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### RECENT DEVELOPMENT OF MAGNETIC THIN-FILM DEVICES

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#### 1. INTRODUCTION

Recently, a new research field called micro-magnetic devices has drawn the attention of an increasing number of researchers. The objective in this field is the development of very small magnetic devices with planar structure which can be integrated with silicon and other kinds of electronic circuits monolithically. The micro-magnetic devices cover both bulk-planar devices and thin-film devices. Thin-film devices includes thin-film inductors and transformers used over 10 MHz range, and thin-film sensors and actuators.

This paper reviews recent developments of magnetic thin-film devices.

#### 2. KEY TECHNOLOGIES

Three technology areas are being exploited to develop magnetic thin-film devices : first, the development of new materials, second, micro-lithography and dry etching techniques, and third, the analysis, simulation and design of devices.

#### 3. THIN-FILM INDUCTORS AND TRANSFORMERS

There is an increasing number of application oriented works about the development of magnetic thin-film inductors [1]-[4] and transformers [5], [6]. They occupy only a few square-millimeters, operate over 10 MHz range, and can be integrated with semiconductor integrated circuits. Some papers have already demonstrated their application for small power supplies used for personal electronic equipment [5], [6].

Besides, magnetic thin-film inductors have a potential for miniaturized LC filters, especially at several tens of megahertz region. We manufactured thin-film LC filters composed of thin-film inductor and thin-film capacitor by using RF sputtering and dry-etching techniques, measured the frequency characteristics, and then discussed the merits of magnetic thin-film inductors comparing to non-magnetic thin-film inductor in LC filters application. It is clarified that both obvious size reduction and improved electric characteristics are attained by using magnetic thin-film inductors comparing to non-magnetic thin-film inductors at the 10-100 MHz range.

#### 4. THIN-FILM SENSORS AND ACTUATORS

In the micro electro mechanical systems (MEMS), it is thought that electromagnetic force is more promising than electrostatic force for a millimeter-size devices [7]. Accordingly magnetic thin-film sensors and actuators are coming into current interests.

We proposed a new kind of magnetoelastic element composed of a piezoelectric substrate and magnetostrictive FeSiB thin-films, which is composed of a 600  $\mu\text{m}$  thick piezoelectric PZT

substrate with both sides covered with 1  $\mu\text{m}$  thick magnetostrictive  $\text{Fe}_{78}\text{Si}_{10}\text{B}_{12}$  at%(at target) amorphous films. The magnetic permeability showed a total variation of about 28% and the coercive force showed a 10% variation when the applied strain varied between plus-minus 400 volts. The initial permeability also varied dynamically when sinusoidal and triangular electric fields are applied.

We also proposed a thin-film cantilever actuator made of TbFe (positive magnetostriction) and SmFe (negative magnetostriction) magnetostrictive amorphous films on opposite sides of a poly-imide film. The cantilever actuator exhibited over 7100  $\mu\text{m}$  of displacement.

## 5. CONCLUSION

The research area of thin-film devices covers from materials to applications. At present, the most promising devices are thin-film inductors and transformers in Japan. We hope this article would be of interests in Korea.

## 6. REFERENCES

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