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Debris-free laser plasma sources for EUVL based on gas jets

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Pulsed nozzle jets have been studied for use as debris-free laser plasma source targets. Conversion efficiencies near 13 nm and mirror reflectance lifetimes will be presented.

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EUV sources for EUVL must not only be bright for throughput, they must also be debris-free to increase condenser longevity. Many schemes to achieve bright, clean sources for EUVL have been studied, including mass-limited targets[1,2], cryogenic targets[3-5], electric discharges[6], and electron-beam pumped vapor [7]. Several of these sources show promise, with varying degrees of brightness, debris reduction, and system complexity. We have studied pulsed gas jets, which we find to be relatively simple, debris-free sources when used under appropriate conditions. Under transverse, 1.06 μm irradiation of the jet (Fig. 1) at incident laser intensities in the range of 10^{11}-10^{12} Watts/cm^2, the conversion efficiency into 2π steradians is in the range of 0.3-0.4%, or approximately half the value exhibited by solid Au or W targets under similar conditions. Source sizes in the range of 350 μm x 400 μm can be achieved, as shown in Fig. 2, depending sensitively on both laser and gas jet parameters.

One issue that must be overcome in the use of gas jet targets is the requirement that the laser-irradiated plasma be located as far from the jet nozzle as possible to avoid debris generation while maintaining adequate EUV conversion. We will describe conditions under which these criteria are met. Measurements of the reflectance lifetimes of multilayer-coated mirrors placed near the plasma source under these conditions will also be presented. The potential for scaling such sources up to meet the requirements of a commercial EUVL system will be discussed.

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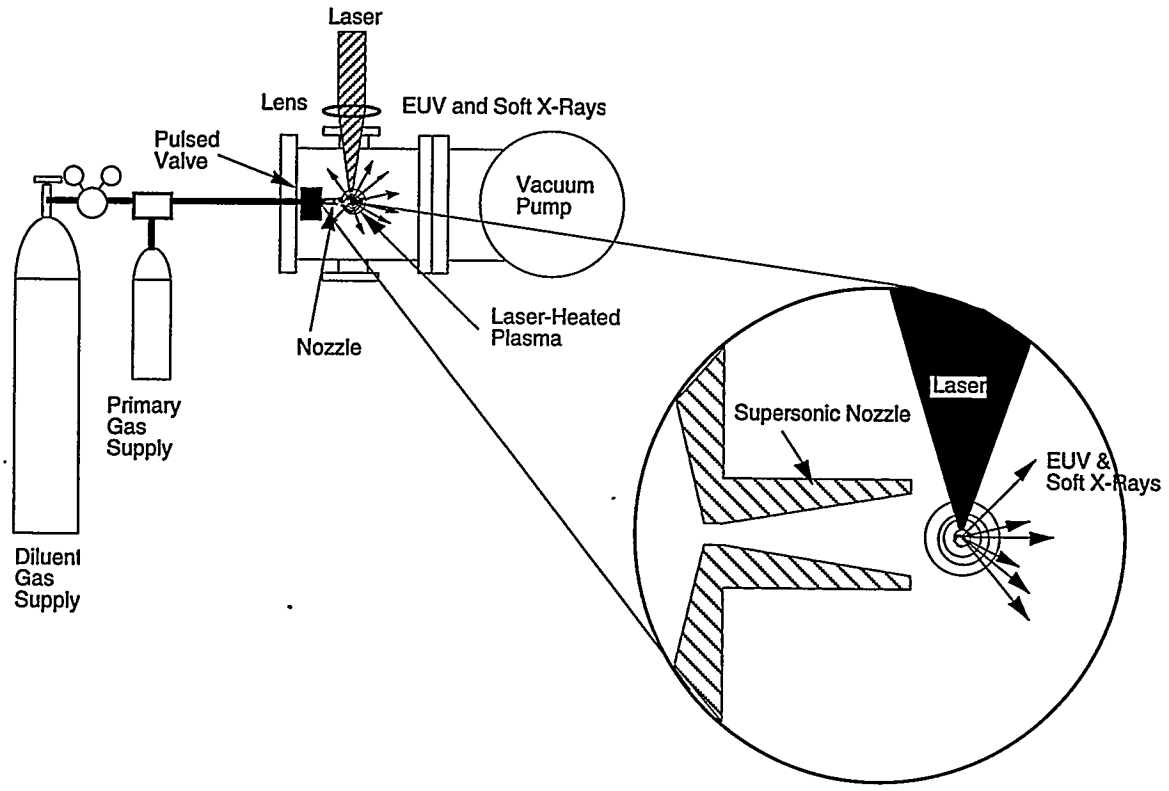

Figure 1. Schematic diagram of laser-produced plasma EUV source based on a pulsed nozzle jet target.

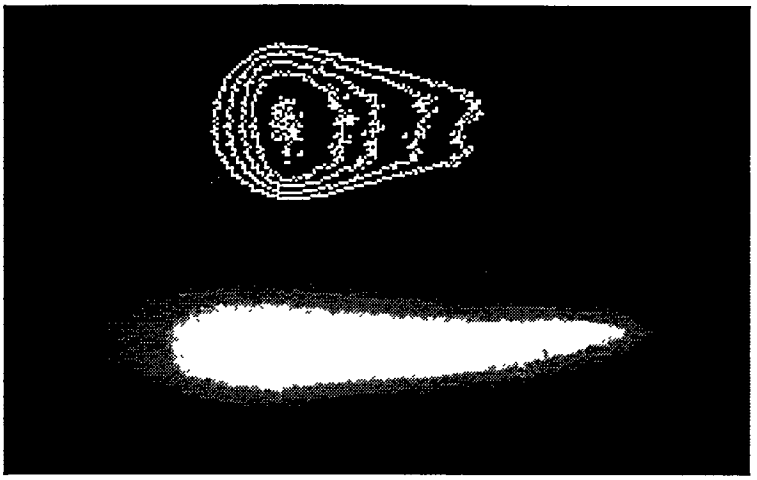

Figure 2. Iso-intensity contour plot of 70-108 eV emission produced from optimized jet source target (top). The dimensions of the half-power points are approximately 350 μm x 400 μm. Under non-optimized conditions, a larger emission volume results, as shown in the bottom image at the same scale.