

## Interface Formation between a Monolayer and Cobalt

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Molecular-based materials are attractive for next-generation electronics because of the nearly limitless possibilities in tailoring the chemical structure of molecules for a desired functionality. An emerging field is to combine the molecular engineering capabilities of self-assembled monolayers (SAMs) with spintronics. Self-assembly of molecules onto gold has been extensively studied due to its stability in forming an Au-S bond [1]. Self-assembly of organic molecules onto a ferromagnet does not form as readily on a ferromagnet due to the lack of control of the interface composition (i. e., oxide formation). A common route to prepare organic-ferromagnet interfaces is to directly evaporate organic molecules onto ferromagnets since the metal-organic interface can be better controlled (i.e., without breaking vacuum) (for example, see [2] and [3]). However, vacuum-based deposition of organic materials increases manufacturing costs, and so developing a solution-based process is attractive for organic-based electronics. We have self-assembled SAMs onto a template-stripped cobalt surface to investigate the molecular-metal interface from a structural, chemical, and electronic point of view to provide a holistic picture of this organic-ferromagnetic interface.

Template-stripping is a method to prepare smooth Co surfaces protected from oxidation. First, Co is evaporated onto a chemically-treated Si (tSi) surface, and then the Co surface is laminated to a plastic substrate. The plastic/Co surface is stripped off of the tSi when SAM deposition is ready to take place, and the stripped Co substrate is immediately placed into SAM solution. This method provides a route to minimize the oxidation of Co surfaces when handled in ambient conditions. Octadecanethiol (ODT) and mercaptohexadecanoic acid (MHA) are molecules used to self-assemble onto Co. MHA is chosen because the thiol (-SH) and carboxylic acid (-COOH) ends provide a test for selective attachment on Co surfaces. For electrical measurements, the plastic/Co/MHA was laminated onto an H-terminated n-Si surface ( $\rho = 0.001 - 0.005 \Omega \cdot \text{cm}$ ) [1]. This hybrid molecule-metal interface is investigated by using microscopy, infrared spectroscopy, photoelectron spectroscopy, and electrical characterization to provide details of the physical, chemical, and electronic structure at that interface.

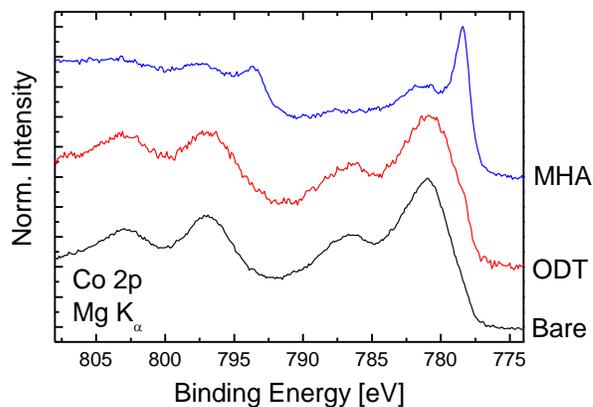
The self-assembly of ODT and MHA are directly confirmed by infrared spectroscopy and X-ray photoelectron spectroscopy (XPS). The absorbance intensities of the C-H stretches of ODT and MHA on Co are comparable to those on Au, which indicates similar packing density on both surfaces. The MHA molecular layer has added complexity to the organic-ferromagnetic interface since both the -SH and -COOH functional groups are able to bond. Moreover, the -COOH groups also affect the Co surface by reducing the native oxide as shown by XPS. Molecular electronic junctions formed on Si by flip-chip lamination [4] show that electron transport is heavily influenced by the MHA/Co interface when compared to a Si/MHA/Au control device. Preliminary results suggest that SAMs on Co surfaces are a promising route for controlling the organic-ferromagnetic interface for next generation devices.

### References

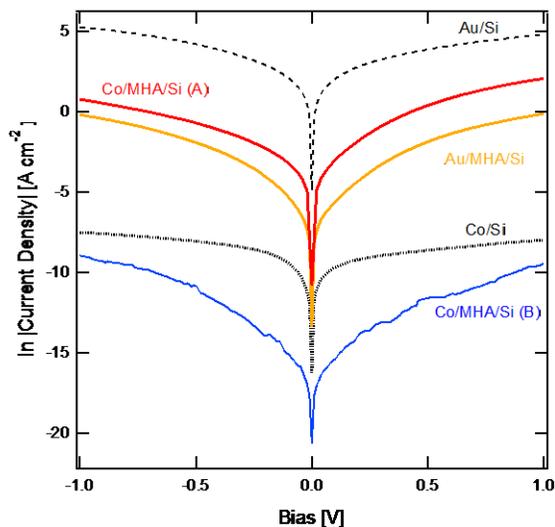
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**FIGURE 1.** XPS Co 2p spectra of template-stripped Co (bare, in black) and modified by ODT (red) and MHA (blue).



**FIGURE 2.** Current density vs. voltage characteristics of MHA molecular electronic junctions with Co ("A" in red and "B" in blue) and Au (in orange) contacts. Metal directly deposited onto identical H-Si wafers are shown as reference for Au (black dash, top most) and Co (black dot, 2<sup>nd</sup> from bottom).