Dual-Domain Scanning Illuminator for the Berkeley Micro Exposure Tool

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In this work we present and characterize recent upgrades to the existing Fourier-synthesis custom coherence Mirco Exposure Tool (MET) illuminator.[1] Current printing capabilities at the MET are often hampered by day-to-day variations in illumination uniformity. In practice, the intrinsic Gaussian intensity profile and coherence of the synchrotron radiation combined with daily up-stream mirror re-alignments lead to daily fluctuations in field illumination. These problems tend to limit the usable field, impeding experiments such as full-field mask studies, aberrations measurements, profile analysis, etc.

With the goal of increasing tool utility, performance, and reproducibility on a long-term time scale, we present a scanning fly's eye illuminator enabling consistent, robust, uniform illumination over the entire 3 mm × 1 mm object-side field of the MET. As depicted in Figures 1 and 2, a pair of diamond-turned cylindrical lenslet arrays (fly's eyes) is used to map small neighboring sections of the incoming illumination footprint to the same physical location (the surfaces of the Fourier-synthesis scanning mirrors) wherein the region of overlap is highly uniform in intensity. To further enable control over the illuminated field size, the overlap region is designed to fill a 1mm × 1mm subset of the field and the fly's eye lenses are mounted to programmable scanners similar to those used for coherence control.[1] We offset each cylindrical lenslet in the fly's eye lens by the illumination coherence length of approximately 500 nm to eliminate unwanted interference effects between overlapping beams emerging from different lenslets. The rough diamond-turned surfaces of the lenslets are rendered suitable for multilayer deposition with an in house smoothing technique.[2] In this configuration, the up-stream Kirkpatrick-Baez mirrors serve as field lenses mapping the footprints of all the beams emerging from different fly's eye lenslets to the same 1 mm × 1 mm location in the reticle, thereby maximizing tool efficiency. When combined with the Fourier-synthesis scanning mirrors, the tool possesses dual-domain control of the effective source size and spatial bandwidth.

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[1] P. Naulleau, "Fourier-synthesis custom-coherence illuminator for extreme ultraviolet microfield lithography," Appl. Opt. **43,** 820-825 (2003)
[2] F. Salmassi, P. Naulleau, E. Gullikson, "Spin-on-glass coatings for the generation of super-polished substrates for use in the extreme ultraviolet regime," Appl. Opt., **45**, 2404-2408 (2005)

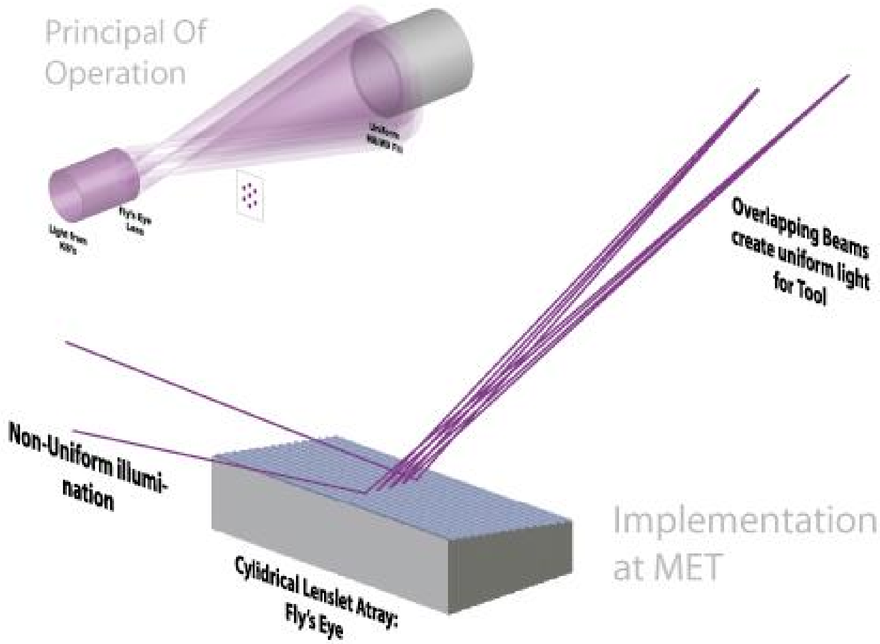

Figure 1: Schematic of conventional fly's eye lens in operation and a 1D ray trace schematic of our implementation scheme at the MET. Non-uniform light from upstream optics strikes one of two fly's eye lenses producing highly uniform illumination for tool.

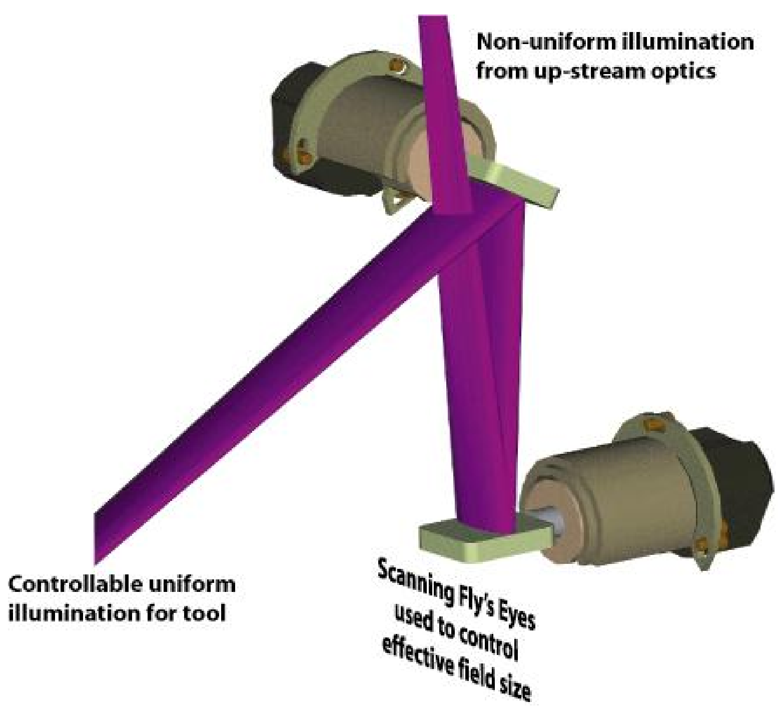

Figure 2: Schematic of scanning x and y fly's eye lenses used to provide controllable uniform illumination to the surfaces of the Fourier-synthesis scanning mirrors that control illumination coherence