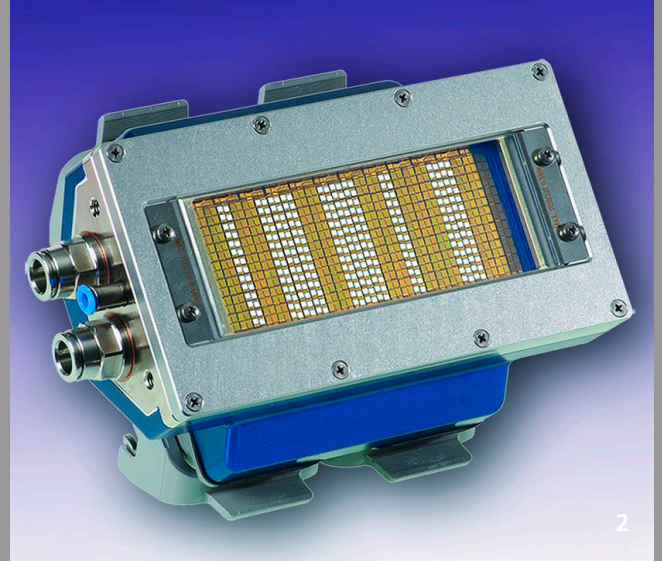


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VCSEL PREHEATING FOR LASER POWDER BED FUSION

Task

A preheating system is commonly used in laser powder bed fusion (LPBF) to process crack-susceptible materials and reduce component distortion. Preheating reduces thermal gradients and, thus, internal stresses. Conventional preheating systems heat the substrate, but are insufficient due to the layered process inherent in LPBF: the distance between substrate and working plane increases in the course of the process, whereby the temperature decreases in the working plane. To compensate for this, the substrate temperature is increased. However, the melting temperature of the substrate must not be exceeded, so that in the final analysis the build height is limited.

As part of the Digital Photonic Production DPP research campus, Fraunhofer ILT and the Chair for Technology of Optical Systems TOS at RWTH Aachen University and Philips Photonics GmbH are investigating the use of vertical-cavity surface-emitting lasers (VCSELs) for direct pre-heating of the working plane.

Method

The core of the 808 nm wavelength VCSEL module used is made of six single emitters consisting of thousands of synchronized micro diode lasers. The laser power per emitter can be adjusted in two zones for each. These individually

controllable emitters have 400 W and enable an adapted energy distribution in the working plane. The module was installed in an LPBF laboratory system with inductive preheating system. An infrared camera was used to measure the temperature of the working plane. With this setup, samples were made for density and distortion measurement.

Results

At 500 °C substrate plate temperature, the difference between the substrate plate and the component surface of Inconel 718 ($\Delta T_{BT, SP} = 100$ °C, height 10 mm) samples can be compensated for within 20 seconds by switching on the VCSEL. Specimens made of IN718, which were preheated with the VCSEL module to $T = 500$ °C, achieve a density of > 99.95 percent and have a distortion of up to 2 mm less compared to room temperature processing.

Applications

With a preheating system based on VCSEL technology, it is possible to maintain consistent temperatures in the working plane regardless of the height. In addition to a significant reduction in distortion, this system can also be used to process materials difficult to additively manufacture such as TiAl with LPBF.

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1 Exposure at local preheating using VCSEL.

2 VCSEL module, source: Philips Photonics GmbH.