Additive Manufacturing of Tungsten for Plasma-Facing Component Application

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The refractory metal tungsten (W) is regarded as preferred plasma-facing material (PFM) for future magnetic confinement thermonuclear fusion devices. The reasons behind this choice are mainly that W exhibits a high threshold energy for sputtering by hydrogen isotopes as well as a low retention of tritium within the material. However, W is an intrinsically brittle metal with high hardness which means that the processing and machining of W is difficult and expensive. Furthermore, this also implies that very simple geometries, e.g. flat tiles or simple monoblocks, are typically used for W parts in plasma-facing components (PFCs).
Against these limitations, additive manufacturing (AM) technologies could be a highly versatile and innovative approach for the realisation of W elements for PFC applications. The characteristic feature of AM processes is that three-dimensional objects are created by sequential layerwise deposition of material under computer control which means that such a technology is capable of producing objects with more or less arbitrary shape.
Within previous work [1], it was found that bulk pure W can be consolidated by means of direct laser beam melting (LBM) with a comparably high relative mass density of more than 98%. However, it was also found during these investigations that pronounced crack formation can occur within the material as selective LBM processes typically induce high thermal gradients during bulk material manufacturing.
In this context, the present contribution will summarise topical results regarding the AM of pure W by means of powder bed based LBM for material manufactured by using preheated W substrates with temperatures of up to 1000°C. These elevated substrate temperatures are intended in order to maintain the ductility of the material during the LBM process to in turn minimise the formation of crack defects.
Furthermore, it will be discussed how the versatility of AM for producing tailored W structures can be exploited for PFC design in order to realise a high-integrity PFC with high heat removal capability and results regarding the manufacturing of a corresponding PFC mock-up will be presented.

[1] A. v. Müller et al., *Microstructural investigations of tungsten manufactured by means of laser beam melting*, Proceedings of the 6th International Conference on Additive Technologies iCAT2016, ISBN 978-961-285-537-6