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Atomic ordering and magnetic properties of polycrystalline $L1_0$-FePd dot arrays

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ABSTRACT

The polycrystalline $L1_0$-FePd (0 0 1) films considering a highly ordered dot array with various sizes have been successfully prepared by using a microfabrication process. The lateral size of square dots was changed in between 1 and 10 μm. The coercivity (H_c) of patterned $L1_0$-ordered FePd films was found to be slightly reduced compared to that of continuous film. Furthermore, H_c was slightly decreased after annealing at 500 °C. In the pinning mechanism, H_c can be determined by strong pinning sites for domain walls, which are the grain boundary regions in $L1_0$-ordered polycrystalline FePd films. These results indicate that the dot size dependence of H_c before and after annealing may be related to the pinning mechanism. The long-range ordering parameter (S) was increased after annealing. This demonstrates that post-annealing accelerates $L1_0$-FePd ordering, but there is no clear correlation between S and H_c.

1. Introduction

Currently, the most important issue in developing ultra high density of magnetic recording media is how to increase the areal storage density, i.e. the number of bits per in^2, and thermal stablity. In order to achieve beyond Tbit/in^2, it was required to develop a recording media with smaller particles [1]. However, a thermal fluctuation of magnetization becomes serious as the reduction of the bit size (superparamagnetic limit). One of the possible solutions is to use a high magnetic anisotropy material. Accordingly, $L1_0$-ordered FePt and FePd films have been recently paid attention for a magnetic recording media because of their high uniaxial magnetic anisotropy [1]. Highly ordered $L1_0$-FePt and FePd films can be deposited with an anisotropy axis perpendicular to the film plane that makes them suitable for the application of high density magnetic recording. Therefore, there have been many reports on high magnetic anisotropy of $L1_0$-FePt [2–4]. However, because the $L1_0$ ordering of FePd forms at a temperature lower than that in FePt, $L1_0$FePd may be more preferable for the application of magnetic recording media [5]. Recently, nanoscale patterned and particulate magnets are considered as one of the methods for ultra high density of magnetic recording media. In particular, the development of the microfabrication techniques enables us to fabricate the magnetic dot array with well-defined geometry. There are a number of research works on investigating the magnetic properties of FePt dots [6–13]. Furthermore, it is of great interest to study the coercivity and magnetic reversal mechanism in nanocrystalline films.

In this paper, a possible coercivity mechanism of polycrystalline FePd continuous film and dot arrays was discussed. The polycrystalline $L1_0$-FePd (0 0 1) dot arrays with various dot sizes were fabricated on MgO (0 0 1) substrates by using the microfabrication process. The magnetization process in the dot arrays was compared with that of continuous film. In addition, the effect of post-annealing on the magnetic properties was investigated.

2. Experimental procedure

FePd alloy thin films were deposited on MgO (0 0 1) substrate using DC magnetron sputtering system. The basic pressure during sputtering was kept below 5×10^{-7} Torr and the Ar working gas was controlled at 15 mTorr. A Fe layer of 1 nm and an epitaxial Cr (0 0 1) layer of 30 nm were deposited prior to depositing FePd alloy as a seed and a buffer layer, respectively. Monoatomic layers

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