摘要

具有高磁晶異向性常數之 $L1_0$ FePt 合金薄膜被認為具有成為下一代超高密度記錄媒體的主流材料潛力。欲使 FePt 薄膜應用於垂直磁記錄媒體，就必須獲得具有垂直磁異向之 $L1_0$ FePt 合金薄膜。然而，fct 結構之最密堆積面為(111)，因此 FePt 容易形成[111]從優取向使易磁化軸平行膜面。本研究探討磊晶及非磊晶成長機制對垂直磁異向性之 FePt 合金薄膜顯微結構與磁性質之影響。

本研究第一部分是將不同厚度之單層 $Fe_{100-x}Pt_x$ 薄膜直接沈積在不同溫度之基板上，探討 Pt 含量、基板溫度及薄膜厚度對於單層 FePt 薄膜顯微結構和垂直磁性質之影響。研究發現在 620 ℃ 之基板溫度以臨場直流磁控共鍍 30 nm 厚之序化 $Fe_{54}Pt_{46}$ 合金薄膜時，當薄膜厚度固定在 30 nm 時，以非磊晶機制可使單層 FePt 薄膜成長出很強的[001]從優取向，並呈現相當優異的垂直磁性質(垂直方向頑磁力達 14.0 kOe、飽和磁化量為 473 emu/cm^3 及垂直方向角形比為 0.96)。

本研究第二部分發現引入 5 nm 厚之 NiO 薄膜於單層 FePt 薄膜下方會使薄膜之垂直磁異向性產生劣化。增加 NiO 厚度至 10 nm 時，FePt 薄膜之垂直方向頑磁力值更大幅下降至 4.2 kOe。相較於 NiO 底層，引入 10 nm 厚之 MgO 底層其垂直方向頑磁力值則可達 12.5 kOe。將 MgO 底層厚度降低至 5 nm，FePt 薄膜之垂直磁異向性可進一步提升，不僅垂直方向頑磁力值可高達 13.6 kOe，其垂直方向角形比值更增加至 1。

本研究第三部分是利用高功率脈衝磁控濺鍍系統改變不同靶材尖峰功率密度將單層 FePt 合金薄膜直接沉積於康寧 1737 玻璃基板上，並將薄膜後退火熱處理於 550 - 700 ℃ 持溫 30 min。研究發現將靶材尖峰功率密度從 1196 W/cm^2 增加至 3538 W/cm^2，FePt 合金薄膜之垂直磁異向性會被大幅提升。另一方面，將退火熱處理溫度降低至 600 ℃ 持溫 30 min，10 nm 厚之 FePt 合金薄膜呈現細小晶粒。其垂直方向頑磁力值、垂直方向角形比值、磁晶異向性常數及平均晶粒尺寸分別為 6.5 kOe、0.99、3.1×10^7 erg/cm^3 及 6.1 nm，具備應用於高密度垂直磁記錄媒體的潛力。

Abstract

The $L1_0$ FePt thin film with high magnetocrystalline anisotropy constant is considered as a potential candidate for the next-generation of high-density magnetic recording materials. To realize the application of the FePt films as perpendicular magnetic recording media, it is necessary to obtain $L1_0$ FePt film with a perpendicular magnetic anisotropy. However, the close-packed plane of fct structure is (111), the FePt film normally has (111) preferred orientation and the easy axis incline towards film plane. In this study, we investigate the effect of epitaxial and nonepitaxial growth mechanism on microstructures and magnetic properties of FePt films with perpendicular magnetic anisotropy.

In the first topic, single-layered $Fe_{100-x}Pt_x$ films with various thicknesses were deposited directly on substrates at different temperatures, and the effects of Pt content, substrate temperature and film thickness on microstructures and perpendicular magnetic properties of FePt films were investigated. It was found that nonepitaxial single-layered $Fe_{54}Pt_{46}$ film with a thickness of 30 nm by in-situ depositing at 620 ℃ showed strong (001) preferred orientation and good perpendicular magnetic properties (perpendicular coercivity of 14.0 kOe, saturation magnetization of 473 emu/cm^3 and perpendicular squareness of 0.96, respectively).

In the second topic, the perpendicular magnetic anisotropy degrades when a 5-nm NiO film is introduced under this single-layered FePt film. Upon further increasing the thickness of the NiO film to 10 nm, the perpendicular coercivity of the FePt film decreases greatly to around 4.2 kOe. Compared to a NiO underlayer, the perpendicular coercivity of the FePt film remains above 12.5 kOe when a 10-nm MgO underlayer is introduced. Furthermore, when the thickness of the MgO underlayer is decreased to 5 nm, the perpendicular magnetic anisotropy of the FePt film is further

enhanced. The perpendicular coercivity not only stays high at 13.6 kOe, but perpendicular squareness also increases significantly to 1.

In the third topic, single-layered FePt films with various peak power density was deposited directly onto Corning 1737 glass substrate by high power impulse magnetron sputtering. The films were then post-annealed at 550 - 700 ℃ for 30 min. It is found that the perpendicular magnetic anisotropy of FePt films was enhanced greatly by increasing the peak power density from 1196 to 3538 W/cm^2. On the other hand, the 10-nm FePt thin films with fine grain can be obtained as the post-annealing temperature was decreased to 600 ℃ for 30 min. Its perpendicular coercivity, perpendicular squareness, magnetocrystalline anisotropy constant and average grain size are 6.5 kOe, 0.99, 3.1 × 10^7 erg/cm^3 and 6.1 nm respectively, which reveal its promising potential as perpendicular magnetic recording media for high-density recording.