UNIVERSITY OF TECHNOLOGY
IN THE EUROPEAN CAPITAL OF CULTURE
CHEMNITZ

Institute of Materials Science and Engineering

Materials and Surface Engineering

Surface Functionalization of Selective Laser Melted 17-4 PH by Plasma Polishing and Interstitial Diffusion Hardening for Thin Films

*Thomas Lindner *[1], Maximilian Grimm [1], Frank Schubert [2], Kerstin Winkler [2], Jan Tomáštík [3], Alina Vladescu (Dragomir) [4], Thomas Lampke [1]*

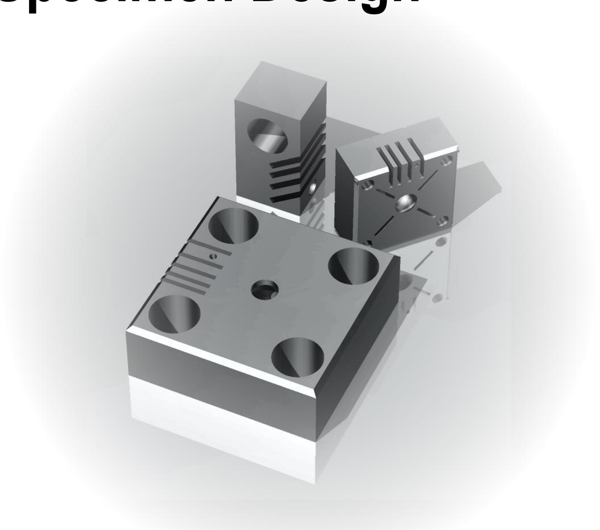
[1] Materials and Surface Engineering, Institute of Materials Science and Engineering, Chemnitz University of Technology, D-09107 Chemnitz, Germany
[2] Institute of Lightweight Structures and Polymer Technology, Chemnitz University of Technology, Chemnitz, 09126, Germany
[3] Palacký University in Olomouc, Faculty of Science, Joint Laboratory of Optics of Palacký University and Institute of Physics AS CR, 17. listopadu 12, 771 46 Olomouc, Czech Republic
[4] National Institute of R&D for Optoelectronics-INOE2000, Department for Advanced Surface Processing and Analysis by Vacuum Technologies – ReCAST, Magurele - Bucharest, 077125, Romania
* Correspondence: th.lindner@mb.tu-chemnitz.de , +49-371-531-38287

abstract

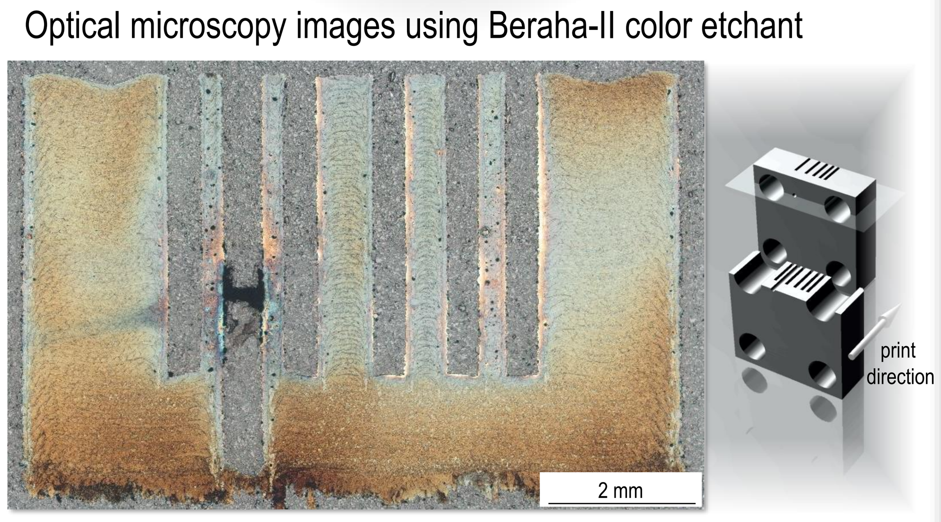
The powders used as feedstock in selective laser melting (SLM) process fundamentally limit the surface quality of these components. Particle contamination on the surfaces of the parts can remain rounded or agglomerated contributing to a very rough surface at the microscale. Furthermore, the manufacturing advantages of a closed component design lead to limitations in the mechanical finishing process, especially regarding undercuts and cavities. In addition to corrosion protection requirements, demands for wear resistance become increasingly important. This study deals with the development of a process chain for the surface functionalization of selective laser melted 17-4 PH by plasma polishing and interstitial diffusion hardening. In this context, both the leveling of the surface topography and the development of graded coating properties are of particular interest. In addition, this technology can be used to protect thin films against locally acting forces by providing sufficient support for the substrate materials.

production routine

>> Specimen Design



Optical microscopy images using Beraha-II color etchant

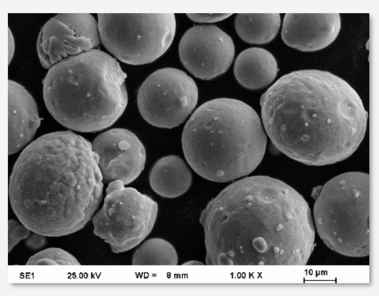


1. Selective Laser Melting

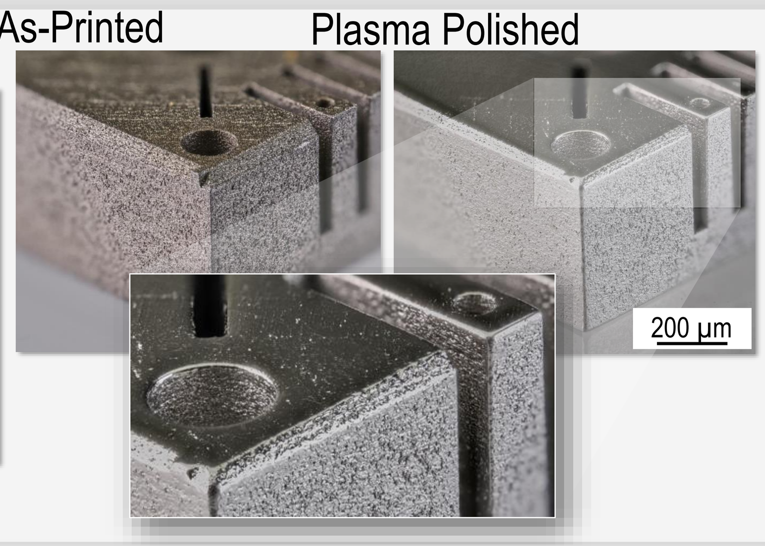
Chemical Composition of 17-4 PH in wt.%

Cr	Ni	Cu	Nb+Ta	C	Si	Mn	S	P
15–17.5	3–5	3–5	0.15–0.45	<0.07	<1	<1	<0.03	<0.04

Particle Size Distribution
–53+25 µm

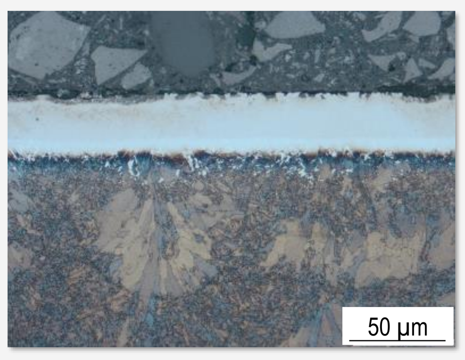


2. Plasma Polishing



3. Thermochemical Treatment (NC)

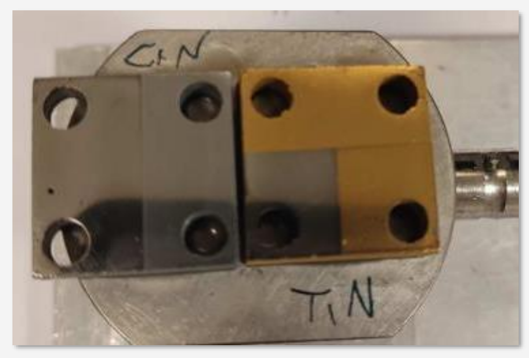
- Gasnitrocarburization (NC)
- Temperature < 420 °C, 24 h
- Interstitially supersaturated surface layer (approx. 30 µm)



4. Thin Films (Ti_xCr_yN)

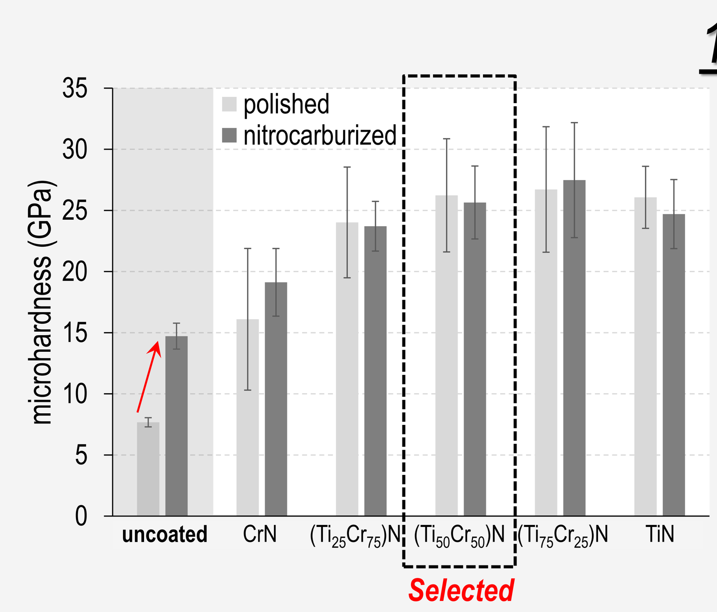
- x,y = 0, 25, 50, 100%
- Approx. 2 µm

Current Ti (A)	Current Cr (A)	Deposition time (min)	**Coating Type**	Coating thickness (µm)	Cr concentration (EDX at% measurement)
	100	60	**CrN**	1.92	
60	105	42	**$(Ti_{25}Cr_{75})N$**	1.79	75.5
120	80	37	**$(Ti_{50}Cr_{50})N$**	1.86	45.2
150	40	42	**$(Ti_{75}Cr_{25})N$**	1.90	19.2
100		87	**TiN**	1.91	

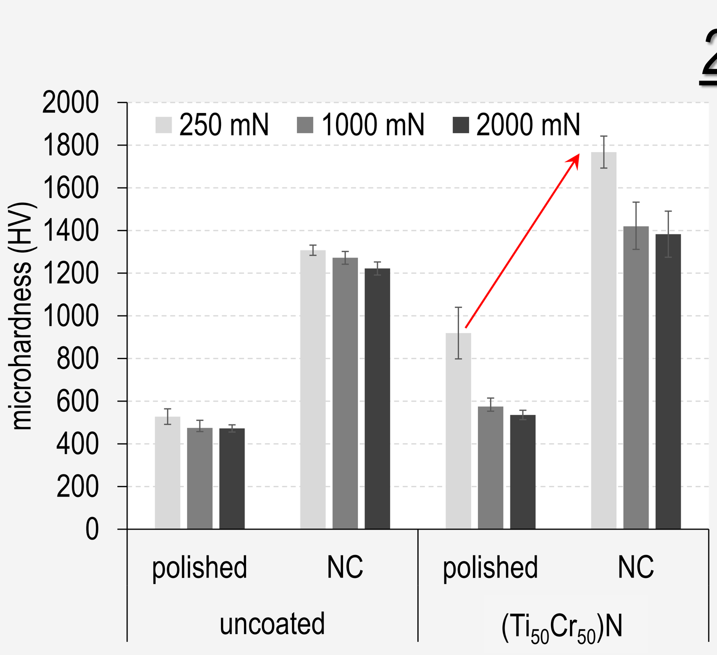


properties

Microhardness



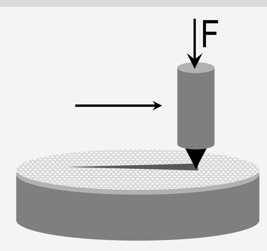
- Strong increase in microhardness by nitrocarburization
- Microhardness increase for thin films with high Ti content
- No influence of precondition under 10 mN



- Substrate influence by increase in indentation force
- Strong support effect of nitrocarburization

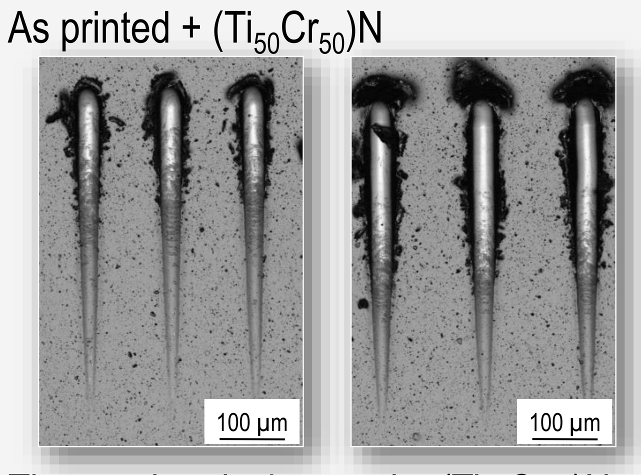
Approach confirmed

Wear and Impact Resistance

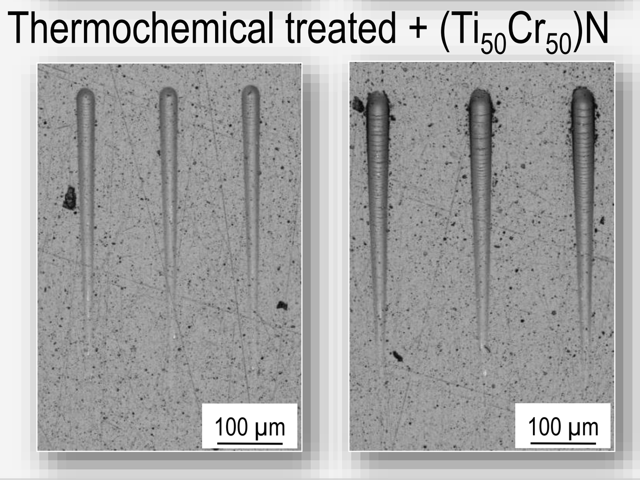


0.001–10 N *0.001–15 N*

As printed + $(Ti_{50}Cr_{50})N$



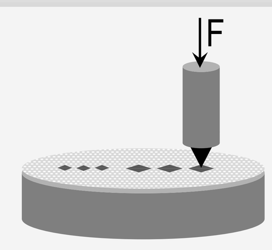
Thermochemical treated + $(Ti_{50}Cr_{50})N$



Strong increase in wear and impact resistance by thermochemical surface hardening

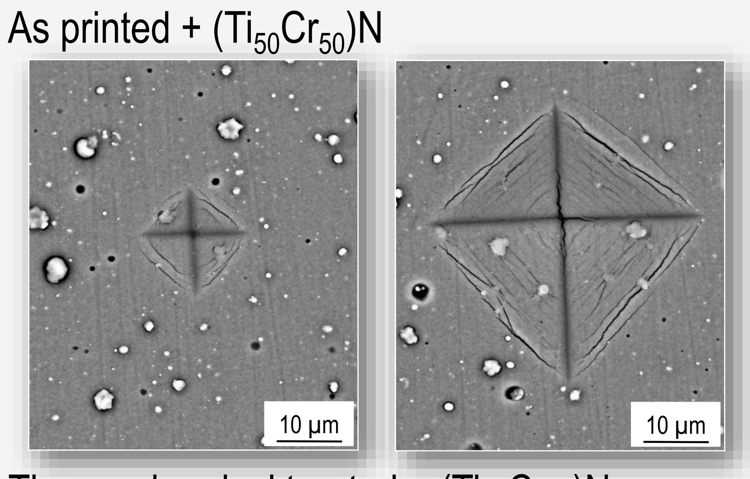
- Spallation of thin coatings in as printed condition
- Reduction in indentation depth
- Reduction in crack formation

Support effect of thermochemical treatment verified

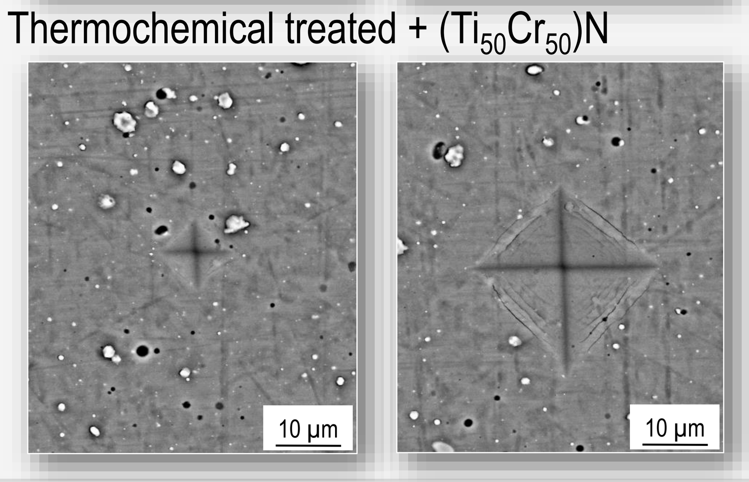


1 N *5 N*

As printed + $(Ti_{50}Cr_{50})N$



Thermochemical treated + $(Ti_{50}Cr_{50})N$



summary

While plasma polishing offers appropriate potential for the formation of smooth surfaces, low-temperature diffusion processes can increase the microhardness and wear resistance by promoting a reliable support effect for thin films. This technology promises a high application potential to protect thin films with high hardness against locally acting forces. As a result, both the resilience and service life of tools can be increased.

Materials and Surface Engineering
Professor T. Lampke

Erfenschlager Str. 73, D-09107 Chemnitz

This measure is co-financed with tax revenue on the basis of the budget approved by the Saxon state parliament. Sächsische Aufbaubank - Förderbank/SAB-100632831