DISPERSED CO THIN FILMS ON POLYIMIDE SUBSTRATE

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INTRODUCTION

A lot of recent works devoted to investigation of thin metal films dispersion kinetic. The materials often used in researches are low-melting metals such as tin, lead, bismuth (see eg [1, 2]). On their example scientists do attempts to work out theoretical models for describing this process. In other works (such as [3, 4]) present the results of studying physical properties of dispersed films, in some of them this process is considered as a method of producing magnetic and nonmagnetic metallic nanoparticle arrays, which can be used to create functional elements of microelectronics and sensor technics. This article devoted to the method of obtaining cobalt nanoparticle arrays on a polymer substrate during thermal annealing of thin metal films in a vacuum.

METHODS OF SAMPLE MANUFACTURING AND ANALYSIS

Polymer substrates for thin metal films deposition were obtained on microscopic copper grids from a solution of polyamic acid (see more details in [6]). Imidization (transformation to solid polyimide state) was made in vacuum at T = 420 K for 40 min. The thickness of produced polymeric substrates was less than 100 nm. Thin films of Co with an effective thickness of 1.5-3 nm were obtained using vacuum system VUP-5M with a residual gas pressure 10-3 Pa by thermoresistive evaporation of material. Effective thickness was measured using quartz crystal method. Studying of the structure and phase composition of samples prosecuted using a transmission electron microscope TEM-125K.

RESULTS AND DISCUSSION

Microscopic studies of Co thin films with an effective thickness of 1.5-3 nm showed that all samples after the deposition have nano-dispersed structure and hexagonal close-packed (hcp) crystal lattice.

To obtain arrays of metal nanoparticles samples were annealed in vacuum at different temperatures and annealing modes. Examples of TEM images showing structure and electronograms of cobalt films with initial effective thickness of 1.5 nm, annealed at T = 1000 K for different time periods are given on *fig. 1*.

Images shows dispersion process of Co films and metal islands formation with subsequent coalescence and formation of nanoparticles. The average particle size in the array in fig. 1b is 10 nm. Also there is a transition from the (hcp) lattice to a face-centered cubic (fcc).

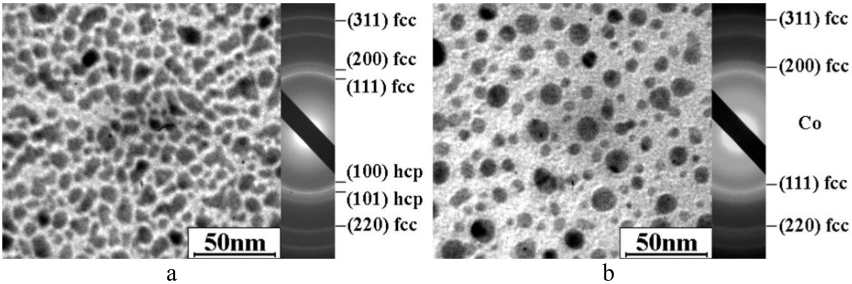

Fig. 1 – TEM images of Co thin films (initial effective thickness 1.5 nm) annealed in vacuum during 30 min (a) and 60 min (b) (T = 1000 K)

Experimental data shows that the increasing of initial effective thickness of metal films cause the increasing of average particle size. For example for Co films with initial effective thickness of 1.5 and 2 nm obtained nanoparticle average size (T = 900 K) was 6-7 and 8-9 nm, respectively.

Another factor affecting on the size of the metal nanoparticles is the annealing temperature. The increase in temperature leads to coalescence of smaller particles and increases their average size. *Fig. 2* shows TEM images of structure and electronograms of dispersed Co films with an initial effective thickness of 1.5 nm, annealed at T = 850 K and T = 1030 K.

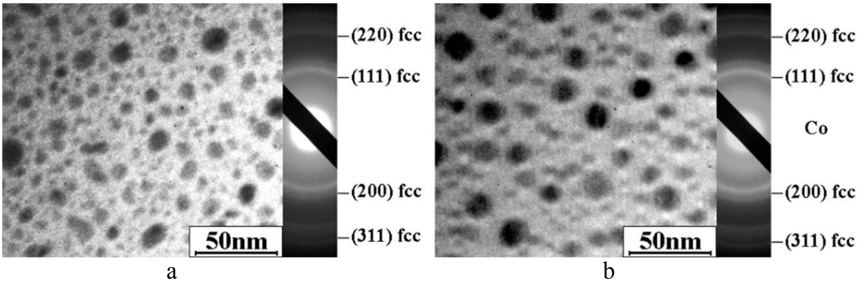

Fig. 2 – TEM images of Co thin films (initial effective thickness 1.5 nm) annealed in vacuum at T = 850 K (a) and T = 1030 K (b)

The average size of obtained nanoparticles is 6-7 and 11-12 nm, respectively.

Annealing of samples at different conditions showed that the decrease in speed of heating during annealing from 30-40 K/min (images of samples are shown in fig. 1, 2) to 3-6 K/min leads to formation of labyrinthine structures.

Also it should be noted that the optimal initial effective Co films thickness for formation of uniformly distributed on the substrate surface metal nanoparticle arrays (for chosen modes of annealing) was 1.5-2 nm.

CONCLUSIONS

The process of cobalt thin films dispersing, considered in this article gives the ability to create magnetic metal nanoparticle arrays with uniform distribution on the polymeric substrate surface. Thus selection of annealing mode and initial effective thickness allows to set the size of produced particles. Advantage of the given method is its relative simplicity as it doesn't demand introduction of surfactants and other substances to control the formation and coating process of nanoparticles, exception (reduction) of superficial interaction between them and fixing on a substrate surface (that frequently is necessary when using chemical methods).

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