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Protective oxide film on aluminium encapsulated with different nanocontainers

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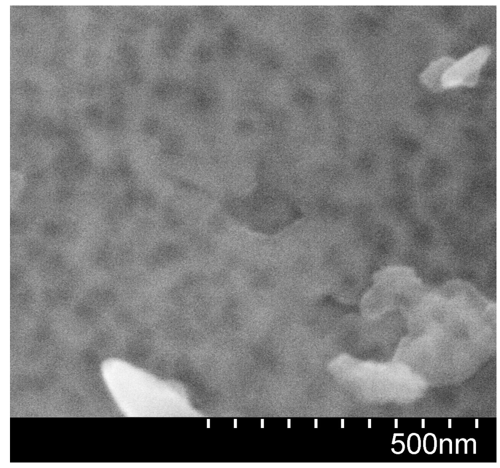
Anodic oxidation of metals is widely used method for corrosion protection. There are two main methods of anodization: conventional (galvanostatic or potentiostatic) and plasma electrolytic oxidation (PEO). The conventional anodization methods allow production of thin oxide films of controlled thickness and quality. The PEO technique is relatively new; it operates with potentials above the breakdown voltage of an oxide film and allows to obtain rather thick films. A new method of oxide film preparation – powerful pulsed discharge oxidation has recently been reported [1-3]. In PPDO, the reaction proceeds at the metal-electrolyte interface on applying an pulse of high voltage (up to 2 kilovolts). The most important distinction of this technique in comparison to the conventional anodizing is an extremely high rate of the film growth under the action of discharges in electrolyte. In the case of a PEO process, the multiple discharge channels, where the oxidation actually occurs, are created. During powerful pulsed discharge ionizes an oxide film completely, thus, as opposed to PEO coating, PPDO film growths not only near breakdown areas (channels) but simultaneously over the whole surface of the electrode. This results in formation of oxide films with properties different than those obtained by conventional approaches. For example the anodic films prepared by pulsed discharge method in sulphuric acid electrolytes are constituted by a single uniform dense amorphous oxide, while films of the same thickness prepared by the conventional galvanostatic method more complex structure consisting of two layers: an inner crystalline and an outer amorphous one [3]. Using PPDO method it is possible also to create not only dense films, but also more complex structures.

In present work, composite oxide films on aluminium were prepared by powerful pulsed discharge oxidation. Nanocontainers loaded with corrosion inhibitors were injected into the volume of the oxide film during discharge pulses. Different types of nanocontainers were used: layered double hydroxides, silica capsules, calcium carbonate, and carbon nanotubes. Influence of pulse voltage on structure and morphology of the obtained films was studied. It was found that pulses at voltage above 1.5 kV result in destruction of the nanocontainers distributed over volume of the film, while those lower than 0.8 kV lead to the very low growth rate. Variation of the discharge voltage shows that the optimal voltage for the composite film formation is in the range 1.2-1.4 kV. It was also found that application of a low DC (1-2 V) potential to the electrodes results in increment of the nanocontainers number in the film.

For structure and thickness studies of the composite film a scanning electron microscopy, transmission electron microscopy (surface and cross-section) and electrochemical impedance spectroscopy were also used. Oxide with thickness up to 150 nm was obtained. EDS measurement proves presence of corrosion inhibitors inside the deposited containers.

Figure shows SEM image of the film obtained in the colloidal solution of SiO_2 particles on aluminium electrode.

Effect of the incorporated nanocontainers on the corrosion protective properties of the obtained composite films was also studied.



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