CASE STUDY

PRINTED TUNGSTEN PARTS FOR APPLICATIONS IN VACUUM

Removing and cleaning 3D-printed tungsten parts

Due to the difficulties encountered in processing **tungsten,** this metal is only in limited use at present. 3D printing does away with the old limitations and opens up completely **new potential applications** for this **extremely durable metal**. The example of X-ray tubes is an impressive indication of the benefits to be gained from the material properties and the **new design options.**

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Tungsten belongs to the refractory metals group and is characterized by extreme heat resistance, among other things. The melting point is above 3400° C, far beyond the range of use of steel or iron alloys. This makes it the ideal material for use in extreme temperatures, for example for protecting sensitive components from heat. Such high temperatures of up to 2300° C, for example, arise in the hot cathodes of X-ray tubes, where the electron beam that generates the X-rays is produced. Another area of application for tungsten, that has a lot of potential, is radiation protection. When X-rays are generated, undesirable scatter radiation is always produced at the same time, which needs to be shielded by means of very heavy lead sheathing. Tungsten parts near the focal spot would eliminate the scatter radiation locally, enabling significant savings in terms of material and weight.

Potential printed tungsten parts in X-ray tubes

Components in X-ray tubes are generally very delicate, making their production very complicated and hence very expensive. Therefore, in the past, the choice of material and design of tube components has been restricted by the limited manufacturing capabilities.

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Functional aspects (such as high functional integration) or economic issues (material conservation, reuse) often took a back seat when it came to designing parts. 3D metal printing provides a unique opportunity to solve these problems as illustrated by various delicate parts and complex designs, which have been successfully implemented already.

Special cleaning process for use in vacuum
In order to reliably produce X-rays by means of high-voltage and the resulting emission of electrons, a high vacuum must be generated in the tubes. This prevents electrons from being deflected by contaminants, such as residual gas molecules. The vacuum also facilitates the control input protection of the X-ray tubes. Hence, all components in the vacuum must be particularly clean in order to eliminate any contamination. This is especially important for components that reach a very high temperature during operation. Thus, outgassing should always take place at temperatures above operating temperature. If this does not happen, the parts would lose their residual molecules during operation and contaminate the vacuum. This can lead to electrical flashover so that, in the worst cases, the expensive tubes have to be replaced prematurely.

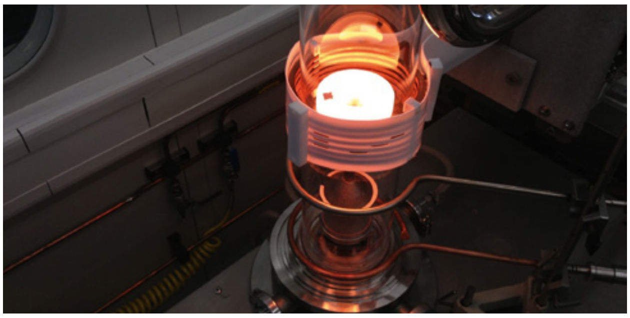
In addition, the residual gas can also contaminate the emitter such that fewer electrons are released. This results in a lower X-ray dose and a shorter service life.

Bringing all processes together: 3D printing and cleaning
First, the tungsten parts are produced using the so-called DMLS additive process method (Direct Metal Laser Sintering) based on a CAD design. This requires special 3D printing technology developed for tungsten, as well as many years of experience in order to precisely control and reproduce the process. Dunlee offers both with decades of experience in the development and production of tungsten parts using the 3D printing process. Customers now benefit from completely new design options for their tungsten components. Ducts, small parts and similar features are produced in a single batch and no longer have to be laboriously retrofitted and milled.

The components are then cleaned in the process specially developed by Dunlee, so that they can be used in a vacuum. This multi-stage cleaning process guarantees clean parts suitable for high-vacuum and high-voltage applications.

X-ray tube part with integrated functions

Measurement results are used to prove vacuum compatibility
In the final step, the behavior of the printed and cleaned components under a vacuum is analyzed with a mass spectrometer. In this procedure, the composition of the residual gas is measured to ensure that undesirable impurities remain below a maximum level or are completely eliminated. Suitability for usage under high-voltage was proven by means of experiments in X-ray tubes. In summary, the tests and experiments provide convincing proof that printed tungsten parts can be used in a vacuum.



Testing tungsten parts in real operating conditions

Printed tungsten parts save money and improve performance
This example of printed tungsten parts impressively shows the advantages that result from the additive manufacturing process of this metal:

- New designs and functional integration reduce manufacturing costs and improve functionality
- Printed tungsten parts can be used in a vacuum and under high-voltage and can improve performance and prolong service life through very good heat resistance
- Tungsten can stop radiation directly at the source and reduce the need for heavy lead sheathing
- At the end of a tube's lifetime, tungsten parts can be easily cleaned and reused

These advantages are also easy to transfer to other applications.

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