$L1_0$-structure formation of FePtCu nanoparticles at 613 K using rf-magnetron sputtering

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$L1_0$-FePt and FePtCu nanoparticles have been directly synthesized by co-deposition of Fe, Pt and Cu using rf-magnetron sputtering onto NaCl substrate without any post-deposition annealing. Although the coalescence and sintered growth of the binary $L1_0$-FePt nanoparticles is more prominent than those of the ternary $L1_0$-FePtCu nanoparticles with increasing sputtering duration from 40 to 150 s at 613 K, the coercivity of nanoparticles of $L1_0$-FePtCu (9 kOe) at 10 K is much higher than that of FePt(2.4 kOe). The long range order (LRO) parameter (S) of individual isolated binary $L1_0$-FePt and ternary $L1_0$-FePtCu nanoparticles was determined by quantitative analysis of nanobeam electron diffraction (NBD) intensities and intensity calculations considering the multiple scattering of electrons. The particle thickness determination for the intensity calculation was made by taking advantage of the electron holography technique. For the ternary $L1_0$-FePtCu structure, Cu atoms were presumed to be randomly distributed on the Fe atom sites after our result of an ALCHEMI experiment. The estimated values of S for $L1_0$-FePtCu nanoparticles are found to be changed from 0.58 to 0.41 with decreasing the particle size from about 15 to 6nm, while those values for $L1_0$-FePt nanoparticles show a small particle size dependence and are as low a value as 0.2-0.3 within the same particle size range. High resolution electron microscopy revealed that the critical particle size for the $L1_0$-FePtCu structure formation was as small as 3nm. Although both ternary FePtCu and binary FePt alloy nanoparticles were fabricated under the same substrate temperature of 613 K, the LRO parameters of FePtCu nanoparticles show higher value than those of FePt nanoparticles which are consistent with the results of coercivity measurements.