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Additive manufacture 3D-printed, metallic X-ray mirror for synchrotron & XFEL facilities

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We have designed and fabricated the world's first, Additive Manufacture (AM) mirror for X-ray beamlines. For traditional optics, beamline performance is limited by: distortion caused by mechanical clamping; heat-bumps induced by photon-beam illumination; and strain caused by differential thermal expansion when dissimilar materials are cooled. AM enables the creation of intricate internal structures, and the fusion of multiple components into a single piece*. The optical substrate, beamline mount, and internal cooling manifold were combined into a monolithic structure. The X-ray mirror was 3D-printed in aluminium alloy AlSi10Mg. Single point diamond turning created an optical surface, which was coated in $\sim 75 \mu\text{m}$ of electroless NiP, followed by "super-polishing" using chemo-mechanical processing. Optical metrology demonstrates the AM mirror has surface quality comparable to a traditional silicon mirror, and is virtually immune to clamping deformations, which simplifies beamline installation. AM unlocks exotic internal channel designs, including enhanced cooling performance by turbulent flow, reducing vibrations caused by fluid flow, and conforming to the heat load distribution.

Footnotes

* "Additively manufactured mirrors for CubeSats", C. Atkins et al, Proc. of SPIE 11116, 1111616 (2019)
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