Wear resistance NiCrBSi coatings obtained by laser cladding and subsequent deformation processing

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Introduction

NiCrBSi coatings obtained by gas powder laser cladding are characterized by significant undulation and roughness.

The use of surface plastic deformation is an efficient way of increasing the strength and wear resistance of machine part surfaces. Prospects of the application of friction treatment as finishing surface deformation processing of NiCrBSi coatings was demonstrated in [1] for the relatively plastic cladding PG-SR2, with average microhardness HV 570 and the hardness of the strengthening phases not exceeding HV 1000-1050 (0.48% C; 14.8% Cr; 2.6% Fe; 2.9% Si; 2.1% B, Ni – base).

The aim of this work is to study whether the use of friction treatment can improve the characteristics of the surface layers of the NiCrBSi-PG-10N-01 high-strength cladding containing higher amounts of carbon, chromium, boron and silicon than the PG-SR2 cladding.

Material and Methods

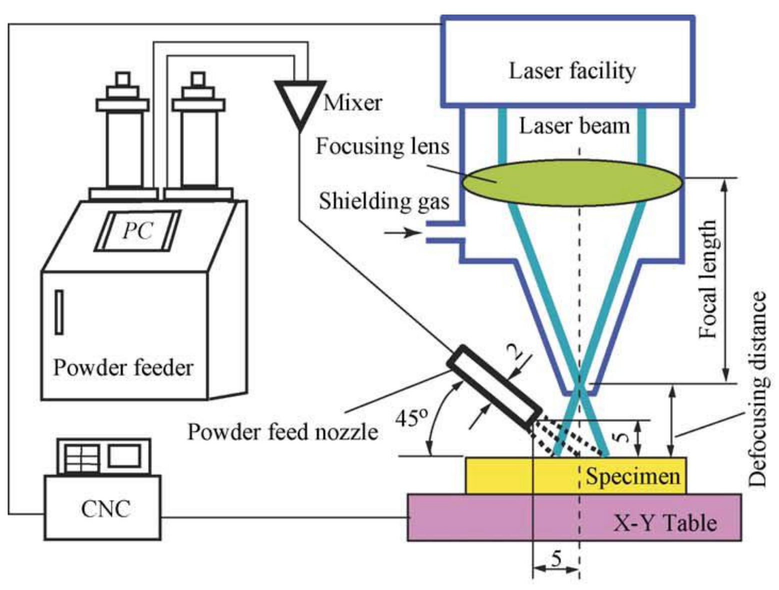
Chemical composition (wt. %) of the powder

Coating	Ni	Cr	B	Si	C	Fe
PG-10N-01	balance	18.2	3.3	4.2	0.92	2.6

A continuous wave CO_2 laser beam was used for laser cladding, whose process parameters are 1.6 kW laser power, 6x1.5 mm beam, 160 mm/min traverse speed, 2.9-3.8 g/min powder feed rate.

An overlap of 60% between successive tracks was selected and argon gas was blown into melt pool to inhibit oxidation during treatment.

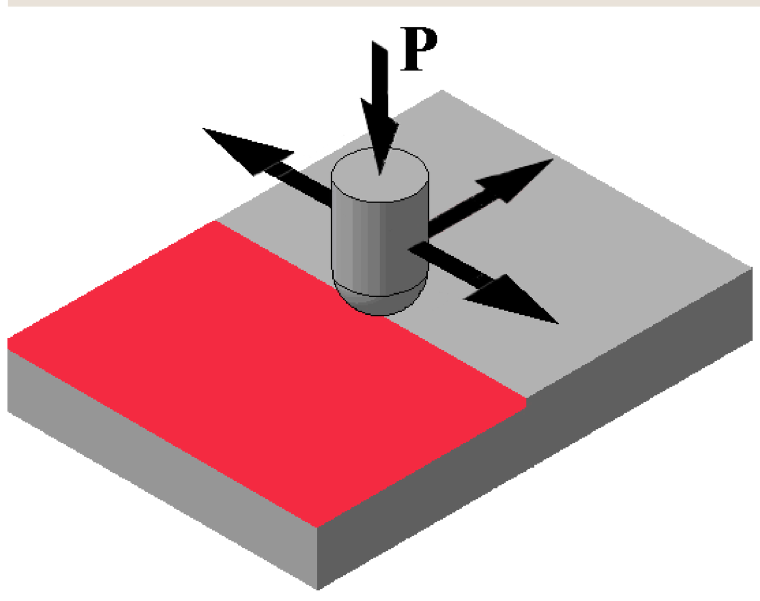
Gas powder laser cladding



The steel plate with coating after laser cladding

The cross-section of a coated specimen after cladding and grinding

Schematic friction treatment with a hemispherical indenter



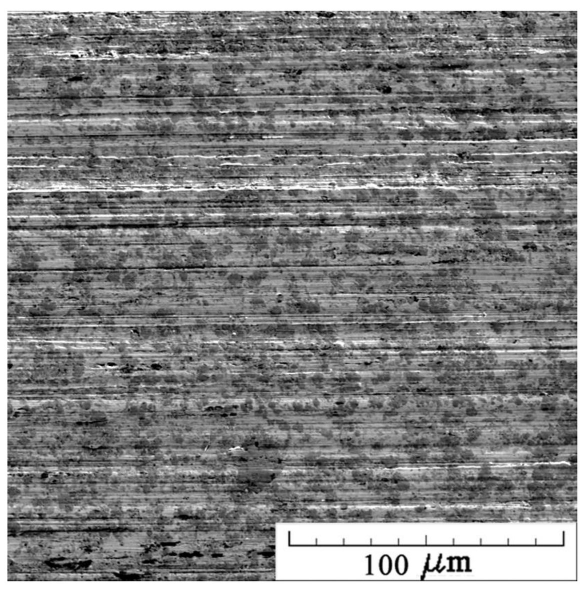
Indenter: dense cubic boron nitride (DBN)
In air
Scans of the surface: n = 2 - 5
Loads: P = 300 N - 1000 N

Results

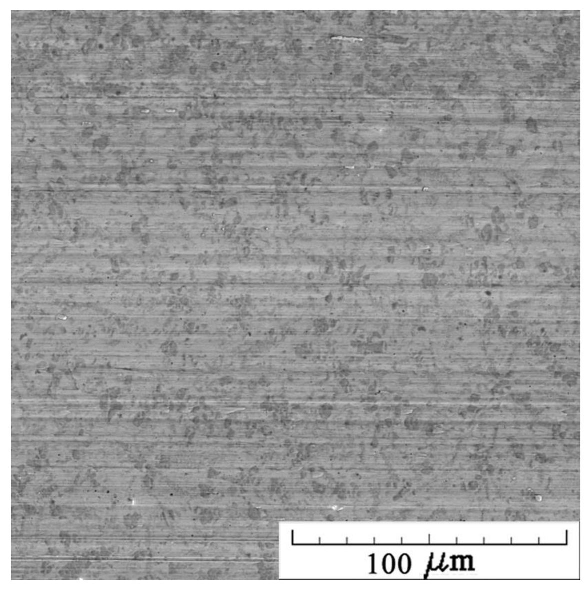
Microhardness HV 0.025, residual stresses σ and the average values of the lattice parameters of the γ-solid solution on the coating surface after different treatments

Treatment	Process parameters		HV 0.025	σ, MPa	d, Å
	P, H	n			
Grinding	-	-	1045±30	+90	3.5394
Polishing	-	-	990±35	−85	3.5374
Friction treatment	300	5	1170±70	−55	3.5418
	500	5	1210±20	−135	3.5422
	700	2	1165±30	−590	3.5424
	700	4	1220±35	−1140	3.5408

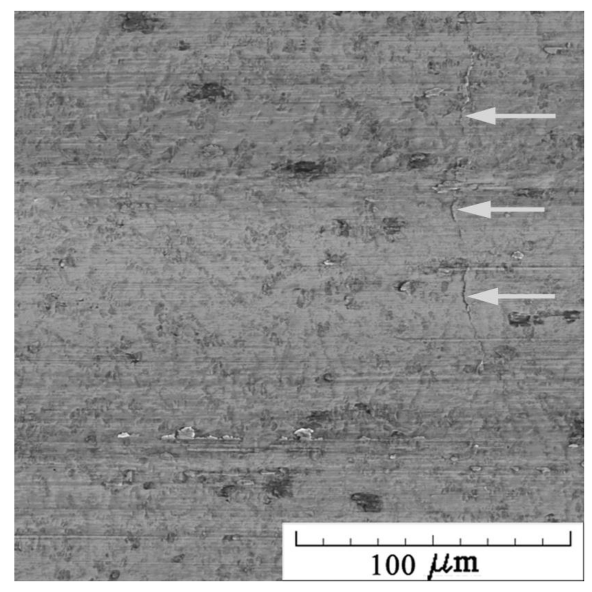
The surfaces of the specimens with coating after different treatments



Grinding

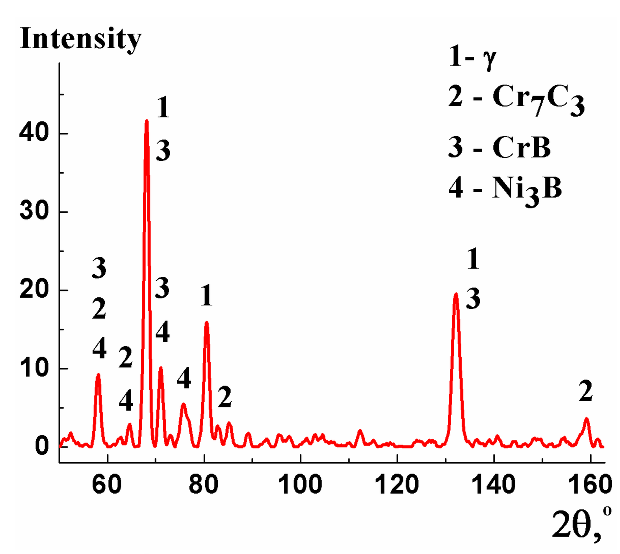


Frictional treatment DBN, air, P=300, n=5

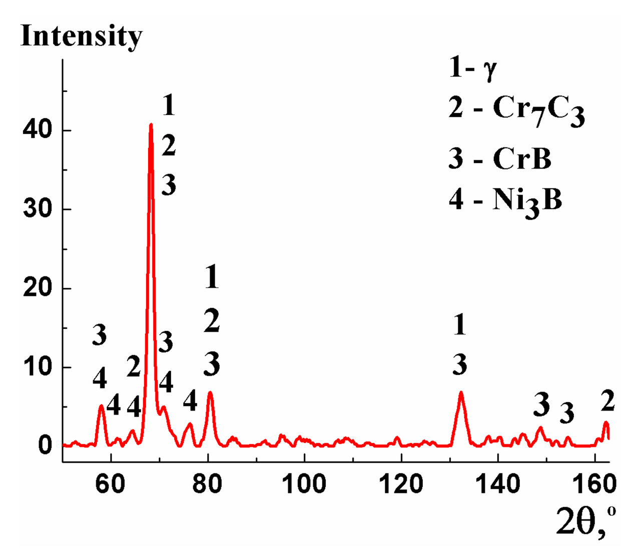


Frictional treatment DBN, air, P=700, n=4

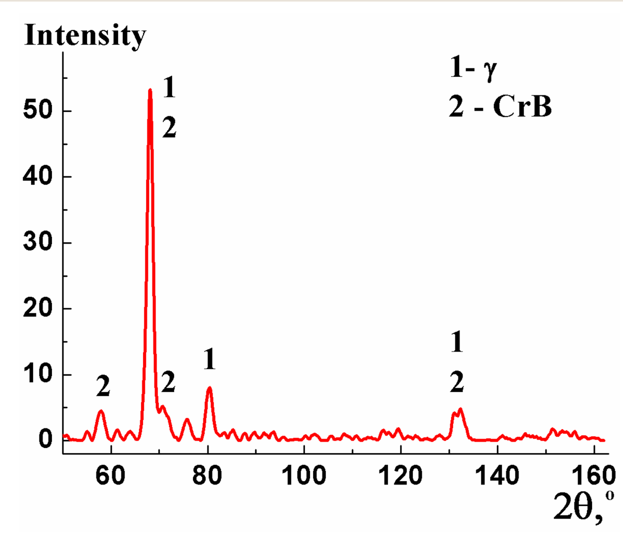
X-ray diffraction patterns of the PG-10N-01 coating surface after different treatments



Without frictional treatment



Frictional treatment DBN, air, P=300, n=5



Frictional treatment DBN, air, P=700, n=4

Conclusion

The friction treatment of the PG-10N-01 high-strength (HV 0.025=990) NiCrBSi laser coating with a sliding hemispherical indenter made of dense cubic boron nitride additionally strengthens the surface to HV 0.025=1165-1220 and forms favorable residual compressive stresses. As the load on the indenter grows from 300 to 700 N, the level of residual compressive stresses increases from −55 to −1140 MPa.

Friction treatment under a minimum load of 300 N does not change the initial phase composition of the surface layer, where, along with the Ni-based γ-solid solution and the γ+Ni_3B eutectics, there are the strengthening Cr_7C_3 and CrB phases. Only a partial strain-induced dissolution of borides and carbides seems to occur. The increase of the load on the indenter during friction treatment to 500-700 N results in the intensive strain-induced dissolution of borides Ni_3B and carbides Cr_7C_3. This increases the lattice parameter of the Ni-based γ-solid solution and activates the solid-solution strengthening mechanism due to the enrichment of the solid solution with carbon, chromium and boron.

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