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Additive machines discover superalloys

Fraunhofer lighthouse project "futureAM" expected to speed up "additive manufacturing" by a factor ten

(Dresden, May 17, 2019) Scientists at the Fraunhofer Institute for Material and Beam Technology IWS in Dresden have developed innovative methods enabling more materials to be processed in additive manufacturing than ever before. For example, additive manufacturing systems could facilitate better future aircraft engines with lower fuel consumption. However, engineers must first improve the current industrial 3D printers in such a way that these machines can also process very strong and extremely heat-resistant alloys. Here, the Dresden researchers rely on their profound experience with laser powder buildup welding technologies and employ artificial intelligence (AI). They contribute their profound materials expertise to the Fraunhofer joint project "futureAM". The aim of the partners is to speed up additive manufacturing systems for metal components by a factor ten and also to manage superalloys.

Fraunhofer IWS engineers have refined laser powder buildup welding over decades in order to allow more materials to be applied in additive manufacturing. In this procedure, a system feeds various filler powders into a process zone. There, a laser melts the powder and deposits it on a workpiece surface. As a result, the desired part is generated in a layer by layer process. "One of the advantages of this additive procedure is that we can adapt the process very flexibly to the requirements of high-performance materials," explains Fraunhofer IWS project administrator Michael Müller. In this way it is also possible, for example, to print nickel-based alloys that are difficult to weld and process using traditional methods. However, this only works if the temperature, powders, feed rate and other parameters are correct. "We have to adjust all the set screws precisely," explains Michael Müller. "This is the only way we can find the right recipe." Within the framework of the Fraunhofer lighthouse project "futureAM - Next Generation Additive Manufacturing", IWS engineers are recording numerous sensor data with very high sampling rates for this purpose. However, this generates large amounts of data ("big data") that are difficult for people to understand.

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AI learns to decide

Nevertheless, Fraunhofer experts use advanced methods of "artificial intelligence" (AI) and "machine learning", which are also researched under the catchword "Big Data" in a working group led by Prof. Karol Kozak, Head of Image Processing and Data Management at Fraunhofer IWS, to find hidden connections in these signal floods. For example, special analysis algorithms link the measured sensor values with the institute's powder database and evaluate further process parameters. Gradually, the machines learn to make their own decisions. For example, they can determine for themselves whether a slight rise in temperature in the welding process can be tolerated or whether they have to take immediate countermeasures before the entire component ends up as waste. "Industry is looking for ever more and ever different materials which are, however, often difficult to process," emphasizes Prof. Frank Brückner, Business Unit Manager Generation and Printing at Fraunhofer IWS.

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Better aircraft engines in sight

The aircraft engines mentioned above are examples illustrating precisely this prospect: they could work more efficiently and at higher temperatures if most materials were not already failing at temperatures of around 1200 degrees. Admittedly, there are materials that can withstand such high temperatures, but they are very cost-intensive and difficult to process using traditional methods. Additive manufacturing is intended to solve this dilemma. Moreover, it could help to achieve a more cost-effective design: "Using laser powder buildup welding, we can feed different powders into the process zone simultaneously or successively with precisely adjustable feed rates," explains Michael Müller. Designing an entire component out of a singular material is not very effective since the component is not exposed to the same heat at all points. "Preferably, the expensive, highly resistant material should only be used where it gets really hot," says Michael Müller. "In other areas, a less expensive material will be sufficient." This is precisely what can be achieved with additive manufacturing systems – once they have learned to process the required superalloy. "The next step is to combine various high-performance materials within a single component," announces project administrator Müller. In the "futureAM" joint project, the IWS and five other Fraunhofer Institutes are pooling this technology and further expertise to push additive manufacturing to a new level. By summer 2020, they want to integrate all their expertise into the additive manufacturing process chain and demonstrate it on realistic components.

The **Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS Dresden** stands for innovations in laser and surface technology. As an institute of the Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., IWS offers one stop solutions ranging from the development of new processes to implementation into production up to application-oriented support. The fields of systems technology and process simulation complement the core competencies. The business fields of Fraunhofer IWS include PVD and nanotechnology, chemical surface technology, thermal surface technology, generation and printing, joining, laser ablation and separation as well as microtechnology. The competence field of material characterization and testing supports the research activities.

At Westsächsische Hochschule Zwickau, IWS runs the Fraunhofer Application Center for Optical Metrology and Surface Technologies AZOM. The Fraunhofer project group at the Dortmunder OberflächenCentrum DOC® is also integrated into the Dresden Institute. The main cooperation partners in the USA include the Center for Coatings and Diamond Technologies (CCD) at Michigan State University in East Lansing and the Center for Laser Applications (CLA) in Plymouth, Michigan. Fraunhofer IWS employs around 450 people at its headquarters in Dresden.

Background information: This is "Additive manufacturing"

Additive manufacturing (AM) is regarded as a key technology for "Industrie 4.0". It is designed to combine the advantages of mass production and manufacturing and even to generate individual parts ("batch size 1") economically on an industrial scale. AM machines can also freely create highly complex components that cannot be produced using conventional milling and turning machines. These machines use principles similar to those used by 3D printers in the creative and DIY scene: The desired component is designed on the computer; subsequently this model is fed into the system, whereupon a heating module or laser heats a plastic. From this material melt, the system generates the designed part layer by layer. Compared to 3D printers for private use, AM systems are far more efficient. They can, for example, process metals and ceramics as well as plastics, usually use laser technology and work with extreme precision and more complex CAD models.

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"futureAM" takes additive manufacturing to a new level

In November 2017, the Fraunhofer lighthouse project futureAM was launched with the aim of accelerating additive manufacturing of metal components by at least a factor of ten. The focus is on a holistic view of digital and physical added value from incoming order to the finished metal 3D printing component. The central goal is a leap into a new technology generation of additive manufacturing. Five other Fraunhofer institutes are participating in this project under the leadership of the Fraunhofer ILT: IWS, IWU, IAPT, IGD and IFAM.

Visit us at the exhibitions "[LASER World of PHOTONICS](#)" in hall A2, booth 431, and "[RAPID.TECH + FABCON 3.D](#)" at AGENT-3D booth 2-435.

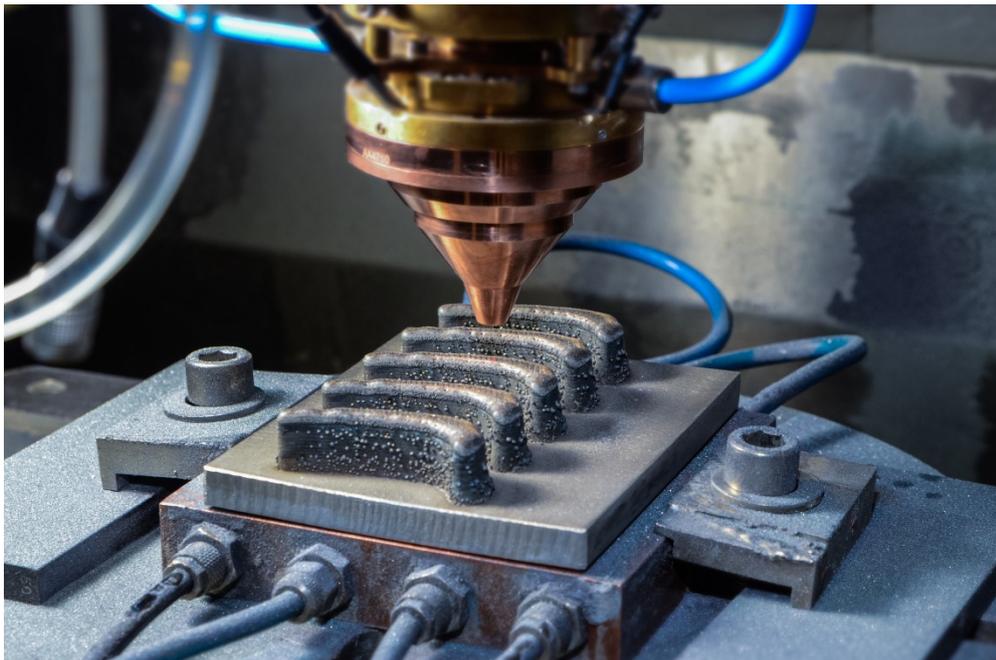
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By means of laser powder build-up welding, components made of different materials can be integrally manufactured. Thus, specific materials can be placed exactly where their properties are required. This offers, for example, the prospect of lighter, better and cost-reduced blades for gas turbines.

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Additively manufactured superalloy blades show a tailor-made graded material transition from a nickel-based to a cobalt-based superalloy in order to better meet the requirements of industrial applications.

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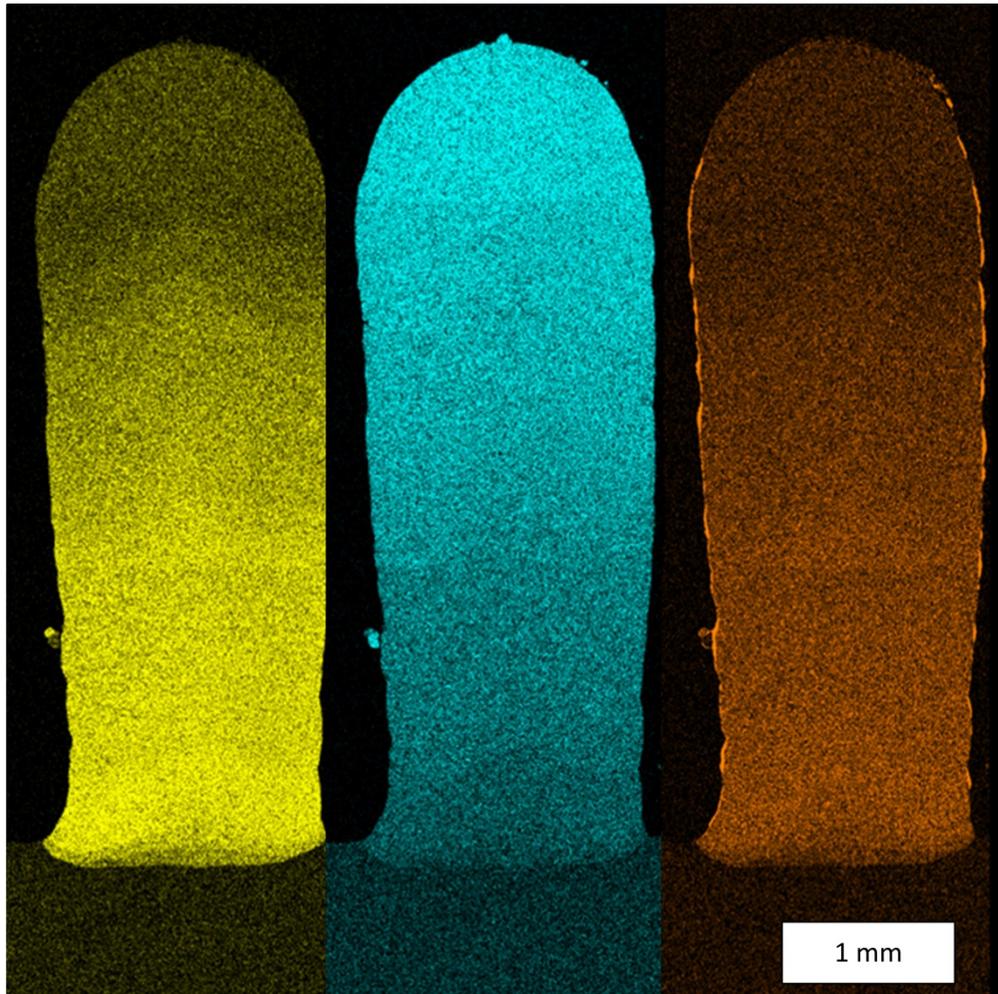
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Fraunhofer IWS Dresden has developed a process and material database which stores all details of the manufactured components. This database allows complex conclusions between the welding result and already obtained data.

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EDX-Mapping: The chemical analysis of a test geometry proves the material transition. The colors illustrate the continuous transition from the cobalt-based alloy Merl72 to the nickel-based superalloy IN 718 (yellow: cobalt, blue: nickel, orange: aluminum).

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