Development of ferromagnetism in Pd nanoparticles with reduction in size

MOHINDAR SEEHRA, JAMES RALL, West Virginia University, J. LIU, C. ROBERTS, Auburn University — Bulk fcc Pd is a paramagnet just missing the Stoner criterion for ferromagnetism ($N(E_F)\Gamma > 1$) [1]. Several groups have reported weak ferromagnetism in 2-4 nm Pd nanoparticles (NPs) [2]. We report systematic development of weak ferromagnetism in Pd NPs with reduction in size. Magnetic measurements ($M$ vs. $T$) are compared for bulk Pd with those of size $D \approx 50$ nm, 7 nm, and 6 nm. The samples of size $D = 7$ nm and 6 nm were prepared by an aqueous seed-mediated growth and characterized by TEM and X-ray diffraction with the latter showing expansion of the lattice with decrease in size. Compared with the low-field magnetic susceptibility $\chi$ of bulk Pd, $\chi$ for the 7 and 6 nm NPs are enhanced by an order of magnitude. For the 50 nm NPs, $\chi$ follows nearly the Curie law. The hysteresis loops ($M$ vs. $H$) for the 7 and 6 nm NPs shows a decrease in coercivity and remanence from 2K to 300K suggesting $T_C > 300$ K. Origin of this ferromagnetism in terms of surface magnetism and lattice expansion is discussed.