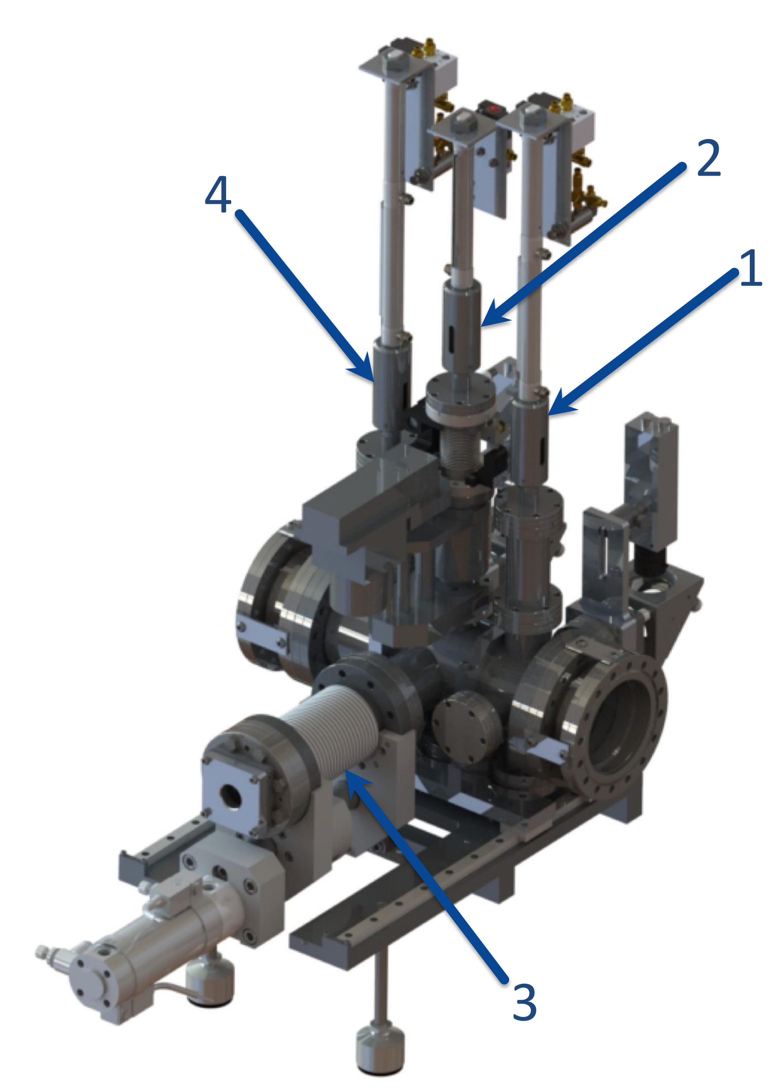
Abstract
RadiaBeam Technologies has developed a compact transverse beam profile measurement system for the Extreme Ultraviolet Lithography (EUL) experiment at the Brookhaven National Laboratory-Accelerator Test Facility (BNL-ATF). The EUL experiment requires fine e-beam and laser alignment across multiple passes. To accomplish this, the system consists of four profile monitor diagnostics: Interaction Point (IP), upstream, downstream, and a sub-micron resolution diagnostic 11.5 mm downstream of the IP. Care was taken in the design to minimize footprint, avoid possible diagnostic collisions, and maximize ease of assembly and alignment. This paper will review the requirements for the dimensional and optical constraints and solutions for this experiment.

Chamber
Four different beam diagnostics are needed to monitor a 50-μm RMS beam size at the IP. They need to fit between two opposing, off-axis parabolic mirrors arranged equidistant from the IP focus which are used to focus and re-collimate the laser. The required separation distance is 120 cm, which caused a particularly challenging limitation for fitting in so many diagnostics. The parabolic mirrors are placed inside larger chambers upstream and downstream of the multi-diagnostic assembly. These three chambers are kept separate for ease of installation and serviceability in the experimental hall.



Type	Distance from IP	Purpose
YAG & OTR Target	85.7 mm upstream	Measure transverse profile
Germanium Target & Pinholes	IP	CO_2 laser optics and e-beam positioning
High Resolution OTR Target	11.5 mm downstream	Sub-micron transverse profile measurement
YAG & OTR Target	85.7 mm downstream	Measure transverse profile



(1) YAG & OTR screen, (2) germanium & pinholes, (3) high-resolution OTR screen, and (4) YAG & OTR screen

Dual Position Profile Monitors
To monitor the transverse profile of the beam, both cerium-doped yttrium aluminum garnet (YAG:Ce) crystals and aluminum-coated silicon wafers are used as optical transition radiation (OTR) screens and are placed in the upstream and downstream profile monitors. Both the OTR and YAG screens are 100 μm thick and placed perpendicular to the electron beam on a multi-position pneumatic actuator. Each screen is backed by a 45° turning mirror (an aluminized silicon water) and viewed by CCD cameras through viewports, allowing for uniform magnification across the screen surface. These upstream and downstream profile monitors are mounted on pneumatic actuators to allow for high (25 μm) repeatability and fast extraction from the beam path.

Germanium Target
A 500-μm thick germanium OTR target is installed at the IP at a 45-degree angle to align the CO_2 laser. Below the germanium wafer, a pinhole array is mounted perpendicular to the beam for precise alignment.

Pinholes
The pinhole array is made of 1-mm thick tungsten and contains five pinholes of progressively decreasing diameter: 500 μm, 350 μm, 250 μm, 225 μm, and 200 μm. The laser and electron beam trajectory are passed through progressively smaller pinholes while transmission is monitored, allowing a straightforward method of alignment. The pinhole array is adjustable in three dimensions (insertion, horizontal, and tilt) so that the pinhole array can be aligned to the ideal orbit defined by the permanent magnet triplet.

High Resolution OTR Screen
The high-resolution profile monitor consists of an OTR target mounted at 45 degrees to the beam, a 10x magnifying in-vacuum microscope objective (NA = 0.25), a re-entrant style viewport, and out-of-vacuum imaging optics mounted inside the viewport tube. This profile monitor is used to view spot sizes in the range of 50-75 μm with a resolution of approximately 1 μm/pixel.

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