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STRUCTURAL-PHASE TRANSFORMATIONS IN «Cr/SILUMIN» SYSTEM UNDER PLASMA AND THERMAL IMPACT

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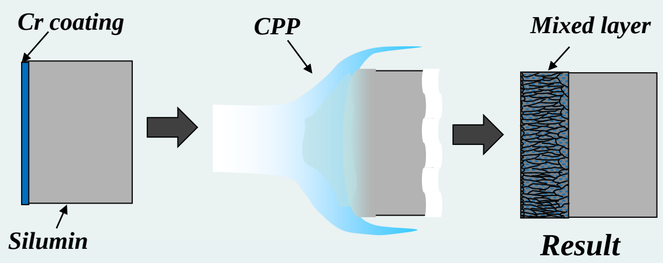
The investigation of structural-phase transformations under thermal treatment in the near-surface layer of the eutectic silumin alloyed with Cr atoms under compression plasma flows impact are presented in this work. The formation of metastable $Al_{74}Cr_{20}Si_6$ in the alloyed layer was found. Annealing of alloyed sample at 550°C resulted in dissolution of $Al_{74}Cr_{20}Si_6$ and formation of $Al_{13}Cr_4Si_4$. The structural-phase transformation in the modified layer led to silumin hardening.

Investigation objects: 12,6 ат.% Si; 0,5 ат.% Cu; 2,7 ат.% Mg; 0,3 ат.% Ni; 0,3 ат.% Fe; 0,2 ат.% Mn.

Experimental procedure

Vacuum-arc Cr coating deposition

Parameters of deposition:
- *Cathode arc current – **100 A***
- *Coating deposition time – **10 min***
- *Coating thickness – **2 μm***



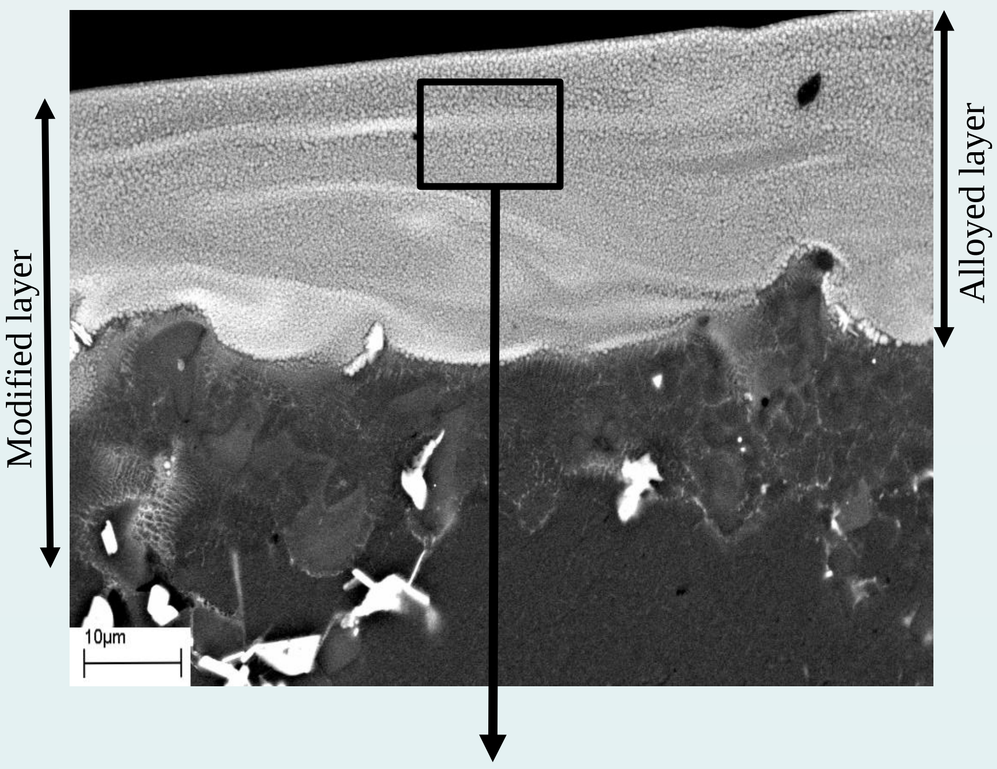
Compression plasma flows impact

Parameters of the CPF treatment:
- *Number of pulses – **3***
- *Nitrogen residual atmosphere (**pressure 400 Pa**)*
- Voltage on the capacitor battery – **4.0 kV**
- Absorbed energy density (Q) – **17 J/cm²**
- Pulse duration **100 μs**

Annealing

Parameters of annealing:
- *Temperature – **450-550°C***
- *Time – **2h***

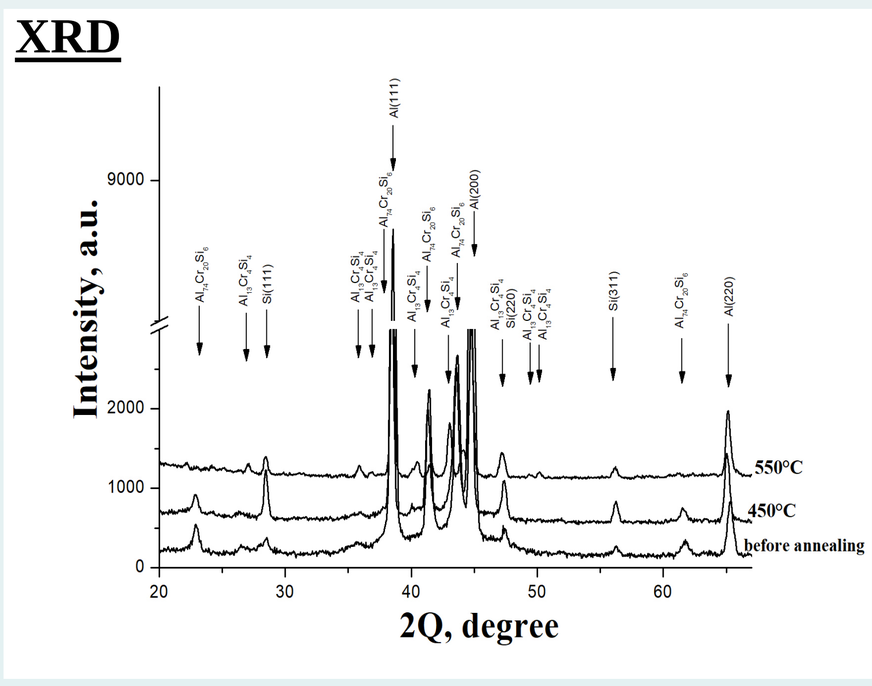
Cross-section after CPF impact

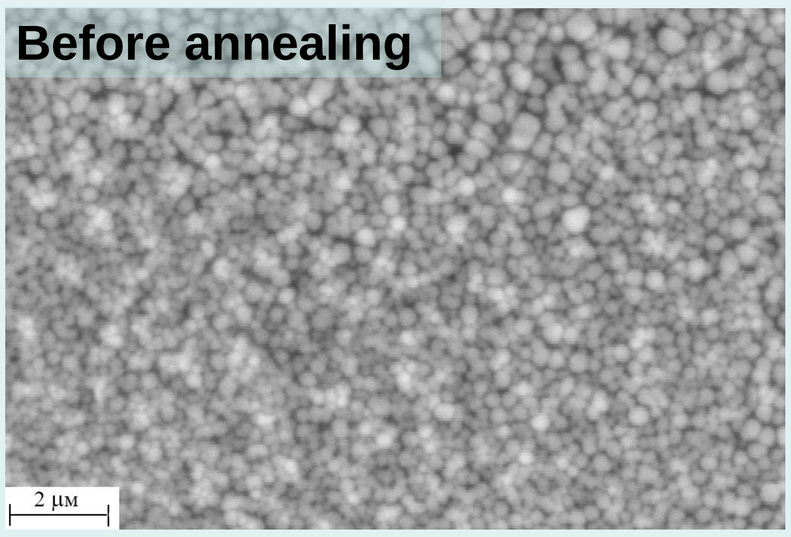


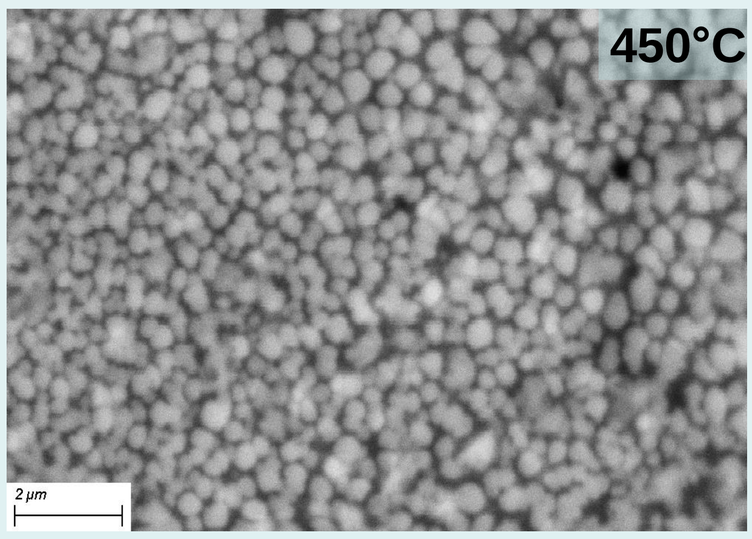
After CPF treatment:

- *formation of alloyed layer with thickness ~25 μm*
- *alloyed layer contains $Al_{74}Cr_{20}Si_6$ precipitates with size of 100-300 nm*
- *decrease of lattice parameter of Al from a=0,4051±0,0002 nm to a=0,4041±0,0002 nm → formation of supersaturated solid solution Al(Si)*

XRD

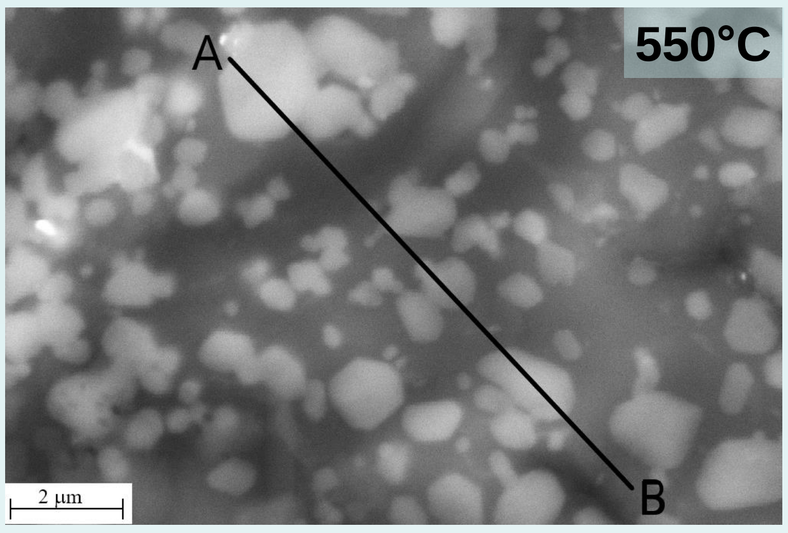


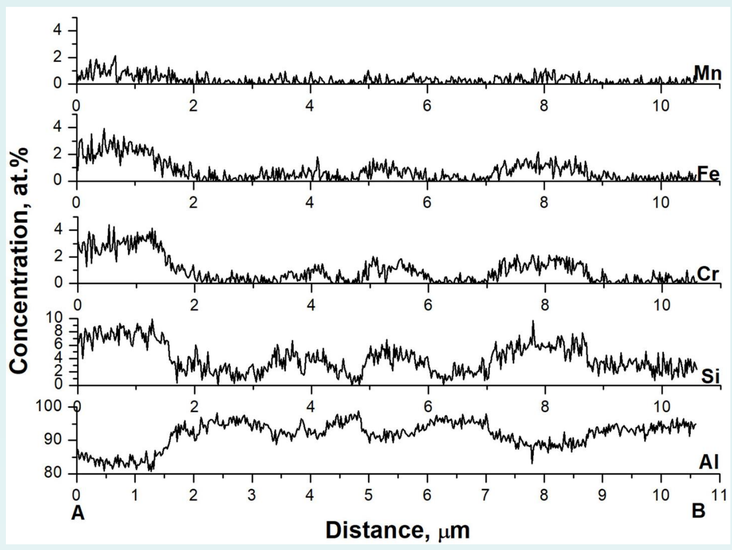




After annealing:

- *according to XRD increasing of aluminum lattice parameter to the value a=0,4053±0,0002 nm and increasing of intensity of Si diffraction lines → decomposition of solid solution Al(Si)*
- *$Al_{74}Cr_{20}Si_6$ remains stable under during annealing at 450°C but its coagulation is observed*





- *decomposition of $Al_{74}Cr_{20}Si_6$ and formation of $Al_{13}Cr_4Si_4$ during annealing at 550°C*
- *according to X-ray microanalysis the composition of $Al_{13}Cr_4Si_4$ phase includes Fe and Mn*

Alloying with Cr atoms eutectic silumin makes it possible to increase its strength characteristics. The microhardness of the initial silumin is 1.3 GPa, and that of the CPP-treated one is ~3 GPa. The microhardness of the alloyed near-surface layer in the studied samples subjected to annealing is higher than the microhardness of the initial annealed samples not subjected to alloying ~2 times . In the samples annealed at 450°C for 2 h, the microhardness is 1.6 GPa, while in the original, annealed under the same conditions, it is 0.8 GPa.