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Laser-wakefield accelerators for high-resolution X-ray imaging of complex microstructures

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Laser-wakefield accelerators (LWFAs) are high acceleration-gradient plasma-based particle accelerators capable of producing ultra-relativistic electron beams. Within the strong focusing fields of the wakefield, accelerated electrons undergo betatron oscillations, emitting a bright pulse of X-rays with a micrometer-scale source size that may be used for imaging applications. Non-destructive X-ray phase contrast imaging and tomography of heterogeneous materials can provide insight into their processing, structure, and performance. To demonstrate the imaging capability of X-rays from an LWFA, we have examined an irregular eutectic in the aluminum-silicon (Al-Si) system. The lamellar spacing of the Al-Si eutectic microstructure is on the order of a few micrometers, thus requiring high spatial resolution. We present comparisons between the sharpness and spatial resolution in phase contrast images of this eutectic alloy obtained *via* X-ray phase contrast imaging at the Swiss Light Source (SLS) synchrotron and X-ray projection microscopy *via* an LWFA source. An upper bound on the resolving power of $2.7 \pm 0.3 \mu\text{m}$ of the LWFA source in this experiment was measured. These results indicate that betatron X-rays from LWFA can provide an alternative to conventional synchrotron sources for high resolution imaging of eutectics and, more broadly, complex microstructures.

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