Proposed sensing technology could assess quality of components in fields such as aerospace

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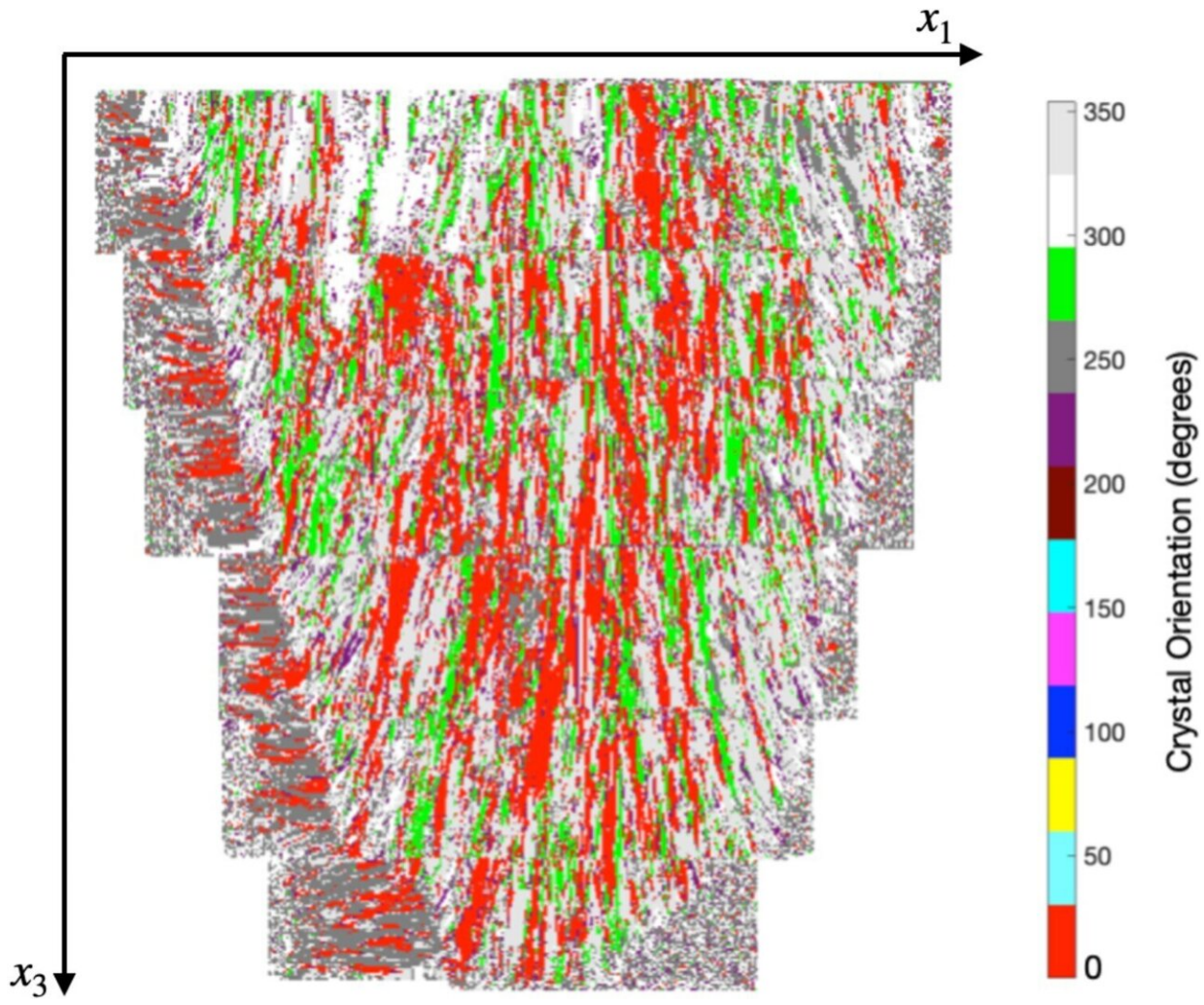

Fanned grain structure of a heterogeneous weld structure. Credit: *Waves in Random and Complex Media* (2024). DOI: 10.1080/17455030.2024.2341283

A sensing technology that can assess the quality of components could transform U.K. industry.

In the study, published in the journal *Waves in Random and Complex Media*, researchers from the University of Bristol have derived a formula that can inform the design boundaries for a given component's geometry and material microstructure.

A commercially viable sensing technology and associated imaging algorithm to assess the quality of such components currently does not exist. If the additive manufacturing (3D printing) of metallic components could satisfy the safety and quality standards in industries there could be significant commercial advantages in the manufacturing sector.

The key breakthrough is the use of ultrasonic array sensors, which are essentially the same as those used in medical imaging in, for example, creating images of babies in the womb. However, these new laser based versions would not require the sensor to be in contact with the material.

Author Professor Anthony Mulholland, head of the School of Engineering Math and Technology, explained, "There is a potential sensing method using a laser based ultrasonic array and we are using mathematical modeling to inform the design of the this equipment ahead of its in situ deployment."

The team built a mathematical model that incorporated the physics of ultrasonic waves propagating through a layered (as additively manufactured) metallic material, which took into account the variability one gets between each manufactured component.

The mathematical formula is made up of the design parameters associated with the ultrasonic laser and the nature of the particular material. The output is a measure of how much information will be produced by the sensor to enable the mechanical integrity of the component to be assessed. The input parameters can then be varied to maximize this information content.

It is hoped their discovery will accelerate the design and deployment of this proposed solution to this manufacturing opportunity.

Professor Mullholland added, "We can then work with our industry partners to produce a means of assessing the mechanical integrity of these safety critical components at the manufacturing stage.

"This could then lead to radically new designs (by taking full advantage of 3D printing), quicker and more cost effective production processes, and significant commercial and economic advantage to U.K. manufacturing."

Now the team plan to use the findings to help their experimental collaborators who are designing and building the laser based ultrasonic arrays.

These sensors will then be deployed in situ by robotic arms in a controlled additive manufacturing environment. They will maximize the information content in the data produced by the sensor and create bespoke imaging algorithms to generate tomographic images of the interior of components supplied by their industry partners. Destructive means will then be employed to assess the quality of the tomographic images produced.

Professor Mullholland concluded, "Opening up 3D printing in the manufacture of safety critical components, such as those found in the

aerospace industry, would provide significant commercial advantage to U.K. industry.

"The lack of a means of assessing the mechanical integrity of such components is the major blockage in taking this exciting opportunity forward. This study has built a mathematical model that simulates the use of a new laser based sensor, that could provide the solution to this problem, and this study will accelerate the sensor's design and deployment."

More information: Alistair S. Ferguson et al, A probabilistic approach to modelling ultrasonic shear wave propagation in locally anisotropic heterogeneous media, *Waves in Random and Complex Media* (2024). DOI: 10.1080/17455030.2024.2341283

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