Self Assembled Monolayers over Ferromagnetic Surfaces

M. Mattera[1], A . Forment-Aliaga[1], S. Tatay[1,2] , E. Coronado[1]

1 Unidad de Investigación de Materiales Moleculares, Instituto de Ciencia Molecular, 46980 Paterna, Spain

2 Unité Mixte de Physique CNRS/Thales associée à l'Université Paris-Sud, 91767 Palaiseau, France

michele.mattera@uv.es

Self-assembled monolayers (SAMs) consist of organized assemblies formed by the spontaneous adsorption of their molecular constituents from solution (or vapor phase), onto solid surfaces [Figure 1].[1] SAMs have well defined structures, are lightweight, flexible, nanometer thick and its properties can be tailored by chemical synthesis. Such characteristics make SAMs valuable high quality interface layers in electronic devices.[1b] For that purpose well known grafting protocols for the functionalization of surfaces like, Silicon or Gold[1c] have been used.

When it comes to spintronics, SAMs expected long spin life-time and the possibility of working at high bias[2] make them promising candidates as tunnel barriers. In this case, traditional non-magnetic electrodes have to be replaced by ferromagnetic metals. However, in the literature we can find just a few examples of SAMs formation over ferromagnetic materials[2b-d] like Cobalt[2e], Nickel[2f] or LSMO[2a]. So, as a previous step to definitely foster the integration of SAMs as spintronics barriers, the missing grafting protocols have to be developed.

Permalloy (Py) is a ferromagnetic nickel–iron alloy, commercially available and currently used in magnetic storage technology, that features high permeability, small coercivity, near zero magnetostriction and significant anisotropic magnetoresistance.[3] In spite of its interest, as far as we know, there is not previous report in the literature about the growth of SAMs on it.

Py, like most ferromagnetic materials, when exposed to air develops a thin oxide layer that covers the surface and prevents further oxidation. We decided to take advantage of this oxide as a binding layer for the formation of SAMs. In this work we report a successful method for grafting alkylphosphonic acids ($C_nP = CH_3(CH_2)_{n-1}PO_3H_2$, n = 12, 14, 16, 18) onto Py surfaces. In this process the previous activation of the surface with hydrogen plasma resulted critical. During our study the quality of formed layers has been carried out by means of dynamic water Contact Angle (CA) [Figure 2] , Atomic Force Microscopy (AFM) [Figure 3], X- Ray Reflectometry (XRR) and X-Ray Photoelectron Spectroscopy (XPS).

References

1. a - Love, J.C., et al., *Self-Assembled Monolayers of Thiolates on Metals as a Form of Nanotechnology.* Chemical Reviews, **4** (2005): p. 1103-1170; b - Zschieschang, U., et al., *Mixed Self-Assembled Monolayer Gate Dielectrics for Continuous Threshold Voltage Control in Organic Transistors and Circuits.* Advanced Materials, **40** (2010): p. 4489-4493; c - Ulman, A., *Formation and structure of self-assembled monolayers.* Chemical Reviews, **4** (1996): p. 1533-1554.
2. a - Tatay, S., et al., *Self-Assembled Monolayer-Functionalized Half-Metallic Manganite for Molecular Spintronics.* ACS Nano, **10** (2012): p. 8753-8757; b - Wang, W. and C.A. Richter, *Spin-polarized inelastic electron tunneling spectroscopy of a molecular*

magnetic tunnel junction. Applied Physics Letters, **15** (2006): p. 153105-3; c - Petta, J.R., S.K. Slater, and D.C. Ralph, *Spin-Dependent Transport in Molecular Tunnel Junctions.* Phys Rev Lett, **13** (2004): p. 136601; d - Hoertz, P.G., et al., *Comprehensive Investigation of Self-Assembled Monolayer Formation on Ferromagnetic Thin Film Surfaces.* J Am Chem Soc, **30** (2008): p. 9763-9772; e - Devillers, S., et al., *1-Dodecanethiol Self-Assembled Monolayers on Cobalt.* Langmuir, **24** (2011): p. 14849-14860; f - Mekhalif, Z., et al., *Elaboration of Self-Assembled Monolayers of n-Alkanethiols on Nickel Polycrystalline Substrates: Time, Concentration, and Solvent Effects.* Langmuir, **3** (2003): p. 637-645.

3. a - Nicholson, D.M.C., et al., *Magnetic structure and electronic transport in permalloy.* Journal of Applied Physics, **8** (1997): p. 4023-4025; b - Nahrwold, G., et al., *Structural, magnetic, and transport properties of Permalloy for spintronic experiments.* Journal of Applied Physics, **1** (2010): p. 013907-6.

Figures

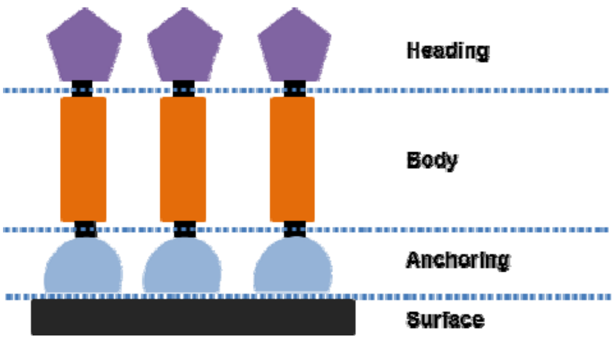

Figure 1 Self assembled Monolayer Scheme

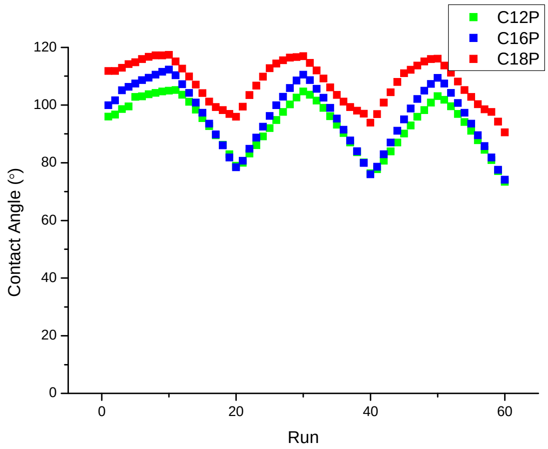

Figure 2 Dynamic Water Contact Angle measurements of $C_{12}P$, $C_{16}P$ and $C_{18}P$.

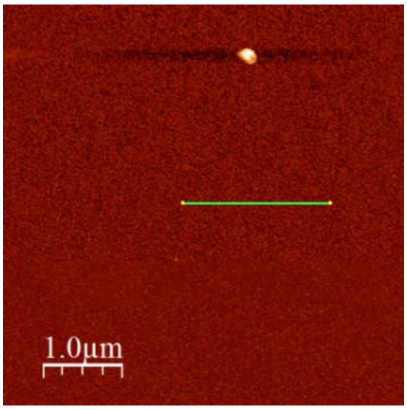

Figure 3 AFM image of a $C_{16}P$ SAM over Permalloy