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Abstracts Book

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Multiscale modeling of rapid solidification phenomena in laser sintering of ultrafine composite powders

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Laser sintering of powder materials is a new promising technique suitable for production of a wide range of wear-resistant and corrosion-proof materials. Multiscale modeling of this process at the macro- and meso-scales was accomplished to get a closer agreement with experimental regimes. Mesoscopic modeling of solute segregation during re-solidification of powder particles was performed using the phase field method while macroscopic simulation of transient heat transfer was done by the extended mushy zone method.

According to the results of modeling, the final microstructure of powder particles strongly depends on the processing conditions. Under continuously operating laser significant powder compaction occurs coupled with enhanced solute redistribution driven by convection in the melted zone. Impulse laser treatment allows achieving partial melting of the powder leaving the porous structure of the layer.

Phase field modeling showed the effect of solute trapping in high-speed scanning laser sintering. This happens due to high solidification velocities up to 1-5 m/s in the skin shells of the particles, fig. 1. Combined with the large temperature gradient (with values up to 10^6 K/m), absolute stability of the solidification front is realized leading to chemically homogeneous composition upon re-solidification of powder particles.

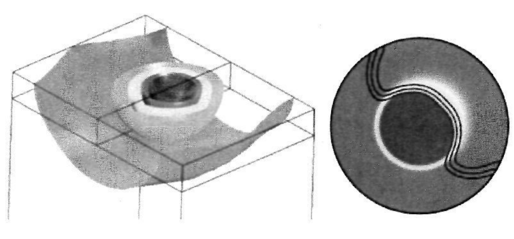

Fig. 1: (left) Isotherms in the powder layer show large temperature gradients up to 10^6 K/m in vicinity of the laser beam. (right) Melting of a composite Fe-Ni particle under laser annealing. Colors represents chemical composition of Ni, black lines give isolines of the phase variable ϕ = 0.1, 0.5 and 0.9.

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