A STUDY OF THE LOCALIZED CORROSION BEHAVIOR OF METALS BY AFM/SKPFM TECHNIQUE

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Atomic Force Microscopy (AFM) allows imaging the topography of different materials with nanometer resolution. However, the classical AFM gives only topographical information, which limits the application of the technique in corrosion research. Introduction of the Scanning Kelvin Probe Force Microscopy (SKPFM) [1] allowed to determine the electrical properties of surface on a sub-micro level with the resolution of a hundred nanometres. The working principle of SKPFM is based on the determination of the Volta potential difference (VPD) (or difference in work function) between the conducting tip and the surface under investigation. The measurements of VPD performed in air can be correlated to the electrochemical corrosion potential of metals [2]. Since the corrosion process involves cathodic zones, which have nobler potential, and anodic zones that are less noble, SKPFM allows determination of the electrochemical nature of such places as it was shown in [3]. However, some factors may influence the Volta potential measurements. For instance, sample preparation procedure, structure and the presence of surface oxide films, layers of the corrosion products and others can significantly alter the experimental results. Nevertheless, understanding the limitations, SKPFM technique becomes a great tool for the characterization of electrochemical properties of metallic surfaces giving important information concerning the mechanisms of corrosion processes on micro- nano-scale.

In the present paper we demonstrate applicability of SKPFM and in-situ AFM techniques to study mechanisms of corrosion and corrosion inhibition processes on aluminum alloys 2024 and 5083. The AFM coupled with SKPFM allowed monitoring the VPD of alloy surface before and after exposure in different corrosion solutions with and without the presence of organic and inorganic inhibitive compounds. Before corrosion VPD map shows an intermetallic with higher VPD (white area across the black line) **Fig. 1(A).** The localised corrosion attack always starts on the border between noble intermetallic that works as an effective cathode and surrounding alloy matrix, which becomes an anode. The VPD increases in the place of cathodic intermetallics and adjacent matrix after corrosion exposure **Fig. 1(B).**

The results showed that the addition of organic inhibitors blocks the corrosion because of specific adsorption on the surface and results in almost unchanged map of VPD between the intermetallic (white area across the black line) and surrounding matrix **Fig. 2**. The use of Ln based inhibitors results in precipitation of insoluble hydroxides in the places with cathodic activity, therefore stopping further corrosion process.

The in-situ AFM experiments allowed calculating kinetics of the localized pitting growth on AA5083 in NaCl solution **Fig. 3**. The influence of NaCl solution concentration on the kinetics of insoluble La hydroxides precipitation is shown for AA2024.

References:

[1] M. Nonnenmacher, M.P. O'Boyle, and H.K. Wickramasinghe, Appl. Phys. Lett., **58** (1991) 2921-2923.

[2] P. Schmutz, G.S. Frankel, J. Electrochem. Soc., **145** (1998) 2285-2295.

[3] P. Schmutz, G.S. Frankel, J. Electrochem. Soc., **145** (1998) 2295-2306.

Figures:

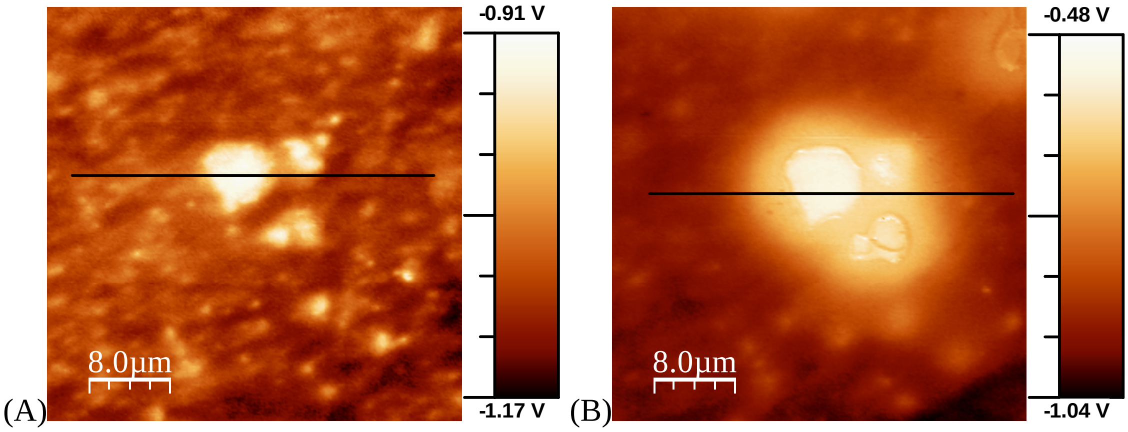

Fig. 1. Evolution of VPD before (A) and after (B) immersion of polished AA2024 in 0.05 M NaCl solution.

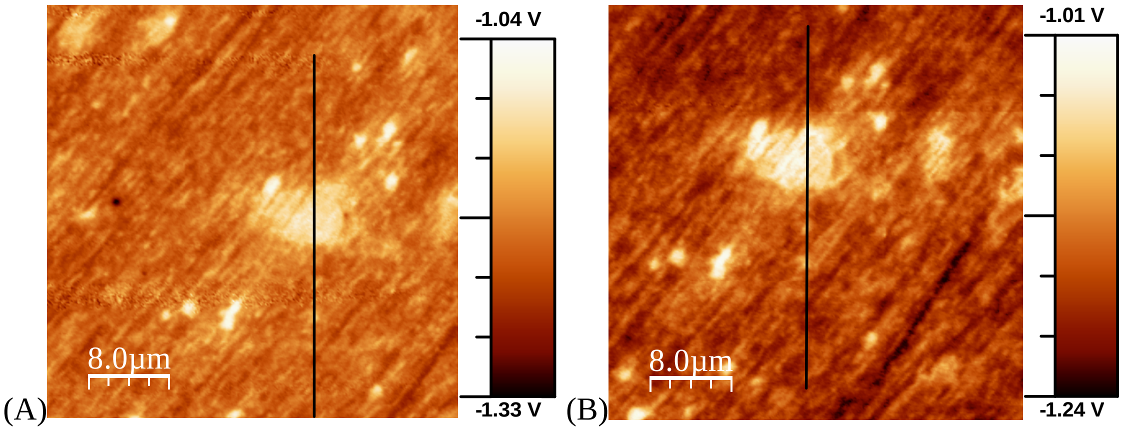

Fig. 2. Evolution of VPD before (A) and after 3h (B) of immersion of polished AA2024 in 0.05 M NaCl solution with organic inhibitor 8Hydroxyquinoline.

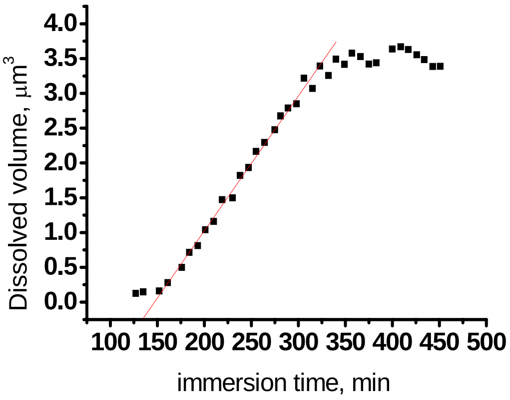

Fig. 3. Kinetics of dissolution of aluminum matrix near Fe-rich intermetallic on AA5083 during immersion in 0.05 M NaCl solution.