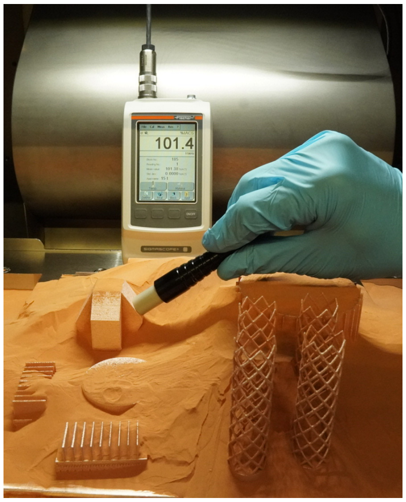
APPLICATION INSIGHT

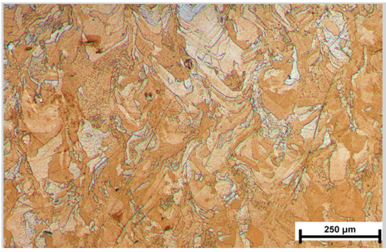
Oxygen-controlled copper printing on 3D Systems DMP platforms

For electrical applications and heat exchangers, the conductivity is the key property for choosing copper. Oxygen in the Cu matrix has a detrimental effect on the electrical and thermal conductivity of copper. Maintaining the purity of the copper powder during printing is therefore of critical importance. This is extremely challenging, given the high surface area-to-volume area for the fine powder used in L-PBF, as well as the higher temperatures in the powder bed to which the powder is exposed during the L-PBF process. Contrary to alternative LPBF systems that rely on purging with an inert gas, the 3D Systems DMP system architecture is better equipped to meet this challenge.

The robust platform architecture of the DMP Flex and Factory 350 allows for a vacuum pre-cycle prior to the printing job which actively removes air and moisture from the build chamber and the powder. After this cycle the chamber is filled with high-purity argon gas. This highly efficient and effective vacuum pre-cycle helps achieve an extremely low oxygen environment (around 5 ppm). Furthermore, the vacuum chamber's leak-tight design ensures that no oxygen can leak into the build chamber and results in exceptionally low argon consumption during printing. This vacuum chamber concept helps to eliminate the risks for oxygen pick up by the powder feedstock, resulting in stable powder chemistry and a significant enhancement of the Certified Oxygen-Free Copper powder batch reusability.

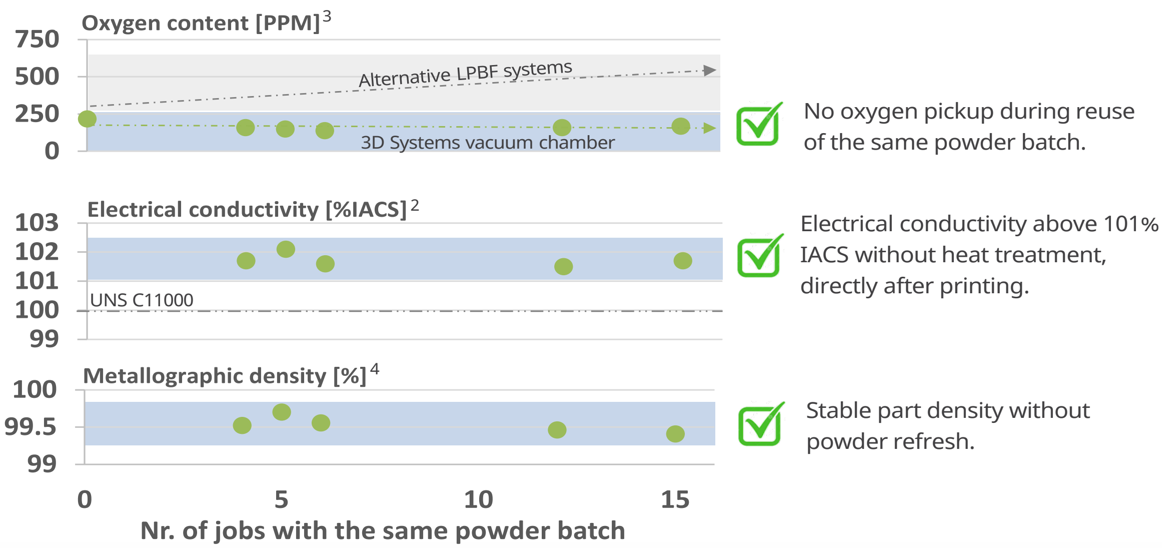


Electrical conductivity measurement after printing using the Electromagnetic (Eddy Current) method.



3D SYSTEMS CERTIFIED OXYGEN-FREE COPPER

3DSystems additively manufactured pure copper adheres to C11000. Monitoring studies on the DMP Flex 350, 1kW and the DMP Factory 350, 1kW show the Oxygen content in the solid material stays stable (typically below 250ppm) job after job[1] when reusing the same powder batch. The electrical conductivity typically exceeds 101% IACS[2] without heat treatment, directly after printing.

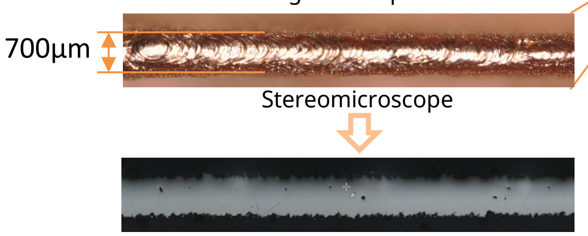


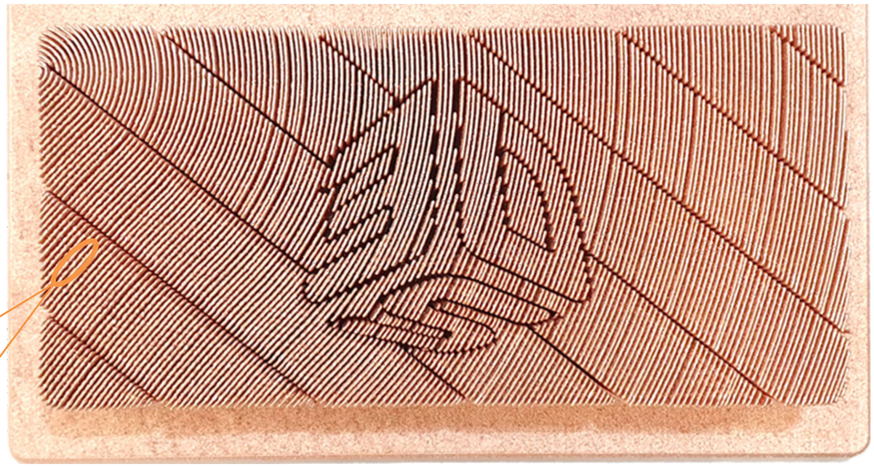
1. Tests conducted on tracking samples that were printed together with various customer application jobs, printed with the same powder batch.
2. Measured on a polished 90° surface using the electromagnetic method according to ASTM E1004-17.
3. Measured on powder (job 0) and printed parts using Fusion Analysis according to ASTM E1019.
4. Relative, based on pixel count.

Application Focus: Heat Exchanger Fins

Replace Traditional Skiving by Additive and leverage the Design Freedom of Additive manufacturing to create fins for cooling applications with any bend.

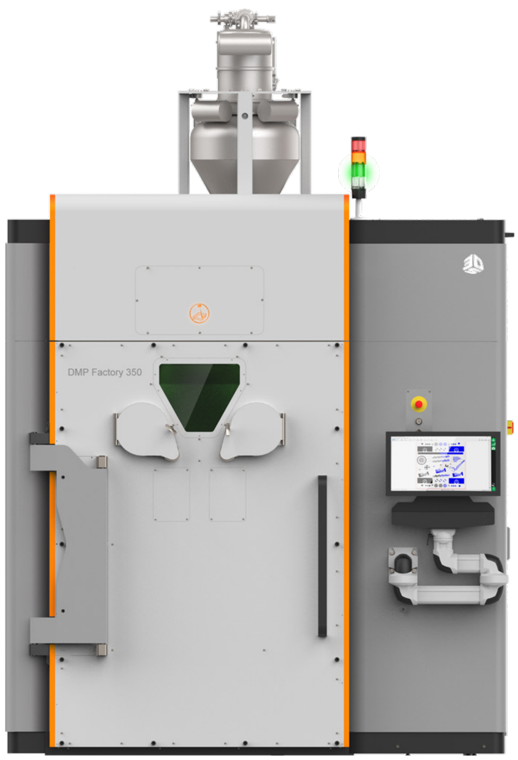
The thickness of the fins can go down to 700µm and the spacing to 400µm. Hybrid printing on a Solid Substrate is possible but the solid substrate can be printed directly as well.





Part: Heat exchanger
Bounding box: 420x200x100 mm
Layer Thickness: 40 µm
Print time: 27h

DMP FLEX 350, 1KW DMP FACTORY 350, 1KW LT 40	TEST METHOD	AS BUILT TYPICAL VALUES[5]	
		METRIC	U.S.
Density - Relative, based on pixel count [%]	Optical	99.4	
Ultimate tensile strength [MPa | ksi] Horizontal direction - XY Vertical direction - Z	ASTM E8	 155 150	 22.4 21.7
Yield Strength Rp0.2% [MPa | ksi] Horizontal direction - XY Vertical direction - Z	ASTM E8	 225 210	 32.6 30.4
Plastic elongation [%] Horizontal direction - XY Vertical direction - Z	ASTM E8	 44 60	
Electrical conductivity [%IACS][6]	ASTM E1004-17	101	
Surface roughness Ra [µm | µin][7,8] Top surface - 0° Up facing - 45° Vertical side surface - 90° Down facing - 45°	ISO 21920-2	 17 11 14 43	 665 430 550 1690



The robust platform architecture of the DMP Flex 350, 1kW and DMP Factory 350, 1kW allows for a vacuum pre-cycle that helps achieve an extremely low oxygen environment

5. Average value based on limited number of test samples (<15). Values might vary based on build location and part shape.
6. Measured on a polished 90° surface using the electromagnetic method according to ASTM E1004-17.
7. Measured before sandblasting using Fringe Projection with Keyence microscope . The extraction of line profile data and calculation of line roughness parameters is according to ISO 21920-2.
8. Values based on a limited sample population from test coupons, may deviate depending on specific part geometry.