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On the Determination of Residual Stresses in AM Lattice Structures

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The determination of residual stresses becomes more complicated with increasing complexity of the structures investigated. Unlike most of the fabrication techniques, laser powder bed fusion allows the production of lattice structures without any additional manufacturing step. These lattice structures consist of thin struts and are thus susceptible to internal stress-induced deformation. In the best case, internal stresses remain in the structures as residual stress. The determination of the residual stress in lattice structures through non-destructive neutron diffraction is described in this work. In the case of lattice structures, we show how to overcome two formidable difficulties: a) the proper alignment of the filigree structures within the neutron beam; b) the proper determination of the RS field in a representative part of the structure. The magnitude and the direction of residual stress are discussed. The residual stress in the strut was found to be uniaxial and to follow the orientation of the strut, while the residual stress in the knots is more hydrostatic. We show that strain measurements in at least seven independent directions are necessary for the estimation of the principal stress directions. The measurement directions should be chosen according to sample geometry and an informed choice on the possible strain field. Indeed, we finally show that if the most prominent direction is not measured, the error in the calculated stress magnitude increases considerably.

Primary author: Dr FRITSCH, Tobias (Bundesanstalt für Materialforschung und -prüfung)

Co-authors: SPRENGEL, Maximilian (Bundesanstalt für Materialforschung und -prüfung); EVANS, Alexander (BAM); Mrs FARAHBOD-STERNAHL, Lena (Siemens AG); Mr SALIWAN-NEUMANN, Romeo (Bundesanstalt für Materialforschung und -prüfung); HOFMANN, Michael; Prof. BRUNO, Giovanni (BAM)

Presenter: Dr FRITSCH, Tobias (Bundesanstalt für Materialforschung und -prüfung)

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