이중 나선형 NiFe 자성 박막인덕터를 이용한 원칩 DC-DC 컨버터 응용

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Double rectangular spiral thin-film inductors implemented with NiFe magnetic cores for on-chip dc-dc converter applications

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Abstract : This paper describes a simple, on-chip CMOS compatible the thin-film inductor applied for the dc-dc converters. A fully CMOS-compatible thin-film inductor with a bottom NiFe core is integrated with the DC-DC converter circuit on the same chip. By eliminating ineffective top magnetic layer, very simple process integration was achieved. Fabricated monolithic thin film inductor showed fairly high inductance of 2.2 μH and Q factor of 11.2 at 5MHz. When the DC-DC converter operated at V_{in}=3.3V and 5MHz frequency, it showed output voltage V_{out}=8.0V, and corresponding power efficiency was 85%.

Key Words : thin-film inductor, NiFe magnetic core, dc-dc converter

1. Introduction

Recently, the information technology has been rapidly developed to increase the functional become an important issue to develop the micro-integrated technology. Due to the progress in fabrication of smaller and lighter portable products, the thin film inductor is one of the promising devices for DC-DC converting systems. When applying magnetic thin-film inductors to MHz switching DC-DC converters, inductors are required to have the inductance of micro Henry and high quality factor over unity.

In this paper, the double-rectangular spiral type thin-film inductors utilizing NiFe core material were developed by the CMOS process and their performances were evaluated. Moreover, a boost-type DC-DC converter circuit that is implemented with the thin-film inductor on the same chip is presented.

2. Experiments and Discussions

The one chip thin film inductor is composed of the double rectangular spiral types of coils which was grown by the 15 μm-thick electroplated copper upon NiFe magnetic core. After implementing the high-voltage, double metal CMOS devices for the boost type DC-DC converter, 2.5μm-thick NiFe magnetic films for the bottom magnetic core were deposited on the polyimide films. Then, additional polyimide film were coated and cured to isolate the magnetic layer from the coil inductor. Through the sequential processes of 6 μm-thick polyimide, PECVD oxide etching, deposition of Ti-Cu seed layer, and electroplating the copper coil, the interconnection between DC-DC converter IC and copper coil of the inductor were done. By using SEM photography and contact string patterns, the contact properties such as cross-section and contact resistance were analyzed. Also the contact resistance was greatly reduced through the RF cleaning process. Using the impedance HP4194A analyzer, we evaluate inductance, equivalent series resistance, and Q-factor of the thin-film inductor. From the results, the monolithic inductor in this work revealed inductance of 1.6mH and Q factor of 11.2 at 5MHz.

3. Conclusions

In summary, a fully CMOS-compatible thin-film inductor with a bottom NiFe core is integrated with the DC-DC converter circuit on the same chip. By eliminating ineffective top magnetic layer, very simple process integration was achieved. Fabricated monolithic thin film inductor showed fairly high inductance of 2.2 μH and Q factor of 11.2 at 5MHz. When the DC-DC converter operated at V_{in}=3.3V and 5MHz frequency, it showed output voltage V_{out}=8.0V, and corresponding power efficiency was 85%.

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