

利用課題番号 : F-13-WS-0013  
利用形態 : 共同研究  
利用課題名 (日本語) : NiFe めっき膜形成  
Program Title (English) : Formation of Ni-Fe electrodeposited films  
利用者名 (日本語) : ツアイチャオ, 進士忠彦  
Username (English) : Chao Zhi<sup>1)</sup>, Shinshi Tadahiko<sup>2)</sup>  
所属名 (日本語) : 東京工業大学、精密工学研究所  
Affiliation (English) : Precision and Intelligence Laboratory, Tokyo Institute of Technology

### 1. 概要 (Summary) :

We aim to develop an integrated electromagnetic actuator utilizing a thin film permanent magnet covered with a ferromagnetic layer. The permanent magnet, also called thin film permanent magnet (TFPM), consisting of 300nm thick NdFeB layer and 10nm thick Ta layer deposited sequentially, attains high magnetic performance. Permalloy is chosen for the ferromagnetic layer. It can reduce the magnetic resistance of the TFPM, thus enhancing the actuator performance.

The actuator in the micro pump possesses a composite structure which consists of TFPM covered with permalloy. Electroplating method is selected due to its low cost, batch fabrication process and high fabrication speed. The permalloy is electroplated in Waseda Univ. To fabricate the permalloy with large magnetic saturation, Ni<sub>60</sub>Fe<sub>40</sub> is selected.

### 2. 実験 (Experimental) :

To fabricate Ni<sub>60</sub>Fe<sub>40</sub> film, an electroplating apparatus was used. The electroplating ingredient composed of the following materials in a 5L bath.

Material	Concentration
Ni(H <sub>2</sub> NSO <sub>3</sub> ) <sub>2</sub> ·4H <sub>2</sub> O	1 mol/dm <sup>3</sup>
NiCl <sub>2</sub> ·6H <sub>2</sub> O	0.1 mol/dm <sup>3</sup>
H <sub>3</sub> BO <sub>3</sub>	0.65 mol/dm <sup>3</sup>
Na(C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub> S)	0.0044 mol/dm <sup>3</sup>
FeCl <sub>2</sub> ·4H <sub>2</sub> O	0.2 mol/dm <sup>3</sup>
NaC <sub>12</sub> H <sub>25</sub> SO <sub>4</sub>	0.00035 mol/dm <sup>3</sup>

The bath temperature is 40°C, and the current during the electroplating is 10mA/cm<sup>2</sup>. The electroplating rate is 7.44 μm/h.

### 3. 結果と考察 (Results and Discussion) :

The electroplated permalloy is tested using a vibration sample magnetometer. The magnetic saturation is around 2T.

Furthermore, the permalloy-magnet is assemble with a micro coil. The electromagnetic force with permalloy increase 30% than without permalloy layer. Thus demonstrating the effect of permalloy. However, after releasing the structure from silicon substrate, the permalloy-TFPM structure bent due to the inner stress generated during the electroplating process. The future work is to reduce/avoid the inner stress generated in the electroplating.

### 4. その他・特記事項 (Others) :

本研究は、早稲田大学の斎藤美紀子教授、加藤邦男次席研究員との共同で行われたものである。

### 5. 論文・学会発表 (Publication/Presentation) :

A paper related with the electroplating is under preparation.

### 6. 関連特許 (Patent) :

なし