

Investigation of anti-corrosion properties of Fe-Cr-Si alloys studied by XPS and Mössbauer Spectroscopy

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Most of the constructing materials widely used in industry are made of iron alloys. They are exposed to atmospheric conditions and damaged by corrosion. According to the World Corrosion Organization, the annual cost of the process worldwide is over 3% of the world's GDP. Therefore, there is still a need to develop materials extremely resistant to oxidation.

The main goal of our work is to develop a new class of iron based materials resistant to corrosion. Previously [1,2] we reported that the addition of Cr and/or Si atoms to α -Fe drastically reduce the oxidation process of iron atoms during exposure to air at high temperature. Transmission Mössbauer Spectroscopy (TMS) as well as Conversion Electron Mössbauer Spectroscopy (CEMS) spectra measured for the $\text{Fe}_{0.85}\text{Cr}_{0.10}\text{Si}_{0.05}$ show that corrosion of this material is almost stopped at 870 K and 1070 K. It was suspected and confirmed later [3] that this phenomenon is connected with oxygen induced surface segregation of Cr and Si atoms.

Our last work [3] was focused on reduction of the amount of solutes in Fe-Cr-Si alloys without deterioration of their anti-corrosion properties. Alloys were heated in UHV to induce the surface segregation (Table 1) and then were oxidized at 870 K. The $\text{Fe}_{0.90}\text{Cr}_{0.05}\text{Si}_{0.05}$ show similar resistance to oxidation as $\text{Fe}_{0.85}\text{Cr}_{0.10}\text{Si}_{0.05}$ investigated before. Now we compare properties of the $\text{Fe}_{0.90}\text{Cr}_{0.05}\text{Si}_{0.05}$ prepared by arc melting and cold-rolled to the thickness of 50 μm to microcrystalline powders prepared by mechanical alloying.

Sample			$c_{\text{Cr}}/c_{\text{Fe}}$	$c_{\text{Si}}/c_{\text{Fe}}$	$c_{\text{O}}/c_{(\text{Fe}+\text{Cr}+\text{Si})}$
$\text{Fe}_{0.90}\text{Cr}_{0.10}$	0h	as-prepared	-	-	3.69
		900K/15 min	1.58	-	0.49
	1270/2h	as-prepared	0.20	-	2.23
		900K/15 min	1.19	-	0.53
	bulk		0.11	-	-
$\text{Fe}_{0.90}\text{Cr}_{0.05}\text{Si}_{0.05}$	0h	as-prepared	-	1.04	2.38
		900K/15 min	1.32	2.35	0.68
	1270/2h	as-prepared	1.13	1.87	1.68
		900K/15 min	1.26	1.17	0.54
	bulk		0.06	0.06	-
$\text{Fe}_{0.88}\text{Cr}_{0.10}\text{Si}_{0.02}$	0h	as-prepared	-	-	3.52
		900K/15 min	2.48	1.59	0.59
	1270/2h	as-prepared	0.68	-	1.90
		900K/15 min	1.08	0.38	0.81
	bulk		0.11	0.02	-

Table 1. Surface concentration ratios of the selected alloys [3].

1) R. Idczak, Corrosion Vol. 75 No. 10, 1083 (2018).

2) R. Idczak, K. Idczak, Metallurgical and Materials Transaction A Vol. 51A, 3076 (2020).

3) M. Sobota, K. Idczak, R. Konieczny, R. Idczak, Metallurgical and Materials Transaction A Vol. 53, 3083 (2022).