Magnetic patterning by oxygen reduction using low energy Helium irradiation

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We introduce a new technique of printing magnetic nanostructure using low energy ion irradiation.[1] This approach transfers pattern through a mask into continuous magnetic film beneath. By avoiding physically fabricating nanostructure, neither bottom up or top down, the magnetic pattern produced by the process will have better shape uniformity and less magnetic interference between nearby patterns.

The general idea of this approach is quite simply. An oxide metal layer, which is non-magnetic, is firstly deposited on the substrate. The sample is then put into a low energy helium plasma etching process. Helium ions strike the sample surface, kicking element out of the non-magnetic film. Because the low mass and energy, oxygen is more likely to be removed from the oxide film, and the sample becomes magnetic again. The reason why we use helium is also because helium is safe and will not produce hydride byproduct.

Figure 1.a shows the theory how this approach works on Co oxide layers. Figure 1.b shows the result from VSM testing a Co oxide film before and after the low energy helium irradiation. The process successfully turns a non-magnetic layer into magnetic layer. With the protection of a predefined mask, area of magnetic and non-magnetic can be controlled and magnetic patterning of nanostructure in large area can be realized.

Figure 2 is the XPS results of Co and Co oxide samples before and after Helium irradiation. In 2.a, the lack of peak between 528 and 531eV, which represents metal oxides, proves the oxygen was kicked out during helium irradiation process. In 2.b, peaks from 780 to 782eV are Co oxide and Co hydroxide compound, and the peak at 778eV, which is Co again supports the theory of the oxygen reduction in helium irradiation.

[1] Kim, S., et al., *Nat Nanotechnol* 2012 Sep;7(9):567-71

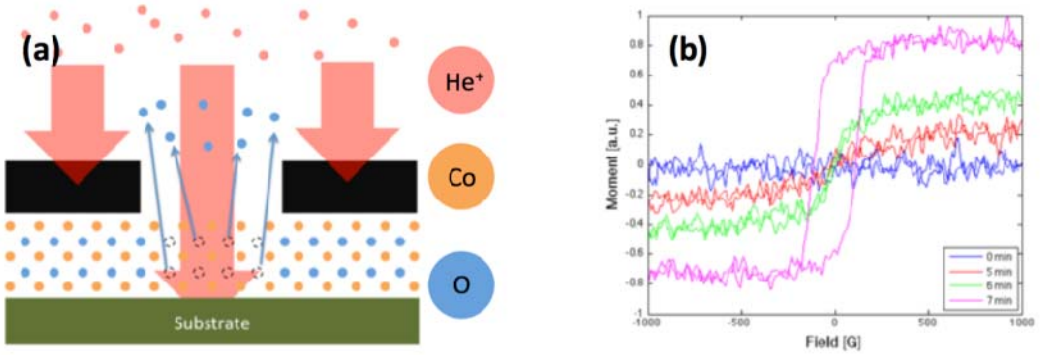

Figure 1: Low energy Helium reduction irradiation: (a) Low-energy helium irradiation is used to selectively remove oxygen atoms from the lattice enabling (b) nonmagnetic Co_xO_y to be transformed into magnetic Co after oxygen reduction.

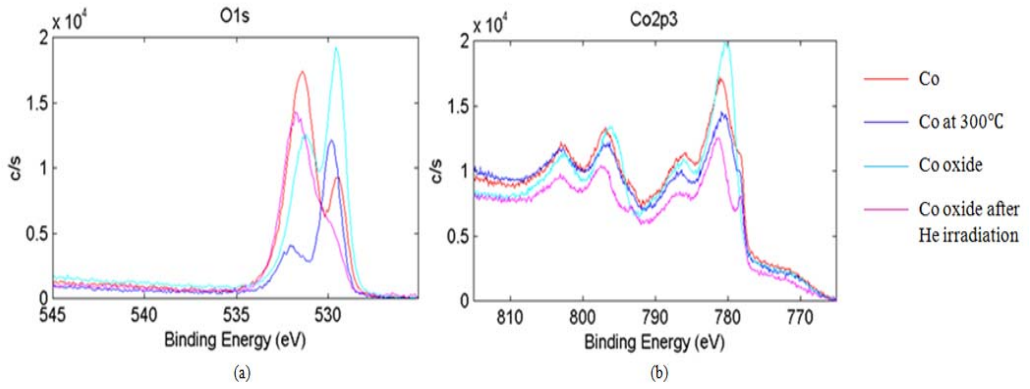

Figure 2: XPS measurement of Co and Co_xO_y before and after helium irradiation: (a) Oxygen peaks, (b) Cobalt peaks.