NOVEL ETCHING TECHNOLOGY OF INP BY INDUCTIVELY COUPLED PLASMA[1]

Chang-Zheng Sun(1), Jin-Bo Zhou(2), Bing Xiong(3), and Yi Luo(4)

(1)Department of Electronic Engineering, Tsinghua University
Department of Electronic Engineering, Tsinghua University, Beijing 100084, P. R. China
E-mail: czsun@ee.tsinghua.edu.cn
(2)As (1) above, but E-mail: zjb01@mails.tsinghua.edu.cn
(3)As (1) above, but E-mail: xbing98@mails.tsinghua.edu.cn
(4)As (1) above, but E-mail: luoy@mail.tsinghua.edu.cn

ABSTRACT

We report on the room temperature dry etching of InP by inductively coupled plasma (ICP) using $Cl_2/CH_4/Ar$ mixtures. Under optimized conditions, vertical sidewall and smooth surface can be obtained simultaneously, together with a moderate etch rate and a good select ratio. The root-mean-square surface roughness is measured to be as low as 0.274 nm. To our knowledge, this is the best result for InP to date.

INTRODUCTION

Dry etching is considered to be an effective micro-fabrication technique for various optoelectronic devices such as etched-facet lasers, vertical-cavity-surface-emitting lasers, and waveguide formation. In these applications, the etched surface should be both smooth and vertical to ensure high reflectivity and avoid light scattering.

The generally used gas mixtures for dry etching of III-V semiconductors are either halogen-based or hydrocarbon-based [1-6]. However, neither of them offers ideal etching results for InP-based semiconductors. Room temperature dry etching of InP by Cl-containing gases can be difficult due to the low volatility of $InCl_x$ [1]. On the other hand, polymer deposition on the sample at high CH_4 concentration not only limits the etching rate, but also leads to micromasking and rough surfaces when using CH_4/H_2 mixtures. Furthermore, hydrogen passivation during the etching process can be another concern for CH_4/H_2-based plasma, as it may cause degradation of device performance [2].

In view of the above mentioned drawbacks of the currently used gas mixtures, we report dry etching of InP by inductively coupled plasma (ICP) using $Cl_2/CH_4/Ar$ mixtures at room temperature. By adjusting the Cl_2/CH_4 ratio, it is possible to realize high anisotropy etching of InP at a moderate etching rate. Meanwhile, leaving out H_2 and addition of Ar are found crucial to the improvement of surface smoothness.

EXPERIMENT SETUP AND RESULTS

In this study, an Oxford Instruments ICP equipment (Plasmalab System 100) is used for the dry etching of InP. Etch rates were determined by alpha-step profiler, whereas the etch anisotropy and surface morphology were examined by scanning electronic microscopy (SEM) and atomic force microscopy (AFM), respectively.

It is found out that Cl_2/CH_4 flow ratio, ICP power, rf chuck power and table temperature can greatly influence the etching results. Under optimized conditions, vertical sidewall and smooth surface can be obtained simultaneously. The SEM photograph of an etched ridge obtained under room temperature is shown in Fig. 1. The AFM profile of the etched

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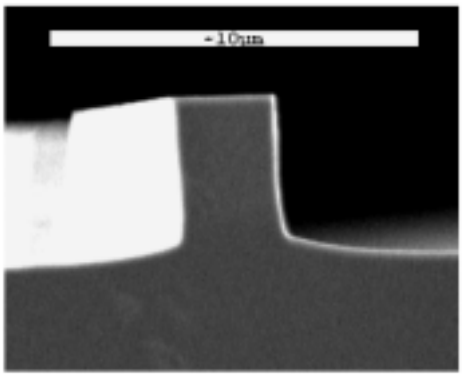

Fig. 1. SEM image of etched ridge.

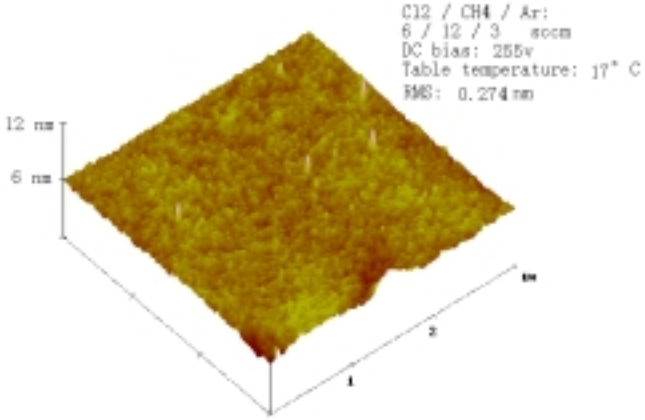

Fig. 2. AFM profile of the etched surface.

surface is given in Fig. 2. The root-mean-square surface roughness is measured to be as low as 0.274 nm. To our knowledge, this is the best result for InP to date. The etch rate is 855 nm/min, and the select ratio over SiO_2 is estimated to be higher than 15:1.

CONCLUSIONS

ICP dry etching of InP has been carried out with $Cl_2/CH_4/Ar$ gas mixtures at room temperature. A smooth etched surface and a vertical sidewall have been demonstrated. The etching technology also manifests a moderate etch rate and a high selectivity. In view of these results, we believe this etching process very promising for applications in the fabrication of InP based optoelectronic devices.

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