Wear behaviour of laser melted an ion implanted materials.

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Summary

The emphasis in this thesis is on the development of wear resistant materials by laser melting. Furthermore, the principle aim is to search for the dislocation characteristics common to the wear process in heterogeneous materials.

Problems encountered in laser processing are the introduction of large tensile stresses at the surface, and the softening that occurs when the surface is scanned, thereby tempering previously made laser melted tracks. The laser melted and worn structures are investigated with electron microscopy, light microscopy and hardness measurements. The wear behaviour is tested with a so-called pin on disk apparatus. Chapter 2 describes the experimental techniques applied. Attention has been paid to the sample preparation for transmission electron microscopic investigations of the surface.

Three types of steel were studied: A martensitic hardenable plain carbon steel (CK60), a chromium steel with a high carbon content (RCC extra) and a high speed steel containing tungsten (G50). Since the heat conductivity of steel is relatively low it is easy to melt locally. The laser melted structure contains dendrites with segregated carbides in an eutecticum. Depending on the laser scan velocity and the type of steel the dendrites contain retained austenite, martensite and/or (delta)ferrite. By the melting process the final structure after laser alloying is homogeneous and during quenching there is no opportunity to form large precipitates. All experiments show that laser melting improves the wear resistance. The influence of parameters like the beam diameter, laser scan velocity and the substrate temperature on the resulting microstructure, hardness, crack formation and wear behaviour has been investigated. To treat larger surfaces laser melted tracks are made adjacent to each other. As a result of the previous made tracks experience a second heat treatment. RCC is insensitive for this process, CK60 is softened by this second heat treatment and G50 is locally hardened. Experimentally it is shown that the orientation of the dendrites in the laser melted structure influences the wear behaviour. In case of larger loads or deformations the crystal orientation is an important factor, which is in turn related to the growth direction. A 'scratch' model is proposed for dendritically solidified material, which describes to the experimental data. For smaller loads the amount of segregated carbides in the surface is of importance.

During laser melting large tensile stresses develop in the surface, which may give rise to crack formation and which detrimentally influence the wear behaviour. By means of ion implantation the tensile stress can be converted into compressive stresses. A comparison has been made between the noble gas neon and the nitride forming

nitrogen. With increasing dose, implantation of neon showed an increasing wear resistance. Transmission electron microscopy confirmed the nucleation and growth of bubbles in the metal during implantation. The pressure and volume of the bubbles is sufficient to create a compressive stress state. In addition the surface is also strengthened by the interaction between bubbles and dislocations. The type of nitrides formed during implantation appeared to be dependent on the implantation dose and temperature, which also affects the wear behaviour. Depending on the implantation parameters the wear resistance increases with a factor of ten. On the contrary, if a layer of brittle carbonitrides is formed on the surface the wear rate increases.