Laser metallurgy. A study on the Microstructure of Laser Processed Materials

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Summary

One of the possibilities to apply a coating is by using a laser. A high intensity laser beam is scanned across a surface of a metal with a high velocity producing a melt bath under the beam. After passage of the beam the heat is rapidly conducted away into the substrate and the surface solidifies with a rate of 10^4-10^6 K/s. By applying before the treatment on the surface a thin layer of powder of an alloying element or a ceramic material, it can be alloyed or molten in the substrate material. This results often in an enhancement of hardness or wear resistance.

The subject of this thesis concerns the analysis of the material produced by this method and the relation between microstructure, hardness and laser treatment.

Specific attention is paid to melting and alloying of material into the surface of the substrate and it was found that both take up and mixing of the material is mainly determined by the gradient of the surface tension in the melt bath. For Al-Si alloys the solidification structures were studied and compared with structures expected theoretically. For the eutectic composition at higher laser scan velocities dendrites were observed while for the hyper-eutectic Al 20% Si alloys eutectic structures were found, which may be explained by the high solidification velocity and temperature gradient. Also tempering effects of overlapping laser tracks were studied in a few iron alloys, which revealed that temperature and time are large enough for carbides in martensite to nucleate and grow.

Hardness, residual stresses, cracks and dislocation density due to the laser treatment were studied. The hardness could be explained by using a model for a pile up of dislocations in laser treated materials with a fine dendritic structure.