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Controlling Crystal Structure in Embedded Magnetic Nanoparticles

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Magnetic nanoparticles and nanocomposite materials have attracted much interest due to their novel magnetic behaviour, and their potential use in a range of applications. One of the main reasons for their novel magnetism, appreciated for some time, is the high proportion of under-coordinated atoms at the surface of nanoparticles. In the case of magnetic transition metals this leads to a narrowing of the 3d bands that are responsible for magnetism in these materials, leading to size-dependent nanoparticle properties. The atomic structure adopted by nanoparticles is also a key factor in determining their magnetism. Unlike in bulk materials atomic structure in nanoparticles can be changed more readily by, for example, embedding them in suitable matrix materials. Here we describe how a high level of control over crystal structure in nanoparticles can be achieved, using EXAFS to "fingerprint" their crystal structure, and show how this in turn leads to a high degree of control over nanoparticle magnetism. We describe a flexible co-deposition process based around a gas aggregation source, which enables a high degree of control over structure in transition metal nanoparticles embedded in various matrices. EXAFS experiments and analysis used to probe atomic structure in embedded Fe and Co nanoparticles are described [1]. Examples presented include the system of Fe nanoparticles embedded in a CuAu alloy matrix where we show that is not only the ability to change the atomic structure of embedded nanoparticles that is important but the ability to fine-tune their structure once changed [2]. In this case, this enables the atomic magnetic Fe moment to be fine-tuned to a value higher than in the bulk Fe structure, in agreement with theory. In some systems alloying at the particle/interface can be significant. We describe how this is the case for Fe nanoparticles in Pd [3], and how such alloying could be useful in forming magnetic nanocomposites with superior properties.

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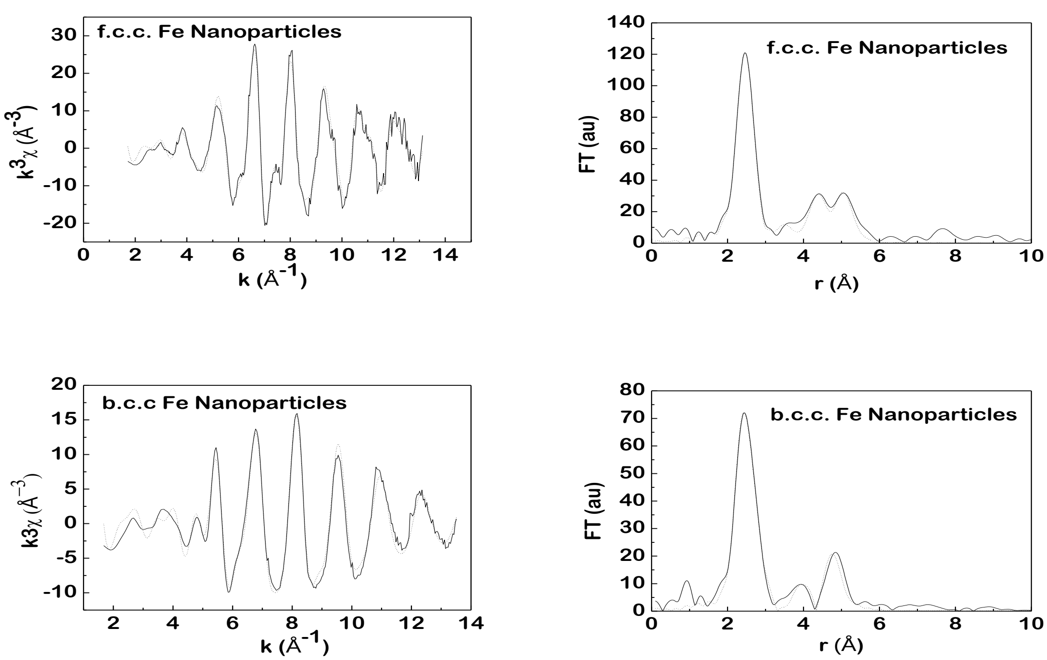

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