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New technique for aberration diagnostics and alignment of an extreme ultraviolet Schwarzschild objective

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Schwarzschild objectives are widely used in the extreme ultraviolet (EUV)/soft X-ray spectral region both as reduction and magnification optics, e.g. for small-field projection lithography and microscopy, respectively. When using a Schwarzschild objective as a micro-exposure tool (MET) at high spatial resolution (half-pitch ≤ 0.1 μm), in addition to the tight requirements on the design and surface figure for the single optics, also an accurate alignment between the two mirrors is needed to reach the planned spatial imaging detail.
Ideally, at-wavelength alignment should be done in order to overcome limitations due to diffractive effects. While this can be easily performed on synchrotron beam lines, it could become time expensive (and components consuming) on low-power laboratory plasma sources.
In this work a new technique has been applied to align a EUV Schwarzschild objective with magnification M=1/10 and numerical aperture NA=0.23 by means of ultraviolet light. Quantifiable aberration amounts have been repeatedly induced by controlled misalignments (with 3 degrees of freedom), whose effects have been revealed by the Foucault technique and analysed with the help of numerical modelling, finally allowing the determination of the best alignment values by interpolation, going beyond the limits imposed by diffraction. The aligned objective allowed the attainment of lithographic patterning with edge response of 90 nm, as part of the laboratory-scale MET for EUV projection lithography realized at the ENEA Frascati Research Centre in the frame of a National Project [1].

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