MAGNETIC PROPERTIES OF PLATINUM NANOPARTICLES

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Nanoparticles (NPs) exhibit physical properties that are different from bulk materials and result largely dependent on their size and structure, mainly because of two reasons: (i) As the size of these system reaches the typical lengths of some phenomena, it is expected that the response of the system depends on the boundary conditions (which are no longer periodic, but determined by the particle size), and therefore, to be different from bulk material. (ii) Because of the large ratio of surface to volume atoms in NPs, the surface energy becomes important when compared with volume energy, and therefore, the equilibrium situation can be different that for bulk materials. An example of this size effects is the superparamagnetic behaviour: The energy barrier to overcome for magnetization inversion is KV, being K the anisotropy constant and V the particle volume. In the case of nanoparticles, the volume is so small that the thermal energy (K_BT) can be enough to invert the magnetization with relaxation times as low as few seconds. Thus, the material looses coercivity and remanence, giving rise to the so-called superparamagnetic behaviour. Therefore, it is difficult to get nanoparticles exhibiting ferromagnetism at room temperature, as for nanoparticles with typical size of few nanometers the blocking temperature is around 10 K. On the contrary, we recently showed [1,2] it is possible that, because of size effects, nanoparticles made of non-ferromagnetic materials in bulk state, show ferromagnetism.

In this work we study the magnetic properties of small (2-5 nm size) carbon-coated Platinum nanoparticles. The particles exhibit ferromagnetism (hysteresis, coercivity and remanence) up to room temperature (fig. 1a). Saturation Magnetization is about 10^{-2} emu/g (fig. 1b) suggesting that only few atoms at the NP participate in the observed ferromagnetic behaviour, while the coercivity decreases with the temperature from 120 Oe at 5 K to 50 Oe at 300 K.

The particles present a large fraction of twin boundaries (fig. 2). The lack of cubic symmetry at the twin boundaries as well as charge transfer in the Pt –carbon bonds could give rise to permanent magnetic moments. The large spin-orbit coupling of platinum accounts for a huge magnetic anisotropy and therefore for the surprisingly high blocking temperature, above 300 K.

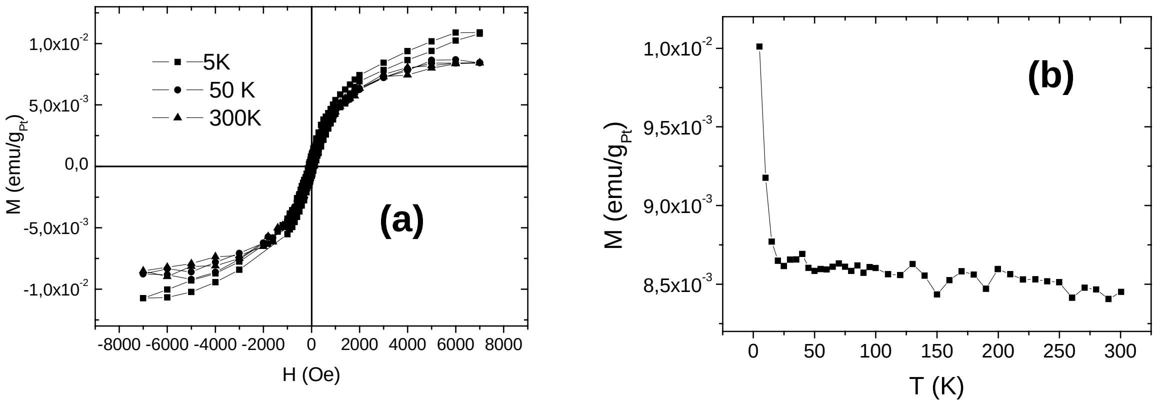

Figure 1. (a) Hysteresis loops of carbon-coated Pt NP at different temperatures. (b) Thermal dependence of magnetization under an applied field of 5000 Oe.

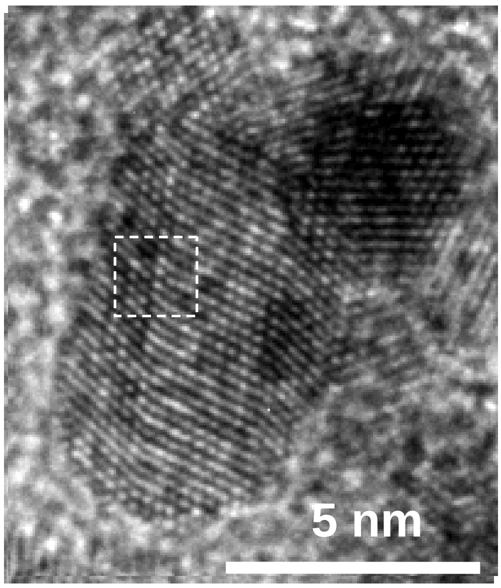

Figure 2. HREM image of a twined Pt nanocrystal along [10$\bar{1}$] zone.

References

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