



*All-Russian Research Institute of Automatics,
Moscow, Russia*

**Properties research
of chemically deposited nickel coatings
modified with nano diamonds.**

S.A. Fedotov, L.P. Ryabchikova, N.S. Fedotova

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Compared parameters:

- **conditions of deposition;**
- **concentration of carbon content in coating;**
- **microstructure;**
- **physical & mechanical properties.**



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Composition of electrolyte:

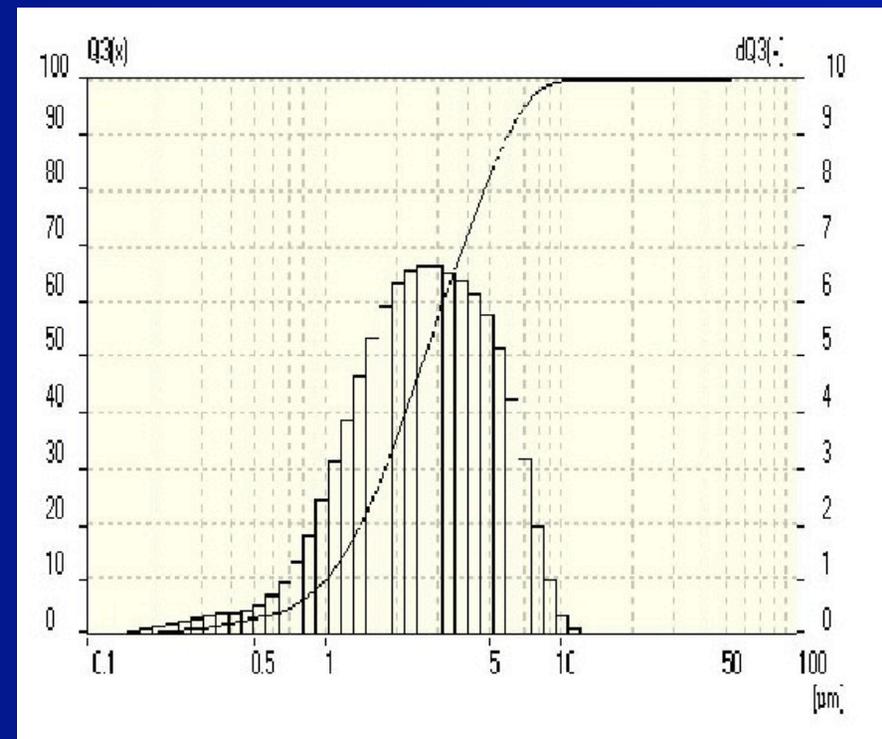
- NiSO₄·7H₂O –20-30 g/l**
- Sodium hypophosphite – 10-25 g/l**
- Acetous sodium – 10-15 g/l**
- Acetic acid – 4-6 g/l**
- Thiourea – 0,001-0,003 g/l**
- Temperature – 82-87°C.**



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Distribution of particles on the size in electrolyte

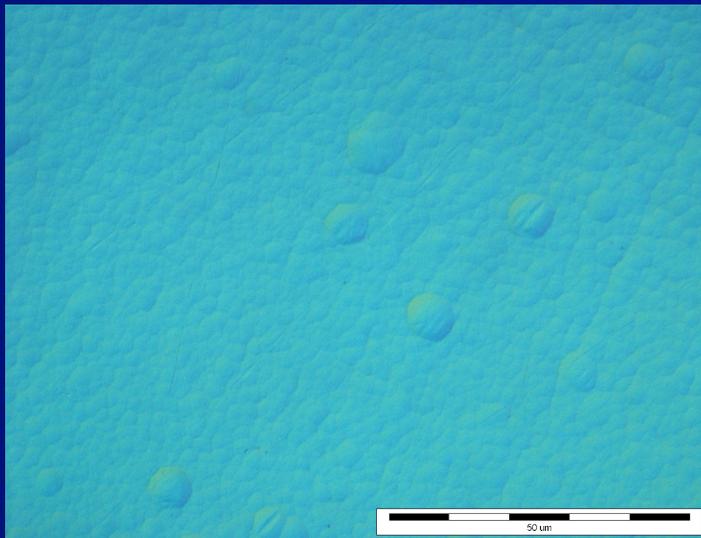
**Laser particles analyzer –
analyzette 22 FRITSCH**



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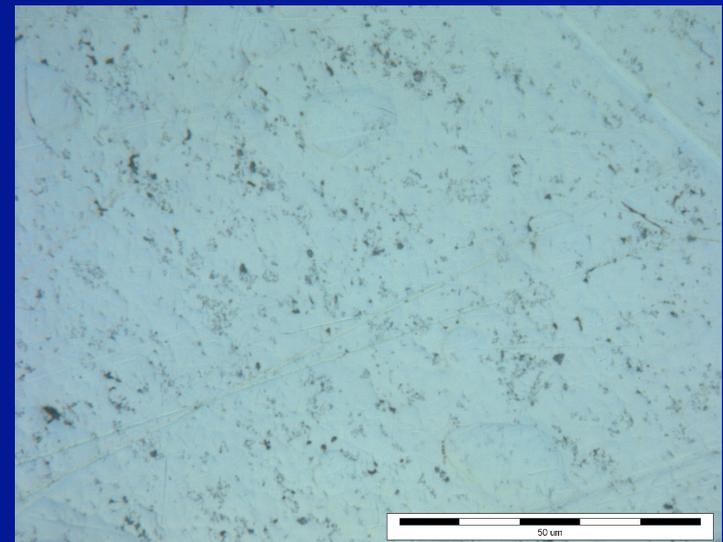
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**Optical microscope Olympus,
magnification 1500x**

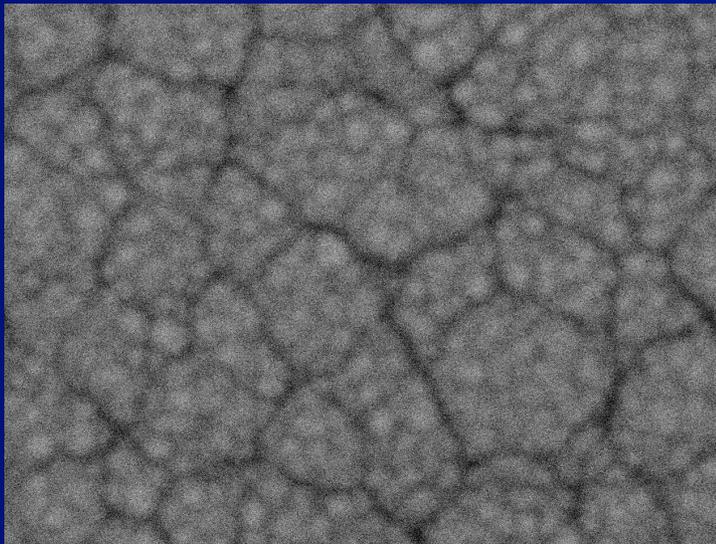
Structure of coating



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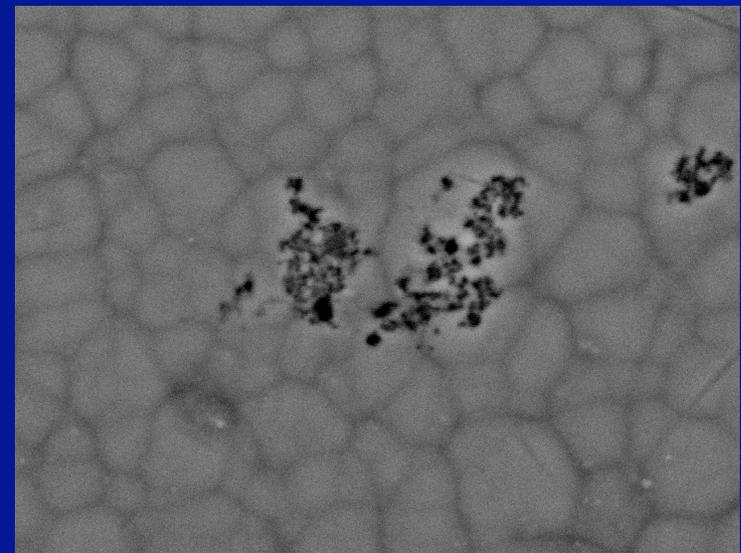
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4_3326 2009.05.14 L x10k 10 um

**Electronic microscope
Hitachi TM-1000,
magnification 10.000x**

Structure of coating



4_3327 2009.05.14 L x10k 10 um

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Experimental samples

№ sample	Nano diamonds concentration, g/l	Thickness coating, µm
0	-	20
1	2	10
2	2	20
3	5	20
4	1	20



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Parameters of microhardness measurements

- **Indenter – Vickers pyramid**
- **Max. indicator load – 300 mN**
- **Load/unload rate – 600 mN/min**
- **Exposure time at max. load – 15 sec.**

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Results of microhardness measurements

Sample	Before treatment		After treatment	
	HV	E(GPa)	HV	E(GPa)
N0	676,370±19,261	137,534±6,246	1165±99,824	183,502±12,626
N1	538,558±27,275	116,945±7,074	999,304±93,040	144,299±10,156
N2	455,361±26,058	97,927±3,937	973,550±45,788	146,527±7,725
N3	554,339±25,796	110,654±7,164	202,538±13,416	58,915±1,264
N4	394,729±27,364	93,143±2,800	1046,480±77,674	150,037±7,127



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**Parameters of wear-resistance and factor of
friction measurements**

- **Rider – the little ball with the 3 mm diameter,**
- **Rider material – 400C (the analog 95X18III),**
- **Normal load – 1H,**
- **Linear speed – 10 cm/sec,**
- **Relative humidity – 49%.**

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Results of wear-resistance and factor of friction measurements

Sample N.	Wear of sample, $10^{-5}\text{mm}^3/\text{N}/\text{m}$	Wear of rider, $10^{-7}\text{mm}^3/\text{N}/\text{m}$	Friction coefficient				Running, min^{-1}
			Start.	Max.	Aver.	Fin.	
0	1,51	9,69	0,13	0,87	0,80	0,86	4045/203
1	1,67	3,46	0,16	0,73	0,61	0,63	3956/200
2	2,02	16.01	0,17	1,01	0,86	0,89	3957/200
3	3,03	7,17	0,13	0,89	0,79	0,87	3956/200
4	2,27	8,90	0,15	0,92	0,85	0,88	3958/200

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Conclusions:

- **In the process of nickel chemical deposition with nano diamonds (ND) take part particles with micro- and nano- meter dimensions.**
- **The ND enter the nickel coating matrix, forming cluster structures.**
- **Microhardness practically doesn't depend on the ND content. Thermal treatment leads to microhardness increase nearly in 2 times.**
- **The lowest friction coefficient has a coating with 0,4-0,5% of the carbon content and 10 μm thickness.**
- **The coating from the electrolyte that has 10 μm thickness and the ND content that equals 2 g/l, can be recommended for wear-resisting property improvement of details that operate in friction conditions.**