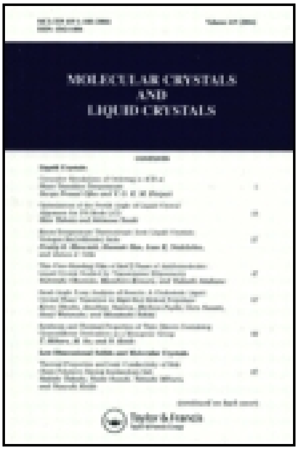

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Surface Micromachining Techniques in InP Based Micro-Opto-Electro-Mechanical System

Jianhua Wang [a], Hua Tong [a], Jin Mao [a], Dan Zhou [a] & Jihu Peng [a]

[a] State Key Lab on Integrated Optoelectronics, Electronic Engineering Dept., Tsinghua University, Beijing, 100084, China

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 371, pp. 481-484

Surface Micromachining Techniques in InP Based Micro-Opto-Electro-Mechanical System

JIANHUA WANG, HUA TONG, JIN MAO, DAN ZHOU and JIHU PENG

State Key Lab on Integrated Optoelectronics, Electronic Engineering Dept., Tsinghua University, Beijing 100084, China

Several Indium Phosphide based surface micromachining processes are presented in this paper, in order to develop Micro-Opto-Electro-Mechanical systems. By fabricating micro cantilevers composed of InP/Air gap pairs, the major techniques of the surface micromachining are studied, including non-selective and selective etching, rinsing and drying and so on. A severe problem of the sticking phenomena during the rinsing and drying is avoided by implementation of the Critical Point Drying (CPD) method.

Keywords MOEMS; chemical etching; critical point drying

INTRODUCTION

Micro-Opto-Electro-Mechanics System (MOEMS) is an integration of photonic, microelectronic and mechanical devices on a compatible substrate. Having advantages in precision, compatibility and mass production, it is very promising in many fields. Surface micromachining is one of the most important techniques in fabricating of the MOEMS devices. InP based materials offer some superiorities over silicon because of their advantages of opto-mechanical sensitivity, direct bandgap and heterostructure-based quantum effects. Hence surface micromachining technique based on InP materials is of vital significance in fabrication of the MOEMS devices [1].

In this paper, some main techniques of surface micromachining used in InP based devices are discussed, including non-selective and selective etching, rinsing and drying. A micro cantilever structure composed of InP/Air gap pairs was fabricated as an illustration.

EXPERIMENTS

In order to form InP/Air gap pairs, an InP/InGaAs muti-layer-membrane was epitaxially grown on a n^+ doped InP substrate by metal organic chemical vapor deposition (MOCVD). The InGaAs layers, with the thickness of 390nm and 780nm respectively, were removed by selective etching. The InP layers with the thickness of 610 nm, being etching stop layers, formed the cantilever after etching. The scheme of the epitaxial structure, with its doping characters, is shown in Fig.1(a).

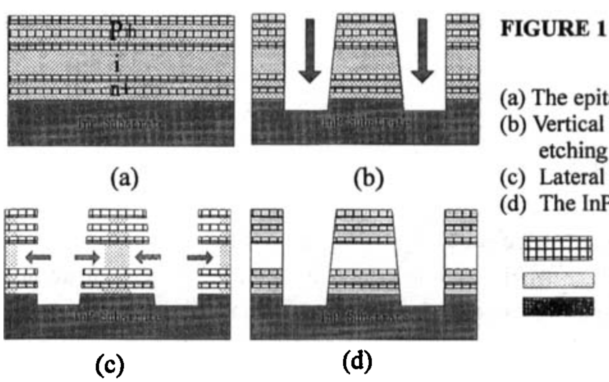

FIGURE 1 Fabrication process

(a) The epitaxial structure
(b) Vertical non-selective etching
(c) Lateral selective etching
(d) The InP/Air gap structure

Firstly, the wafer was patterned by lithography, and etched vertically in a non-selective fashion. Considering strength and influence of the crystal orientation, several kinds of pattern were used. Then the

InGaAs sacrificial layers were laterally underetched selectively. Finally, the wafer was rinsed and dried from liquid. The fabrication process is illustrated in Fig.1(b)-(d).

RESULTS AND DISCUSSION

Non-selective and Selective Etching

Most of the devices in InP based MOEMS involve one or more etching processes[2]. The chemical wet etching was adapted due to its implementability and controllability both in non-selective and selective etching. The result of the etching to InGaAs/InP materials is shown in Table1, which indicates the etching selectivity of some solutions.

Etchants	InP	InGaAs
$HCl : H_2O$	+	−
$H_2SO_4 : H_2O_2 : H_2O$	−	+
$HF : H_2O_2 : H_2O$	−	+
$FeCl_3 : H_2O$	−	+
$HBr : HNO_3 : H_2O$	+	+
$H_3PO_4 : H_2O_2 : H_2O$	−	+

+ etching − not etching

TABLE 1 Etching selectivity of InP/InGaAs of various etchants

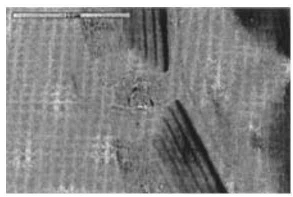

FIGURE 2 The different etching velocity to different doped materials

The shape of cantilevers is patterned by non-selective etching. The $HBr:HNO_3$ solution was used in our experiments. The proportion of mixtures, temperature and reaction time should be controlled carefully and precisely as well.

In normal situation, the upper and lower layers of the microstructure should be doped differently in order to apply a electrostatic bias between the top and bottom layers to make the cantilevers movable. In most etchants, this induces a difference in the etching rate between these differently doped layers. This feature is illustrated in Fig.2. In our experiments, the ratio between the vertical and lateral etching is 15:1 for the p^+ doped layers and 30:1 for the n^+ doped. This result is significant to the mechanics design.

The air gaps are formed by selective etching. The selectivity coefficient of the etchant is the major factor determining the etching results. If this coefficient reaches 100, it will be very suitable for our experiment. We got ideal selective etching results with the solution of $FeCl_3 : H_2O$.

Rinsing and Drying Process

A notorious problem in the surface micromachining especially in the sacrificial layer etching is the permanent sticking of two closer layers after rinsing and drying. Some drying methods have been studied experimentally. The method of CO_2 critical point drying (CPD) was most successful. The SEM photographs of the cantilevers by CPD method are shown in Fig.3. The key points are the selection and substitution of the intermediate fluid, and the releasing rate of CO_2.

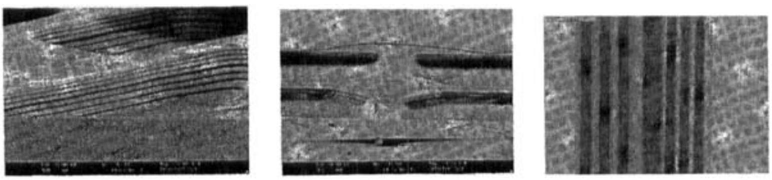

FIGURE 3 SEM photos of perfect microstructures

CONCLUSION

We developed some surface micromachining techniques based on sacrificial layer etching by fabricating a released multi-layer cantilever. Nowadays surface micromachining technology plays a more and more important role in MOEMS. Our work and experience in this field establish a foundation to our further research on integration of microstructures with some photonic devices.

Acknowledgments

This work is supported by National Nature Science Foundation of China and 863 high-tech program.

References:

[1]. J. L. Leclercq, et al., *Microelectronics Journal*, **29**, 613 (1998).

[2]. C. Seassal, et al., *SPIE's Photonics West'97*, **8**, (1997).

[3]. R. Legtenberg, et al., *Sensors and Actuators A*, **43**, 230, (1994).