RESUME

PERSONAL DETAILS

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DATE OF BIRTH:	Apr. 2, 1977
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EDUCATION

Doctor of Microelectronics and Solid-State Electronics **April 2006**
Institute of Micro and Nano science and technology,
Shanghai Jiaotong University, advised by Prof. Yong Zhou
Cumulative GPA 3.4

Master of Advanced Materials Science **March 2003**
Department of Materials Science & Engineering
Northeastern University, advised by Prof. Liang Zuo
Cumulative GPA 3.27

Bachelor of Advanced Materials Science **July 2000**
Department of Materials Science & Engineering
Northeastern University
Cumulative GPA 3.15

RESEARCH EXPERIENCES

Research assistant, Prof. Yong Zhou at the National Key Laboratory of Nano/Micro Fabrication Technology, Key Laboratory for Thin Film and Microfabrication of Ministry of Education, Institute of Micro and Nano Science & Technology，Shanghai Jiaotong University (2003-2005)
Research assistant, Prof. Yuhui Sha at the Institute of Materials, Northeastern University (2001-2003)

COMPLETED & ON-GOING PROJECTS

- Study on Fabrication of Integrated Magnetic Thin Film Microinductor, supported by Innovation Fund Program of Information Industry Department (2002-2004)
- Study on Fabrication of Microindutor with Nano-crystallined Magnetic Thin Film, supported by Nanotechnology Program of Shanghai Science & Technology Committee (2003-2005)
- Research of Microinductor with Soft Nano-crystallined Magnetic Thin Films by MEMS, supported by High Technology Research Development Programme of China (2004-2005)
- Study on Fabrication of Microinductor with Magnetic Core Based on Soft Nano-crystallined

Magnetic Thin Films, Supported by Samsung Advanced Institute of Technology (SAIT), Samsung Electronics Co., Ltd (2004-2006)

TOPIC OF DOCTORAL DISSERTATION

Microfabrication technology of solenoid-type microinductors with magnetic core based MEMS technique （in detail at the last of document）

HONORS & AWARDS

- Title of "Three Goods Student", Northeastern University 1998
  Title of "Three Goods Student", Northeastern University 2002
  Title of "Three Goods Student", Shanghai Jiaotong University 2004
- Different kinds of Scholarship, Northeastern University 1997-2000
- "Lite" Scholarship, Shanghai Jiaotong University 2005
- "Shanghai- Applied Material Research and Development Fund" Scholarship 2005

RESEARCH INTERESTS

- Design, fabrication, and characterization of MEMS devices
- RF MEMS devices
- Thin film microelectronic materials

QUALIFICATIONS & SKILLS

- Strong Commitment to MEMS devices in Research
- Demonstrated ability to use a variety of microfabrication machines and equipments
- A Good Team Worker in cooperation with Others
- Ability to use Computer Applications such as MEMS Analysis Tools，Matlab, AutoCAD, Photoshop, MS-Office, and Acrobat, etc.
- Strong skills in analysis, communication, presentation and problem solving.
- Fluent English writing and speaking skills

JOURNAL PUBLICATIONS

- **Xiao-Yu Gao**, Yong Zhou, Wen Ding, et al. Fabrication of Ultralow-Profile Micromachined Inductor with Magnetic Core Material, IEEE Transactions on Magnetics, 2005, 41(12): 4397-4400. (Sci&Ei）
- **GAO Xiaoyu**, ZHOU Yong, WANG Xining, et al. Study of solenoid-type inductor fabricated by MEMS technique，Chinese Journal of Semiconductors, 2005, 26(6): 1083-1086. (Ei)
- **Gao Xiaoyu**, Zhou Yong, Chen Ji'an, et al. Fabrication of solenoid-type microinductor with different magnetic core schemes by MEMS technique, High technology letters, accepted. (Ei)
- **GAO Xiao-yu**, CHEN Ji-an, ZHOU Yong, et al. Development of the Magnetic Thin Film Microinductor, Electronic Components&Materials, 2005, 4，68-71. (in Chinese)
- **GAO Xiao-yu**, ZHOU Yong, CHEN Ji-an,et al., Application of Different Magnetic Core Materials in Microinductor , Semiconductor technology, 2005, 30(10): 58-61. (in Chinese)
- **GAO Xiaoyu**, ZHOU Yong, LEI Chong, et al. Study of Solenoid-type Microinductor with Magnetic Core Fabricated by MEMS Technique, Research & Progress of Solid State Electronics, accepted. (in Chinese) (Ei)

- Zhou,Yong, Mao,Xin-Hui, Chen,Ji-An, Ding,Wen, **Gao,Xiao-Yu**, et al. Stress-impedance effects in layered FeSiB/Cu/FeSiB films with a meander line structure, Journal of Magnetism and Magnetic Material, 2005, 292: 255-259. (Sci & Ei)
- Zhou,Yong, Ding,Wen, Mao,Xin-Hui, Chen,Ji-An, Zhang,Ya-Min, **Gao,Xiao-Yu**. Stress-impedance effects in multilayered FeSiB/Cu/FeSiB films, Thin Solid Films, 2005, 489(1-2): 177-180. (Sci & Ei)
- **Xiao-Yu Gao**, Ying Cao, Yong Zhou, et al. Fabrication of Solenoid-Type Inductor with Electroplated NiFe Magnetic Core, Journal of Magnetism and Magnetic Material, revised. (Sci & Ei)
- **Xiao-Yu Gao**, Yong Zhou, Ying Cao , et al. Integrated microinductor using copper/polyimide fabrication process with high inductance, Journal of Micromechanics and Microengineering, submitted. (Sci & Ei)
- **Xiao-Yu Gao**, Yong Zhou, Ying Cao, et al. Copper/Polyimide Fabrication Process for Microinductor on Achieving High Inductance, IEEE Transactions on Electronics Packaging manufacturing, revised. (Sci & Ei)

ISSUED PATENTS

- Zhou Yong, **Gao Xiaoyu**, Zhou haitao, Chen Ji-an, Solenoidal Microinductor with Magnetic Core and the Ways of Fabrication, Patent No. 200410017852.8. (granted)
- Zhou Yong, **Gao Xiaoyu**, Zhou haitao, Chen Ji-an, Fabrication of Solenoidal Microinductor with Magnetic Core by MEMS Technique, Patent No. 200410017853.2. (pending)
- Zhou Yong, Chen Ji-an Ding Wen, Zhang Yaming, **Gao Xiaoyu**, Multilayer Soft Magnetic Thin Film Force Sensor and the Ways of Preparation, Parent No. 200410067583.6. (pending)

REFERENCES

- Prof. Dr. Yong Zhou, Shanghai Jiao Tong University, Tutor for Ph.D. yzhou@sjtu.edu.cn, Tel: 0086-21-62933717
- Prof. Dr. Yuhui Sha, Northeastern University, Tutor for Master Degree, yhsha@mail.neu.edu.cn Tel: 0086-24-83684611
- Prof. Xiaolin Zhao, Shanghai Jiao Tong University, Director of lab, xlzhao@sjtu.edu.cn , Tel: 0086-21-62933717

TOPIC OF DOCTORAL DISSERTATION

Microfabrication technology of solenoid-type microinductors with magnetic core based MEMS technique

Recently, the portable electronic products tend to go more and more small size and miniaturization, and have been entering our social life in explosive way. Magnetic components such as inductors are the essential components in constructing the power supply transformer, DC-DC converter, filter, amplifier and oscillator, and the miniaturization and the integration of

inductor with electronic circuit are the key to realize the electronic products with high performance, small size and light weight. Especially, micro DC-DC converters constructed by magnetic thin film microinductor will be extensively applied in all kinds of portable electronic products. With the development of VLSI (Very Large Scale Integrated circuit), system integration, and high density of surface mounted PCB (Printed Circuit Board) component, there has been a great demand for microinductor with high power in the market. So it attracts great attentions for scientists all over the world to fabricate the passive microinductor with high performance.

At present, the requirements for microinductor used in micro DC-DC converter, there are several key factors that must be solved for the inductor, such as: 1) adequate inductance and quality factor (Q-factor) to store high energy. Inductance value greater than 1μH and Q-factor of 1 or more are critical in the 1-10 MHz range; 2) small area. The overall area should be constrained to <20 mm^2 (and <1 mm in height); 3) high saturation current. It should not saturate at low current level; 4) low temperature fabrication process. In recent years, with the development of microelectromechanical system (MEMS), the non-silicon fabrication technology of UV-LIGA (UV-Lithografie, Galvanoformung, Abformung) has especially become one of the most advanced technologies to fabricate the three-dimensional structures and RF-MEMS. The microinductors fabricated by MEMS technique combined with thin film technique should have advantages of low resistance, high inductance, high Q-factor, high efficiency, low loss, low product cost and batch fabrication, which is the key component for the micro DC-DC converter, and can be extensively applied in wireless communication, military affairs/ aerospace equipment, computer/ external equipment and other different kinds of power supply unit for portable electronic products.

In order to meet this demand for microinductor and the development of the microinductor in the world, MEMS techniques such as UV-LIGA, dry etching, wet etching, fine polishing, magnetron sputtering, and electroplating technique were used to fabricate the microinductors with different kinds of structures, materials and thickness of magnetic core. In a word, the main work and the conclusions of this thesis are as follows:

(1) Preparation and characterization of magnetic core materials

Magnetic materials with high permeability and high saturation magnetic induction density are very important conditions for microinductor to achieve high inductance and Q-factor. In this paper, soft magnetic NiFe film and FeCuNbCrSiB film were used as the magnetic core materials. NiFe film was prepared by electroplating method with magnetic field applied during the deposition process in order to induce the uniaxial magnetic anisotropy. Soft magnetic FeCuNbCrSiB film was sputter deposited, and the sputtering conditions such as Ar gas flow rate, sputtering power, sputtering gas pressure were studied and optimized. Differential Scanning Calorimeter (DSC), X-ray, and Atom Force Microscopy (AFM) were used to analysis the structure of the as-deposited film before and after annealing, VSM was used to study the properties of the magnetic film. Experimental results indicate that the NiFe film and the FeCuNbCrSiB film possess very good soft magnetic properties, which is suitable for the magnetic core materials of microinductors.

(2) Microfabrication technology of microinductor with magnetic core

Thin film technology and MEMS were used to fabricate microinductors with different kinds of magnetic core schemes and magnetic materials, including sputtering, coating, lithography, electroplating, dry etching technique, wet etching technique and fine polishing etc. During the fabrication process, the following key issues have been solved: 1) by appropriate designs for mask and double-side mask alignment marks, the problem of double-side mask alignment

photolithography was solved, and the photoresist mold with high aspect ratio was formed; 2) solenoid-type coil and vias were realized by deep electroplating through adding some additives; 3) polyimide and Al_2O_3 film were used as the insulation materials, where the Al_2O_3 film was deposited by sputtering method, and the polyimide was spin coated and solidified at high temperature, and fine polishing was used for polyimide and Al_2O_3 film in order to keep the surface planarity of multilevel metallization; 4) chemical wet etching method was used to etch the FeCuNbCrSiB film, and the removal of seed layer was by dry etching instead of wet etching in avoiding of the erosion of conductor. Through the above-mentioned process, we firstly fabricated the solenoid-type inductor with FeCuNbCrSiB thin film as magnetic core material and polyimide or aluminum oxide as insulator material successfully.

(3) The measurement of microinductor with magnetic core

The fabricated microinductors were measured by the Agilent E4991A Impedance Analyzer and combined with Cascade Cooperation microprobe RF station and characterized by the parameters of inductance L, and quality factor Q etc. in the frequency range of 1-10 MHz. The results show that the performance of microinductor with magnetic core of rectangular shape is almost the same as that with elliptical shape; higher inductance was obtained by magnetic core structure with unequal width than that of equal with in the same profile area. So it provided experiment proof for the miniarization of microinductor in future. The inductance increased and Q-factor decreased along with the increase of film thickness of NiFe film is obtained from the experiments in microinductor with NiFe magnetic core, however, the inductance and Q-factor increases along with the increase of the film thickness of the FeCuNbCrSiB magnetic core, and the inductance values keep relatively constant along with the measured frequency range. So the microinductors obtained in this experiment have been applied in the mobile communication circuit fabricated by China Aerospace Ninth Academy.

(4) The modeling and analysis of microinductor with magnetic core

The microinductors were characterized and modeled using lump element models through Maxwell equations. The Matlab software was used to get the performance of microinductor as function of frequency. The effect of structure parameters of the solenoid-type coil and magnetic core such as line width, space and thickness, width and thickness of magnetic core on the performance of microinductor was modeled, analyzed and optimized within the profile area of 4mm×4mm. The calculated results used Nife film or FeCuNbCrSiB film as magnetic core material are compared with the experiment data in good accordance, and can be used for the guidance of the fabrication of inductor in the future.