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SURFACE TOPOGRAPHY OF SAMPLES OBTAINED USING ADDITIVE TECHNOLOGIES FROM METAL POWDERS AFTER IRRADIATION WITH HIGH-CURRENT ELECTRON BEAMS

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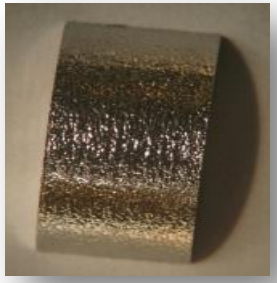
MATERIALS AND METHODS OF RESEARCH

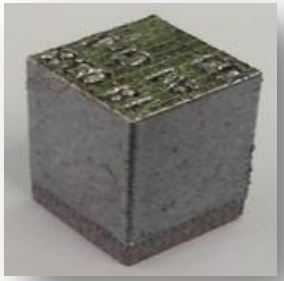
Samples obtained by the SLM method from stainless steel, Co-Cr system alloy, and Al-Si-10Mg system were used as research objects.

Appearance of samples

stainless steel



Co-Cr systems

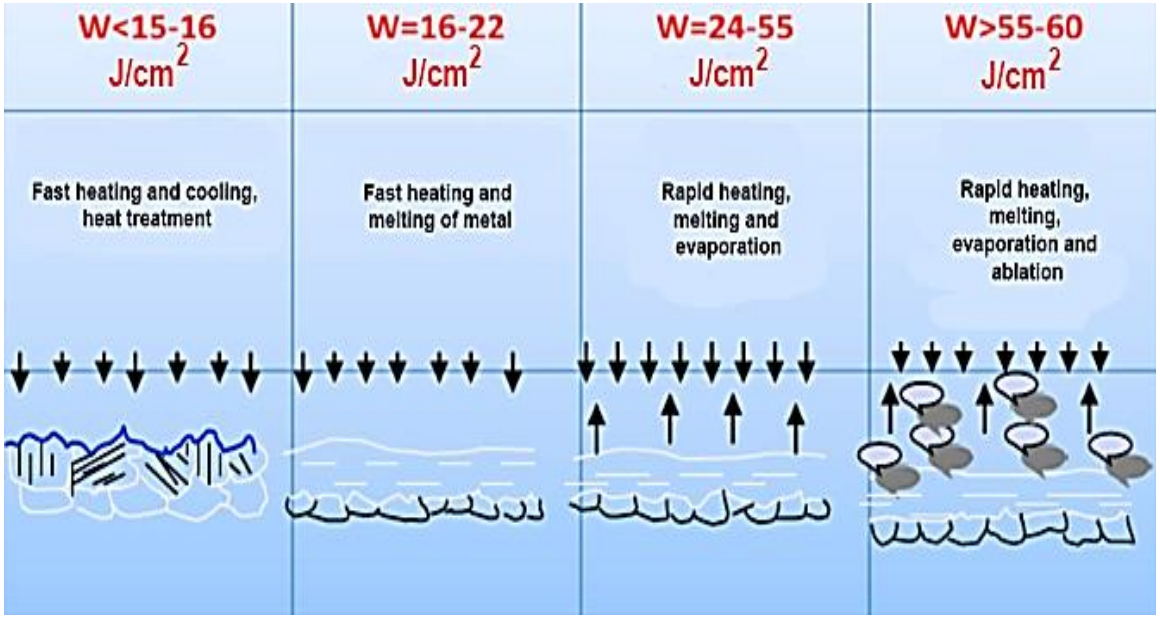


Al-Si-10Mg -systems

The determination of the surface layer physical and chemical state of these objects was carried out by

- surface roughness (R_a)
- optical metallography.
- Characteristics of microhardness (H_μ)

Phenomena during irradiation



Key parameters of irradiation

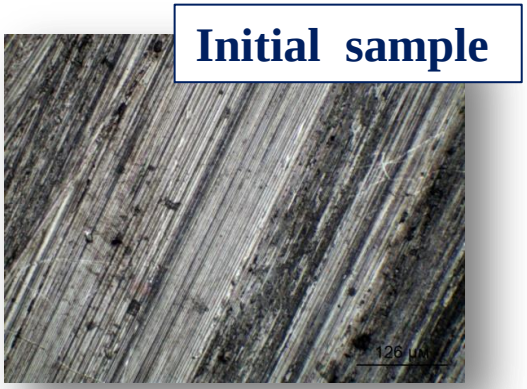
- Maximum electron energy of the beam is 35 kV;
- Pulse duration 2-4 mcs;
- Electron beam diameter up to 100 mm;
- The deposition rate of 100-300 nm/min;
- The thickness of the surface of the alloy 0.1-10 μm;
- Electron beam current up to 25 kA;
- Non-uniform coating thickness is 20%.

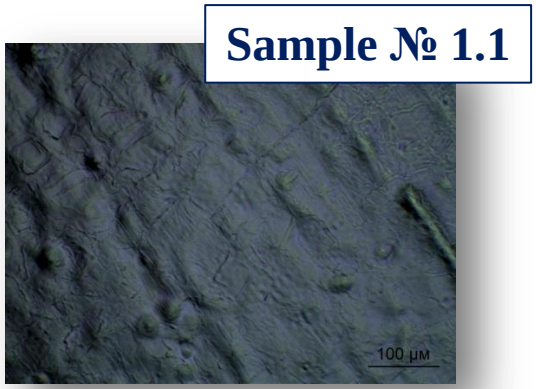
Appearance of the "RITM-SP" installation

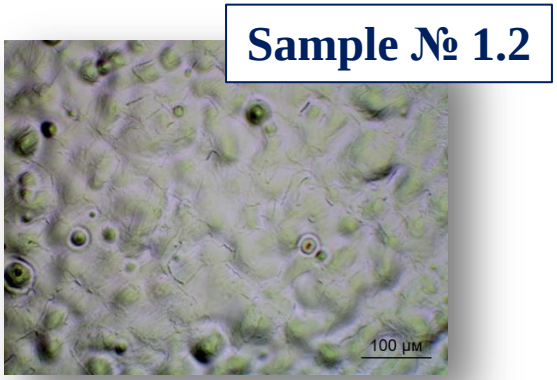
Topography of the stainless steel sampls

Irradiation modes for stainless steel sampls

№ sample's	Irradiation mode		
	Number of pulses, N	Electron energy E, keV	Energy density W, J/cm^2
1.1	30	27	≈4.8±1
1.2	30	30	≈6.2±1.2







State of the surface layer at the cutting site changes after irradiation, depending on the irradiation modes. in addition, when roughness was measured for sample № 1.1 (mode 1), the roughness was Ra=0.31 µm and for sample №1.2 (mode 2) it was equal to Ra=0.54 µm, the initial state of the surface of the samples is equal to Ra=0.35 µm.

Topography Co-Cr systems samples

№ sample's	Irradiation mode		
	Number of pulses, N	Electron energy E, keV	Energy density W, J/cm^2
1.1	60	32	≈7.1±1.5
1.2	60	27	≈4.8±1
1.3	30	30	≈6.2±1.2
1.4	30	27	≈4.8±1
1.5	30	25	≈3.9±0.9
1.6	30	22	≈3.1±0.8

Roughness of Co-Cr system samples after irradiation

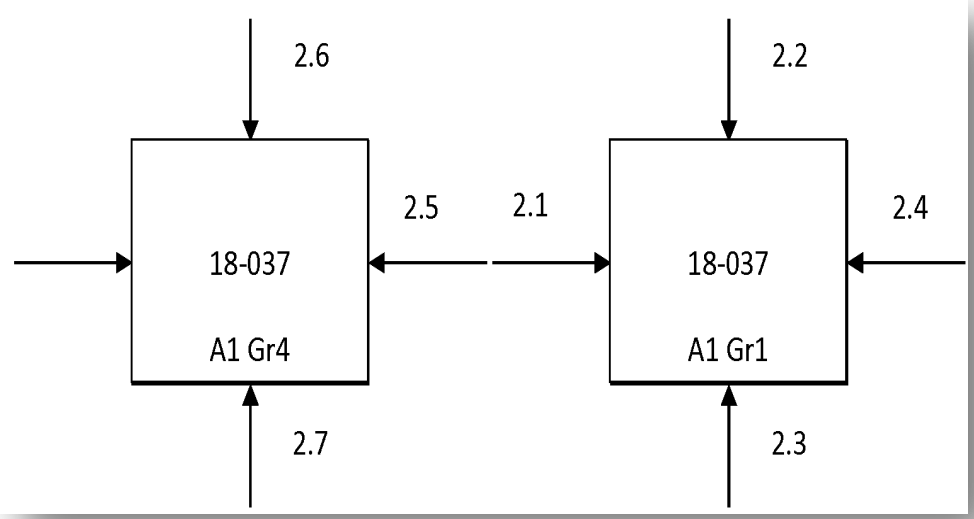
№ sample's	Roughness, R_a, µm	
	min	max
1.1	4,7	5,1
1.2	4,1	4,6
1.3	4,9	5,7
1.4	3,9	4,4
1.5	**3,5**	**4,1**
1.6	**2,9**	**3,7**
Initial sample	5,8	

With an increase in the energy density at equal values of the number of pulses, the roughness of the samples decreases. It should be noted that in the 1.6 mode (N=30, E=22 keV, W≈3.1±0.8 J/cm²), the minimum roughness of the sample surface was achieved, and the average Ra = 3.3 microns, which is almost twice lower than that of the original sample surface.

Irradiation modes for Al-Si-10Mg system sample

№ sample's	Irradiation mode		
	Number of pulses, N	Electron energy E, keV	Energy density W, J/cm^2
2.1	16	20	≈2.6±0.8
2.2	32	20	≈2.6±0.8
2.3	32	25	≈3.9±0.9
2.4	32	30	≈6.2±1.2
2.5	64	25	≈3.9±0.9
2.6	16	30	≈6.2±1.2

The scheme of irradiation for Al-Si-10Mg system samples

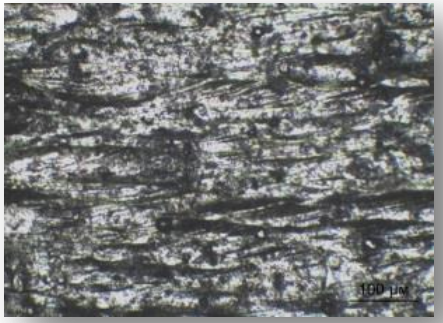


Roughness of Al-Si-10Mg system samples after irradiation

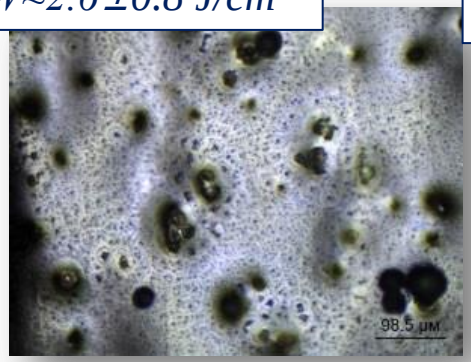
№ sample's	Roughness, R_a, µm
2.1	4,77
2.2	3,65
2.3	3,16
2.4	2,72
2.5	2,78
2.6	3,11
Initial sample	4,57

Topography of the Al-Si-10Mg system sample

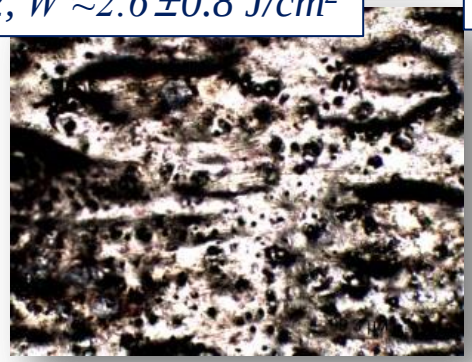
initial sample



n=16, W≈2.6 ±0.8 J/cm²

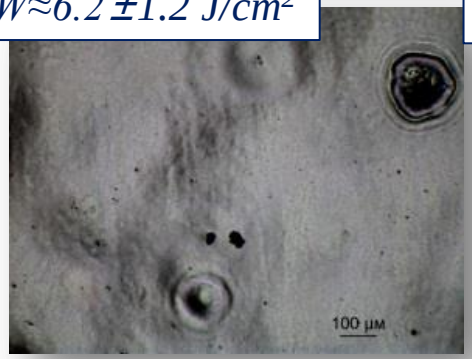


n=32, W ≈2.6 ±0.8 J/cm²



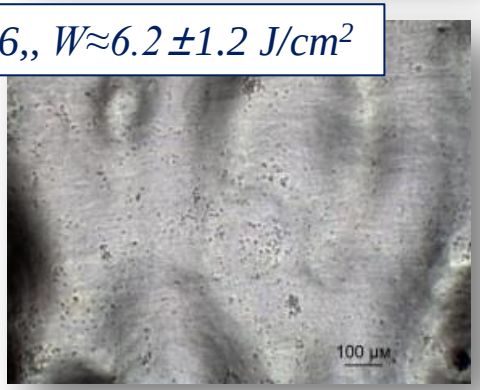
n=32, W ≈3.9 ±0.9 J/cm²

n=32, W≈6.2 ±1.2 J/cm²



n=32, W≈6.2 ±1.2 J/cm²

n=16,, W≈6.2 ±1.2 J/cm²



Conclusions

The obtained data on the surface roughness and topography of samples made of stainless steel, alloys of Co-Cr and Al-SI-10Mg systems after irradiation with high-current pulsed electron beams showed the following:

1. at equal values of the number of pulses, the smallest value of roughness is achieved at the highest values of energy density;
2. with equal energy values, the lowest roughness value is achieved with a larger number of pulses;
3. at high energy densities, separate craters of different structures are formed;
4. irradiation with a high-current pulsed electron beam can become an effective method of post-processing parts obtained using additive technologies.

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Thank you for your attention!