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XFEL sub-10 nm focusing with 10^22 W/cm^2 intensity: wavefront corrected mirror and focus characterization

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We have developed a sub-10 nm focusing system to achieve an ultraintense X-ray laser field with 10^22 W/cm^2 intensity at SACLA. For the sub-10 nm focusing optics, an advanced KB (AKB) mirror system based on Wolter-type III geometry has been adopted. One of the remarkable challenges was the fabrication of steeply curved mirrors with radii of curvature of ~3 m with a shape accuracy of 1 nm. We applied an X-ray wavefront correction scheme using a single-grating interferometer and a differential deposition technique. The horizontal mirror pair was corrected twice and the vertical pair once, resulting in the wavefront error of λ/15 rms which satisfies Maréchal's criterion. The focus characterization was performed by single-grating interferometry and ptychography. Both methods consistently indicated a focusing spot size of 7 × 7 nm^2, while the 2nd-order aberration term, i.e. astigmatism, contained slight uncertainty. To accurately measure astigmatism, we employed speckle interferometry that directly measures the on-focus beam size. From the speckle measurements, remained 3 μm astigmatism was identified and corrected faithfully. Consequently, XFEL 7 nm focusing spot with 1.45 × 10^22 W/cm^2 intensity has been achieved.

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yes

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