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To cite this article: Isolda Costa *et al* 2009 *Meet. Abstr.* **MA2009-02** 1826

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Corrosion resistance of sintered Nd-Fe-B magnets corrosion and surface treatments for corrosion protection

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Nd-Fe-B sintered magnets present outstanding magnetic properties [1] finding a wide range of applications since computer disk drives, fine electro-electronic industry, in large industrial machines and dentistry [2,3]. Despite of their excellent magnetic properties they are highly susceptible to corrosion what has been attributed to their complex microstructure composed of many phases where the main ferromagnetic phase present is the ϕ phase [4]. Research has been carried out to improve their corrosion resistance by either alloying elements addition [5], protective coatings [6,7] and more recently by phosphating [8-10]. Chromating of this magnet has also been used for corrosion protection [11] but this treatment generates toxic and carcinogenic products and other types of environmentally friendly conversion coating layers have been studied to replace the chromating process due to the Cr (VI) toxicity [11].

Phosphating is an environmentally friendly conversion treatment often used as a pretreatment to coatings application. The phosphate layer formed, besides improving the corrosion resistance of the substrate, has a beneficial effect on organic coatings adhesion.

The purpose of this work is to present the effect of surface treatments carried out with Nd-Fe-B sintered magnets, mainly phosphating, on their corrosion resistance.

Figure 1 presents SEM-EDS image of a Nd-Fe-B magnet polished and immersed for 4 h in phosphate buffered solution (PBS) of composition corresponding to NaCl 8.77g/L, Na₂HPO₄ 1.42g/L and KH₂PO₄ 2.72 g/L with pH 7, to simulate human body fluids. Corrosion develops on the magnets due to galvanic coupling between the Fe-rich magnetic phase (gray) and the Nd-rich phase (white) located at the grain boundaries of the magnetic phase. This last phase is anodic to the ϕ phase leading to intergranular corrosion where the Nd rich phase located at the grain boundaries of the ϕ phase corrodes preferentially, and eventually, detachment of the ϕ grains occurs [1]. Previous research carried out in our laboratory showed that it leads to deterioration of the Nd-Fe-B magnetic properties.

Porosities associated to the fabrication process also strongly affect the CR of the magnet investigated. Cathodic polarization curves after 4h of immersion in the PBS solution confirmed that oxygen diffusion controls the corrosion process.

The effect of surface treatments, such as chromate conversion coatings (Cr (III) and Cr (VI)), silane and phosphating in a 10 g/L NaH₂PO₄ solution with pH adjusted to 3.8 on the corrosion resistance of sintered Nd-Fe-B magnet was investigated. The EIS results showed that the surface treatments with silane and Cr (VI) decreased the magnet corrosion resistance, whereas the corrosion resistance of Cr (III) treated samples was slightly improved. Phosphating, however, provided better corrosion resistance among the surface treatments tested.

Figure 2 (a) and (b) shows the SEM micrograph of Nd-Fe-B magnets phosphated (1h) and chromated, respectively, and immersed for 4 h in PBS solution. The increase in the CR of the magnet due to phosphating and chromating (Cr (III)) is clearly indicated (compare Figures 1 and 2). Slight

corrosive attack occurred at the boundaries between the Fe-rich and Nd-rich phases, mainly on the Cr (III) treated samples. On the phosphated sample, the Nd-rich phase was not attacked suggesting that a thin phosphate film is formed on these particles protecting them from corrosion. This hypothesis is supported by the low solubility of neodymium phosphates.

The Bode phase angle diagrams of phosphated magnet showed the presence of a HF time constant that was ascribed to a thin phosphate layer on the sample surface (confirmed by EDS analysis). The EIS results showed that the electrode behaves like a porous electrode and the phosphate layer an increased the loop diameter and displacement of the LF loop to lower frequencies. This result indicates that the phosphate layer is also formed on the pore walls hindering the corrosion reaction.

References

- [1] G.W. Warren, G. Gao, Q. Li, J. Appl. Phys. 70, p. 6609, 1991.
- [2] L.W. Carlyle, J.M. Duncan, J.T. Richardson, L. Garcia, J. Prosthet. Dent. 56 (5), p.583, 1996.
- [3] M.L.N.P.C. Real, M.A.O. Almeida, N. Miekeley, Journal of Dental Research, 80(4) p.1076, 2001
- [4] A.S. Kim, F.E. Camp, J. Appl. Phys., 79(8) part 2A , p. 5035, 1996.
- [5] S. Hirosawa, S. Mino, H. Tomizawa, J. Appl. Phys. 69, p.5844, 1991.
- [6] A.S. Kim, F.E. Camp, J. Appl. Phys. 79 (1996) 5035.
- [7] C.W. Cheng, F.T. Cheng, J. Appl. Phys. 83 (1998) 6417.
- [8] A.M. Saliba-Silva, I. Costa, Key Eng. Mater. 189-191, p. 363, 2001.
- [9] A.M. Saliba-Silva, R.N. Faria, M. A. Baker, A.M. Brown, I. Costa, Mater. Sci. Forum, 418, p. 76, 2004
- [10] S.M. Tamborim Takeuchi, D.S. Azambuja, A.M. Saliba-Silva, I. Costa, Surf. Coat. Techn., 200, p.6826, 2006.
- [11] B.Y. Johnson, J. Edington, M.J. O'Keefe, Mater.Sci. Eng., A, Struct. Mater., 3631, p. 225, 2003.

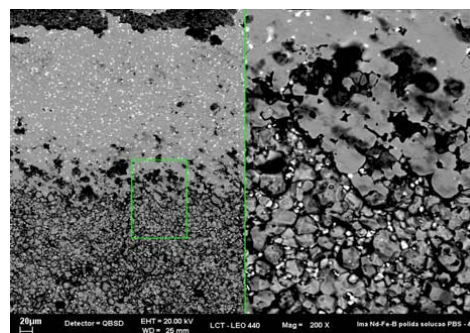


Figure 1 – SEM micrograph of the Nd-Fe-B magnet surface after 4 h immersion in PBS solution.

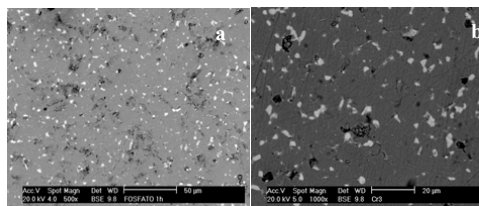


Figure 2 – SEM micrograph of (a) Cr (III) treated and (b) phosphated Nd-Fe-B magnet after 4 h in PBS solution.