行政院國家科學委員會專題研究計畫　期中進度報告

新穎磁性多層膜奈米磁區結構之製作分析與鑄型應用元件製作(2/3)

計畫類別： 整合型計畫
計畫編號： NSC93-2112-M-018-004-
執行期間： 93 年 08 月 01 日至 94 年 07 月 31 日
執行單位： 國立彰化師範大學物理學系暨研究所

計畫主持人： 吳仲卿

報告類型： 精簡報告

處理方式： 本計畫可公開查詢

中　華　民　國 94 年 5 月 27 日

行政院國家科學委員會補助專題研究計畫期中進度報告

新穎磁性多層膜與奈米結構之磁電效應研究—新穎磁性多層膜奈米磁區結構之製作分析與鑄型應用元件製作(2/3)

計畫類別：□ 個別型計畫　　■ 整合型計畫
計畫編號：NSC93－2112－M－018－004－
執行期間：　2004 年　8 月　1 日　至　2005 年　7 月　31 日

計畫主持人：吳仲卿教授

共同主持人：

成果報告類型(依經費核定清單規定繳交)：■精簡報告　□完整報告

本成果報告包括以下應繳交之附件：
□赴國外出差或研習心得報告一份
□赴大陸地區出差或研習心得報告一份
□出席國際學術會議心得報告及發表之論文各一份
□國際合作研究計畫國外研究報告書一份

執行單位：彰化師大物理系

中　華　民　國　94　年　5　月　23　日

中文摘要

在即將過去的一年為本三年期整合型計畫之第二年，延續第一年的研究成果與當初之計畫時程，我們持續探討微磁學相關的部分：內容涵蓋了（一）微米級各種形狀磁性膜元件之磁區結構及其相關磁矩翻轉行為探討；（二）垂直異向性磁性薄膜的矯頑場研究；（三）穿遂磁阻元件的研究；（四）磁通動力學的探討。而就第一項的部分又可以區隔成幾個子項，分別是：（1）橢圓形、網狀、方形、圓形磁膜元件之磁區結構，並分別以磁力顯微鏡及同步輻射之PEEM技術進行探測；（2）各種形狀之元件的翻轉行為，例如我們詳細探討了橢圓磁膜之長寬比與膜厚對翻轉機制的探討，另外磁元裡磁區結構對翻轉之影響也有詳盡之研究；（3）環狀磁膜元件中，不同膜厚相對於磁矩反轉行為也有進一步的瞭解。

接續去年七月之前發表的相關論文，這一年來我們已有十六篇已發表印行之學術論文，其中屬於SCI的論文則有十五篇。這些論文涵蓋了上述的各種研究領域，由這些成果，我們不僅對磁矩分佈有更進一層的認識，尤其對磁矩翻轉機制的探討更有深入的瞭解。在橢圓磁元之磁區結構方面有下列六篇（Refs.11,12,13,14,15,16）；方形磁元磁區結構有一篇（Ref.3）；網狀結構之磁區分佈有一篇（Ref.5）；橢圓磁矩翻轉有三篇（Refs.1,7,8）；環狀磁元之翻轉（Ref.10），尤其對於洋蔥態及漩渦態及其相混和態的形成時機，更對磁矩動態翻轉有了一定程度的掌控，甚至對直徑、線寬、及磁膜厚度相關之上述現象也完全掌握。對於進一步以電流誘致之方式操空磁矩動態行為也有進一步的瞭解，相信很快會有更豐富的成果；另外磁通動態的研究乃是磁區丁扎機制上，進一步研究幾何型態的相對應現象（Ref.17），此方面的研究相信有助釐清部分混淆之物理基礎概念；同時對於垂直異向性磁元之探討也有成果（Refs.4,5），此部分的瞭解將有助於提升儲存密度之研發，尤其應用在MRAM方面已引起國際上同行的一致認知；最後，本年度對於穿遂磁阻元件也有一篇成果（Ref.2），相信後續會有更進一步之成果。

關鍵詞: <u>微磁學</u>，<u>鎳鐵環</u>，<u>磁通動力學</u>，<u>穿遂磁阻</u>，<u>磁矩動態翻轉</u>

Abstract:

During this passed year, which is the second year of our three-year joint project, the micro-magnetism-related subjects studied in this sub-project cover: (1) magnetization configurations and their evolution under external magnetic field on various shapes of micro-structured permalloy devices; (2) the coercivity distribution and switching characteristics of patterned magnetic thin films having perpendicular magnetic anisotropy; (3) fabrication of magnetic tunneling junctions for the application of MRAM; (4) flux dynamics in Nb superconductor having regular artificial pinning centers. In addition, several subfields are categorized in the first item. They are (a) magnetization configurations in elliptical-, network-, disc-, rectangular-shaped elements, in which magnetic force microscopy and photo-emission electron microscopy (PEEM) using synchrotron radiation light source are employed for the domain investigation; (a) switching characterizations on various shapes of elements, such as the aspect ration and thickness; (c) ring-shaped element has been studied one step further as to understand the reversal behavior due to various dimensions.

Following the previous publication prior to last July we have published sixteen journal papers, in which fifteen of them are SCI papers. These achievements cover the aforementioned

fields, leading us to fully understand how the magnetic domain configurations develop in various elements having different shapes, film thickness, and aspect ratio, as well as the characterizations of their magnetization reversal. Refs. 11, 12, 13, 14, 15, 16 listed below are related to the elliptical permalloy elements.; Ref. 3 is related to rectangular permalloy element; Ref. 5 is related to the submicrometer permalloy network; Ref. 10 is related to the ring-shaped permalloy element, especially we have better knowledge in controlling the onion- and/or vortex-state in various rings, such as the diameter, linewidth, and ring thickness, also the current-induced switching in the ring has been further studied in such a way a great potential is expected in the read/write scheme for MRAM; Ref. 17 is related to the flux dynamic in the patterned Nb superconducting films, in which anisotropic effect has been investigated; Refs. 4 and 5 are related to the Magneto-Optical patterned films, which may lead to application for ultra-high density of magnetic data stoage; Ref. 2 is related to the fabrication of magnetic tunneling junctions, with which we have gone to a point where nanometer-sized memory cell shall be realized in the near future.

Keywords: Micro-magnetism, permalloy element, flux dynamics, magnetic tunneling junction, Magnetization.

References: (我們過去一年的發表論文清單)

1. I. Lo, J. Wu and L. Horng, Probing the local magnetization reversal though magnetoresistance measurement, to be published in J. Appl. Phys. 2005 (SCI)
2. A. Canizo-Cabrera, S. C. Li, M. F. Shu, J. M. Lee, V. Garcia-Vazquez, C. C. Chen, J. C. **Wu,** A. Takahashi, and T. H. Wu, Local current distribution and electrical properties of a magnetic tunnel junction using conducting atomic force microscopy, IEEE Trans. Magn. 41, 887(2005) (SCI&IE)
3. Mei-Feng Lai, Zung-Hang Wei, J. C. Wu, Ching-Ray Chang, W. Z. Hsieh, and Jun-Yang Lai, As-deposited magnetic states in arrays of rectangular permalloy elements, IEEE Trans. Magn. 41, 944(2005) (SCI&IE)
4. Te-Ho Wu, L. X. Ye, Chun-Shin Yeh, Y. W. Huang, Bohr-Ran Huang, and J. C. Wu, Magnetic Domain Reversal Behavior for Various Patterned Hole Depths, IEEE Trans. Magn. 41, 950(2005) (SCI&IE)
5. Mei-Feng Lai, Zung-Hang Wei, J. C. Wu, Ching-Ray Chang, N. A. Usov, Ida Chang and Jun-Yang Lai, Magnetization paterns of Permalloy Networks, IEEE Trans. Magn. 41, 953(2005) (SCI&IE)
6. L. X. Ye, J. M. Lee, J. C. Wu, and Te-Ho Wu, Magnetic Domain Structure and Coercivity Distribution for Patterned DyFeCo Thin Films, IEEE Trans. Magn. 41, 956(2005) (SCI&IE)
7. Y.C Chang, C.C Chang, W. Z. Hsieh, H. M. Lee, and J. C. Wu, Investigation on the dynamics of cross-tie walls in elliptical permalloy elements, IEEE Trans. Magn. 41, 959(2005) (SCI&IE)
8. C.C. Change, W.S Chung, Y.C. Change, and J.C. Wu, Influences of the aspect ratio and films thickness of elliptical permalloy elements on the switching properties, IEEE Trans. Magn. 41, 947(2005) (SCI&IE)

9. D. H. Wei, Y J. Hsu, C. C. Lin, C. H. Lai, J. Y. Ou, J. C. **Wu,** Layer- and lateral-resolved magnetization studies using photoemission electron microscopy, J. Magn. Magn Maters., 282, 49 (2004)(SCI)
10. C. C. Chang, Y. C. Chang, J. C. Wu, Z. H. Wei, M. F. Lai, C. R. Chang, and J. H. Kuo, Size effects on switching field of ring-shaped permalloy elements, J. Magn. Magn Maters., 282, 351 (2004)(SCI)
11. Mei-Feng Lai, Zung-Hang Wei, Ching-Ray Chang, N. A. Usov, J. C. Wu, Jun-Yang Lai, Nonuniform magnetization reversals in elliptical permalloy dots, J. Magn. Magn Maters., 282, 135 (2004)(SCI)
12. Zung-Hang Wei, Mei-Feng Lai, Ching-Ray Chang, N. A. Usov, J. C. Wu, Jun-Yang Lai, Nonuniform micromagnetic states in thin circular dots, J. Magn. Magn Maters., 282, 11 (2004)(SCI)
13. C. R. Chang, Z. H. Wei, M. F. Lai, and J. C. Wu, Magnetization processes in single domain permalloy thin films, Trans. of the materials Research Society of Japan 29, 1639(2004)
14. Zung-Hang Wei, Mei-Feng Lai, Ching-Ray Chang, N.A. Usov, J.C. Wu, and Jun-Yang Lai, Magnetization processes in single domain elliptical permalloy thin films, IEEE Trans. Magn., 40, 2107(2004)(SCI&EI)
15. Mei-Feng Lai, Zung-Hang Wei, Ching-Ray Chang, N.A. Usov, J.C. Wu, and Jun-Yang Lai, The metastable states in submicron elliptical thin films, J. Magn. Magn Maters.,272,1331(2004) (SCI)
16. Zung-Hang Wei, Mei-Feng Lai, Ching-Ray Chang, N.A. Usov, J.C. Wu, and Jun-Yang Lai, Magnetization processes in single domain elliptical permalloy thin films, J. Magn. Magn Maters.,272,563(2004) (SCI)
17. Lance Horng, J.C. Wu, P.C. Kang, T.C. Wu, T.J. Yang, Matching effect and .ux pinning force in a Nb superconducting thin film with a triangular lattice of articial pinning centers, J. Magn. Magn Maters.,272,1107(2004) (SCI)