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J.R. Jinschek[1,2], S. Vijayan[2], C. Fink[2] , Y.C. Yang[1], C. König[1], A. Bastos da Silva Fanta[1], E. Kabliman[3], P. Mayr[3]
[1]*Technical University of Denmark, DTU Nanolab, Kgs Lyngby, 2800, Denmark;*
[2]*The Ohio State University, MSE, Columbus, OH, 43221, USA;*
[3]*Technical University of Munich, Chair of Materials Engineering of Additive Manufacturing, Garching, 85748, Germany;*
e: jojin@dtu.dk

The abstract should be less than 200 words,

Metal additive manufacturing (AM) is a promising approach to manufacture components with complex geometries. However, materials are processed under conditions far-from-equilibrium. The physical metallurgy of AM processes has yet to be unraveled. Inherent rapid heat cycles and extreme gradients result in strong anisotropy in microstructure including formation of unexpected or metastable phases. Relationships between (post)process parameters, site/design-specific microstructure and properties are still hard to predict.
To capture and identify significant trends on all length scales, new approaches in material characterization are required. Electron microscopy (EM) needs to be optimized in terms of feature contrast, automated feature detection, high(er) throughput. Extracting statistically relevant information on property-defining features, such as grain boundaries (GB), formed on a micrometer scale, is essential. Examining EBM-Ti64, high throughput SEM imaging indicated strong differences on microstructure when varying EBM beam scan strategies, EBSD results confirmed an unexpected distribution of GB (mis)orientations. Vickers hardness measurements confirmed a corresponding variation in microhardness.
To better understand the impact of complex spatial-temporal thermal transients in AM (post)processing, we currently develop in-situ EM approaches. Supported by COMSOL Multiphysics simulations, we mimic AM-specific far-from-equilibrium thermal conditions in *in-situ* EM heating studies. Such a (pre)process simulation will be essential for optimizing AM (post-)processes.