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Correlation between process parameters and layer formation during plasma nitriding and boriding of nickel based alloys

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In principle nickel based alloys are used for applications where the material is exposed to a high mechanical and thermal stress. Examples for these conditions are turbine blades and hot forming tools. Forming tools are additionally strained tribologically which leads to high wear because of the low hardness of nickel based alloys. In order to meet this challenging environment and ensure a long durability of tools, surface modifications are necessary. Hard coatings like DLC are not suitable for forming tools at high temperatures. Therefore plasma nitriding and boriding represent good alternatives for surface hardening Ni-based alloys.
Three different nickel based alloys were plasma nitrided and borinded with various parameters. The nitrided layers of the samples were 5 to 15 µm thick and reached hardnesses up to 1700 HV. Plasma boriding was carried out in a H_2-Ar-BCl_3 atmosphere for two hours. The Temperature was varied between 500 and 800 °C. The samples were characterized by cross-sections, EDX-analysis, hardness profiles, adhesion of compound layer and tribometer tests. The cross-sections show a compact boride layer of 20 to 60 µm thickness mainly consisting of a mixture of hard nickel and chromium borides. The measurements yield a hardness of approximately 3000 HV directly under the surface and a sufficient adhesion of the boride layer to the ground material. The tribometer testing revealed a low friction coefficient and great wear resistance.
Generally this investigation shows that nickel based alloys can be plasma nitrided and borided within a relativ wide array of process parameters. Plasma boriding has advantages over diffusion treatments using boron containing paste. Especially better controls of the surface properties through process parameters and less effort for per- and post-processing are considerable. Additionally, if a borided tool is in contact with air at high temperatures, boronoxyd can form at the surface which is known as a dry-film lubricant.

Keywords
Plasma boriding and nitriding
Diffusion treatment
Nickel based alloys
Nickel and chromium borides