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IT-5-P-1706 Formation of oxidatively stable M@Fe_3O_4 and MPt@Fe_3O_4 (M = Fe, Co) core@shell nanoparticles using a simple and versatile synthetic procedure

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Core@shell nanoparticle synthesis offers the ability to create materials with dual characteristics, such as a magnetic core and a functionalisable or catalytically active shell. They are currently the subject of extensive research due to the tuneability of their structure and therefore properties.[1] Our research focusses on the coating of magnetically interesting materials to protect against oxidation. Iron and cobalt nanoparticles are both strongly magnetic, but are highly susceptible to oxidation. Much work has been carried out to coat these materials in organic surfactant and polymer layers in an attempt to protect against core oxidation;[1] however the coating procedure used in the current work utilises a 2-3 nm inorganic layer of Fe_3O_4, formed by the decomposition of $Fe(CO)_5$ in solution, to stabilize the particle cores. The recently published Co@Fe_3O_4 system has been shown to have detectable levels of carbon present after oxidative plasma cleaning. This carbon must therefore be contained within the particle structure, suggesting that surfactant molecules that capped the Co seeds became trapped during shell formation.[2] This has been verified using scanning transmission electron microscopy (STEM) to record electron energy loss spectroscopy (EELS) line scans and point scans with very high spatial resolution. Figure 1 shows the use of EELS point scans on a Co@Fe_3O_4 sample to confirm that, after plasma cleaning, no carbon can be detected at the outer surface of the particle shell, yet carbon remains detectable at the core-shell interface. It is also observable that in spite of the highly oxidative plasma cleaning process, the Co core remains metallic in nature. Figure 2 shows a line scan through an Fe@Fe_3O_4 nanoparticle, confirming a structure similar to that of Co@Fe_3O_4.

Recently, research has focused on utilizing the coating procedure to encapsulate FePt and CoPt alloys. These particles have interesting magnetic properties for applications in magnetic arrays for data storage. However, once synthesised, these particles require annealing, which often causes sintering. It has previously been established for FePt particles that a coating of iron oxide will prevent the particles from sintering during annealing.[3] However, the coating procedure used was different to that employed in our work. We are seeking to prove that the same stabilization is granted the particles by our coating procedure, and to further extend the annealing studies to the system of CoPt, the coating of which has not before been reported.

References

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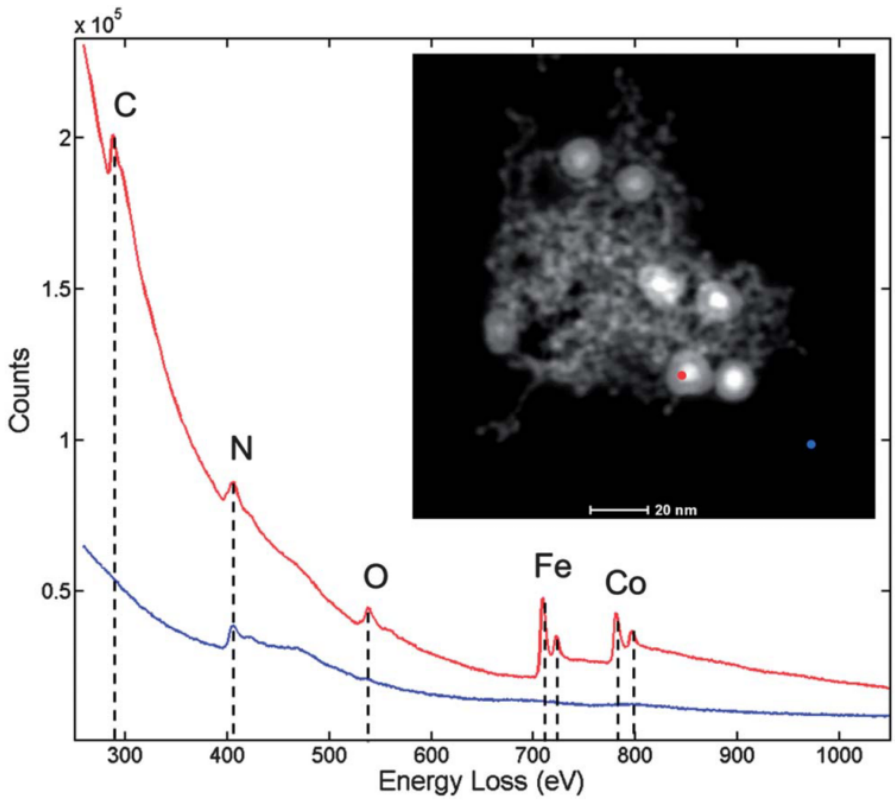

Fig. 1: Electron energy loss spectroscopy (EELS) point scans of the support (Si_3N_4, shown in blue) and the boundary of the core and shell of a particle. The signal clearly shows the presence of carbon within the structure of the particle after plasma cleaning.

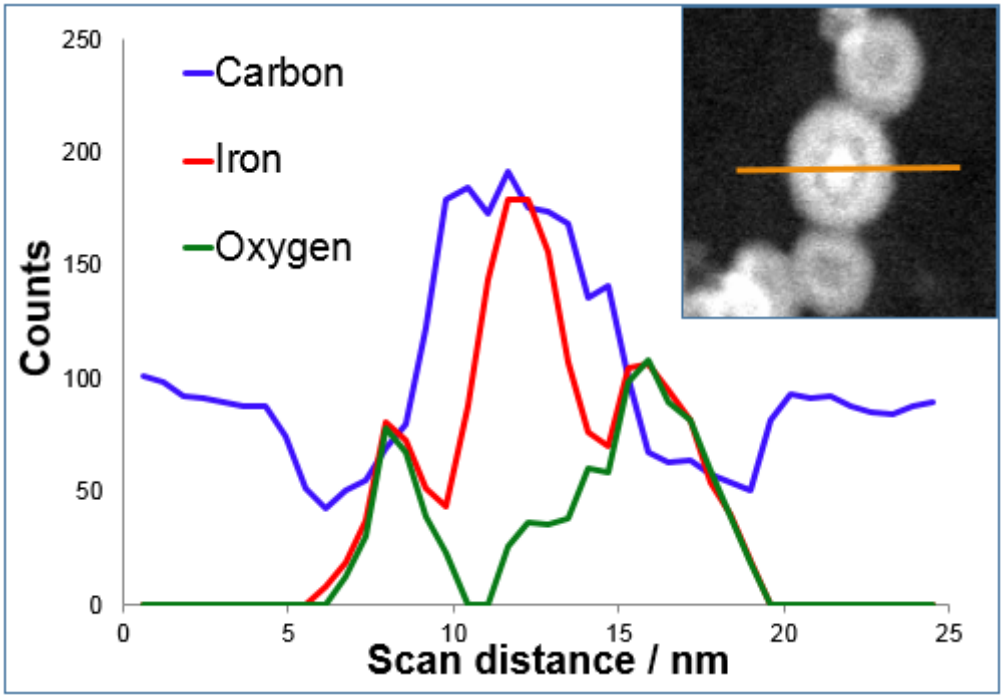

Fig. 2: EELS line scan of an $Fe@Fe_3O_4$ particle, evidencing the presence of carbon within the structure of the particle. Again, the sample had been plasma cleaned, thus removing all carbon-containing ligand molecules external to the particle structure.