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July 6, 1995

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Dear Dr. Shibasaki:

On behalf of the Program Committee and IEEE/LEOS Meetings Manager, Samantha Phillips, I would like to thank you once again for agreeing to give an invited presentation at the IEEE Lasers and Electro-Optics Society 1995 Annual Meeting (LEOS '95). The meeting will be held October 30 - November 2, 1995 at the Parc Fifty Five Hotel in San Francisco, California. Your presentation has been scheduled and is listed below.

PAPER NUMBER: OMP 2.1
PAPER TITLE: The practical Hall elements as magnetic sensors by thin film technology
SESSION: Novel Material Applications
DATE: Monday, October 30, 1995
TIME: 03:30P - 04:00P
ROOM: Cerventes

The time allocated for your talk is 30 minutes. An overhead projector for transparencies will be available during the presentation. **Any additioanl audio-visual equipment, including 35mm slide projector, must be requested in writing to the IEEE/LEOS Executive office by September 15, 1995.** If you have any questions contact me at (908) 562.3898 by phone; (908) 562.8434 by fax; or w.seter@ieee.org by email.

If you have not already done so, please send summary to the LEOS office immediately. **Please, sign and return the enclosed IEEE copyright form to my attention at the IEEE/LEOS Executive Office by September 15, 1995.**

Please note that all speakers, session chairmen and committee members must pay the registration fee in order to support the conference. Complete registration and housing information will be sent to you with the Advance Program as soon as it is available. Thank you for your support of LEOS '95 Annual Meeting and we look forward to seeing you in San Francisco, California.

Regards,

Wanda L. Seter
Wanda L. Seter
IEEE/LEOS Conference Assistant, LEOS Annual Meeting '95

3:30pm - 4:00pm (Invited)
OMP2.1

The practical Hall elements as magnetic sensors by thin film technology

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Abstract

InSb thin films by vacuum deposition, Si-doped InAs thin films and InAs deep quantum well with lattice matched barrier layers to InAs by molecular beam epitaxy were applied to Hall elements as practical magnetic sensors.

§ 1. Introduction

Recently there have been strong demands for Hall elements in the field of electronic equipments such as video cassette recorders, personal computers with floppy disk drives, and compact disk read-only memory drives and other electronic systems. Hall elements are mainly used for brushless motors in those equipments as magnetic sensors. Therefore, over 700 million InSb high sensitive Hall elements by thin film technology are produced and served commercially in 1994. In this paper, practical magnetic sensors made by InSb thin films by vacuum deposition and InAs thin films by molecular beam epitaxy (MBE) including deep quantum well (DQW) structure would be discussed . The importance of thin film production technology would be understood in the field of magnetic sensors.

§ 2. High sensitive InSb Hall elements by vacuum deposition

InSb polycrystal thin films grown on mica substrates by vacuum deposition have high electron mobility and high sheet resistance and applied to fabricate high sensitive Hall elements with nice characteristics i.e. possible to mass production, small size , stable Hall output voltage at room temperature region. [1]

InSb thin films are grown on thin mica substrates by using vacuum deposition system with multi-evaporation sources. The substrate temperature is varied 2 steps wise with growing thin film thickness. Typical properties of InSb thin films are shown in table 1. This thin film is peeled off from mica substrate , bonded on ferrite substrate and then , processed to high sensitive Hall elements with special magnetic amplification structure where InSb thin film is sandwiched between ferrite substrate and ferrite chip as shown in Figure 1. The typical characteristics of this Hall element (HW-101A) are shown in table 2. These are high sensitivity in magnetic field i.e. low power consumption , small offset voltage and large input resistance. Moreover, at constant voltage driving , this Hall elements show stable temperature dependence for Hall output voltage at room temperature range . This is not the case for conventional InSb Hall elements which are made from sliced single crystal of InSb having few ohm input resistance. These properties are good for application . This Hall element is now one of the standard magnetic sensors for DC brushless motor(Hall motor) controls. 700 millions of this InSb Hall elements were produced in 1994. The only problem of this Hall elements is large temperature dependence of their resistance which restricts the operation temperature range near room temperature caused by narrow band gap of InSb.

§ 3. InAs thin film Hall elements by MBE

It was found that the properties of MBE grown InAs thin film on GaAs substrate doped with Si showed stable temperature properties and high electron mobility. The application of this InAs thin film to Hall elements realized practical magnetic sensors. i.e. high temperature stability is superior compared to InSb Hall elements showing possibility to drive good at higher temperature exceeding 100°C and also low temperature . [2,3] To fabricate the practical thin film InAs Hall elements, we designed a production MBE system with multi-wafers substrate holder having large growth area (twelve 2 inches diameter wafers for a subsuate holder) . To obtain thickness uniformity, long distance separation between source and substrates with large incident beam angle is also used.. Others are similar to ordinary experimental MBE system. After a rather long installation efforts, this system worked well .

By using this system , Si-doped InAs thin films were grown on GaAs substrate and this thin films were processed to InAs Hall elements by specially developed wafer process. This InAs Hall element is shown in photograph and their typical properties (HZ-106C) are shown in table 2. The higher driving voltage of 6V is possible to obtain high output Hall voltage. The temperature dependence of this Hall elements is shown in figure 2 showing wide range of operation temperature compared to InSb ones. 3 millions of this MBE Hall elements were already applied to practical purpose i.e. DC current sensors, Hall motors, etc..

§ 4. InAs deep quantum well (DQW) Hall Elements by MBE

InAs DQW having $Al_xGa_{1-x}As_ySb_{1-y}$ ($0 \leqq x,y \leqq 1$) insulating barrier layers lattice matched to InAs shown in Fig.2 was grown by MBE.[4,5] This DQW was processed to Hall elements and packaged using standard mass production line of Hall elements. Typical Hall output voltage is 250mV/0.05T·6V which is comparable to InSb Hall elements. Their temperature dependence and stable operation range is shown in Figure 2. These Hall elements passed the standard reliability test including 1000hr accelerated life tests for commercial Hall elements. The experimental MBE system with wafer holder having four 2" GaAs substrates is used for our experiment to grow InAs DQW and growth time is about 1 hour. This shows high throughput for producing InAs DQW.

§ 5. Conclusions

Thin film technologies such as vacuum deposition and MBE are useful for production of InSb, InAs thin films and InAs DQW and thus for mass production of Hall elements as practical magnetic sensor. These magnetic sensors are recently used much for brushless motors, current sensors and so on, and helps our electronic life and opens new application area of narrow bandgap III－V semiconductor thin films.

References

1) I.Shibasaki, in: Technical Digest 8 Sensors Symp. 1989, p.211

2) I. Shibasaki, Y. Kanayama, T. Ito, F. Ichimori, T. Yoshida, K. Nagase, K. Harada, IEEE, in: Digest Tech. Papers on Transducers, 1991, p.1069.

3) T. Iwabuchi, T. Ito, M. Yamamoto, K. Sako, Y. kanayama, K. Nagase, T. Yoshida, F. Ichimori, I.Shibasaki, J. Cryst. Growth, Vol. 150, 1995, p.1302.

4) K. Nagase, S. Muramatsu, N. Kuze, A. Itch, I.Shibasaki, K. Mori, in: Digest Technical Papers: Late News, Transducers 1993, p.3 4.

5) N. Kuze, K. Nagase, S. Muramatsu, S. Miya, T. Iwabuchi, A. Ichii, I.Shibasaki, J. Cryst. Growth, Vol. 150,1995,p.1307.

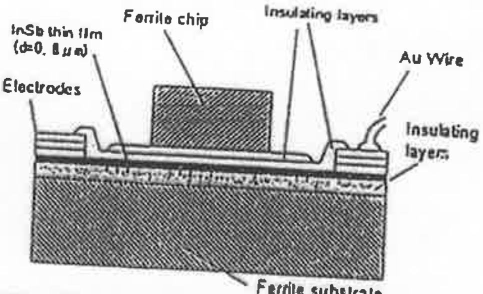

Fig.2 Cross section of the high sensitive InSb Hall Element

Table.1 Properties of InSb,InAs thin films and DQW

	Dope	Electron mobility μ_H (cm^2/Vsec)	Electron density n ($\times 10^{16} cm^{-3}$)	Thickness d (μm)
InSb	non	20000～30000	2	0.8
InAs	Si	11000	8	0.5
DQW	non	20000～28000	50	0.015

Table.2 Characteristics of InSb, InAs and DQW Hall elements

	Driving voltage Vin(V)	Hall output voltage V_H(mV) (B=0.05T)	Offset voltage Vu(mV) (B=0T)	Resistance Rin(Ω)
InSb	1	150～270	≦±7	240～550
InAs	6	100	≦±16	400
DQW	6	250～300	≦±16	700

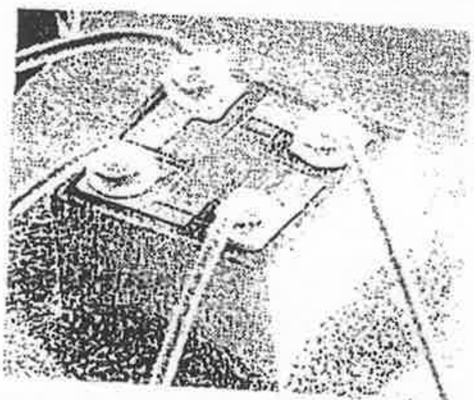
Photo. InAs Hall Element on GaAs substrate by MBE

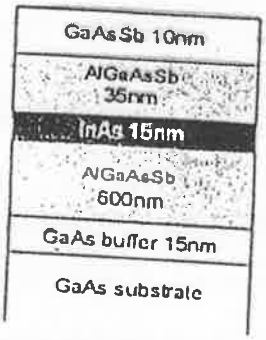

Fig.2 Schematic cross section of InAs DQW

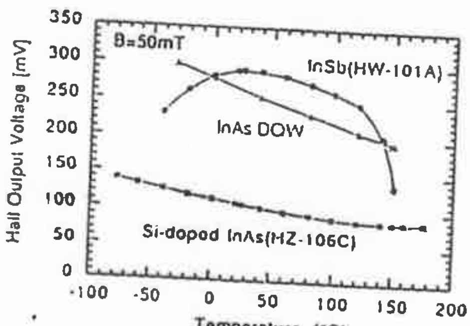

Fig. 3 Temperature dependence of Hall output voltage