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Fabrication of Si based Microchannel by Ar/F_2 Vapor Etching and Plasma Etching

Ar/F_2気相エッチングとプラズマエッチングによる Siマイクロ流路構造の形成

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We demonstrated the fabrication of Si based multistep microchannel without cover plates by Ar/F_2 vapor etching and Cl_2-inductively coupled plasma (ICP) etching process. We think that the proposed microchannel would be also useful for single bacterial cell analysis.

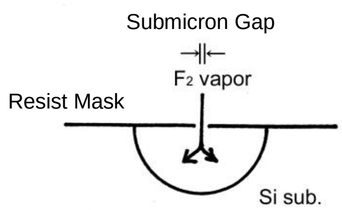
1. Introduction

The microchannel is widely used as micro total analysis systems (μ-TAS) in chemical and biological analysis. The typical size of them is approximately 50-100 μm in width and depth. However, the microchannel of submicron size would be needed for investigation of capillary vessel, analysis of single virus particles and so on. Almost microchannels are fabricated by wet etching, plasma etching and lithography process. It is difficult to fabricate submicron microchannel by wet etching due to the surface tension. Therefore, dry etching technique such as vapor etching or plasma etching is required. Generally, the vapor etching using XeF_2 is also widely used for Si etching [1-3]. XeF_2 is solid and its vapor pressure is approximately 500 Pa at room temperature. A mass flow controller is not necessarily available for the XeF_2 gas flow rate at such a low pressure of the cylinder. While, Ar/F_2 gas can be supplied from cylinder and its pressure is high enough for operation of the mass flow controller. On the other words, the etching process of Si can be controlled by gas flow rate and process pressure as etching parameters.

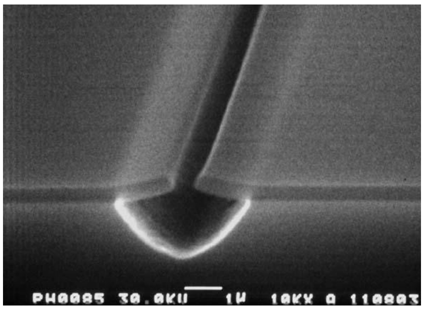
In this paper, we demonstrate fabrication of Si based microchannel by Ar/F_2 vapor etching, and plasma etching process for flatten of the etched channel bottom.

2. Fabrication of Microchannel by Ar/F_2 Vapor Etching

We used electron beam lithography system (Elionix ELS6600) and positive type electron beam resist ZEP520A for mask patterning of microchannel. We also used Ar/F_2 (Ar: 90%, F_2: 10%) as an etching gas. Figure 1 (a) and 1(b) show a schematic diagram of fabrication process



(a)



(b)

Fig. 1 Schematic diagram of fabrication process (a) and SEM image of microchannel fabricated by Ar/F_2 vapor etching process (b).

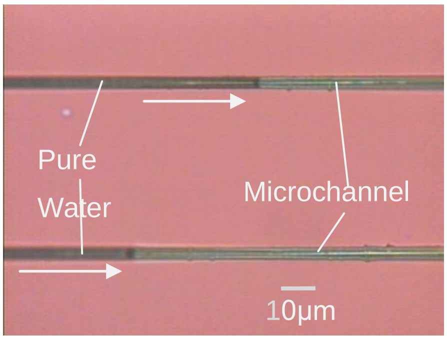


Fig. 2 Optical microscope image (Top View) of Si microchannel fabricated by Ar/F_2 vapor etching.

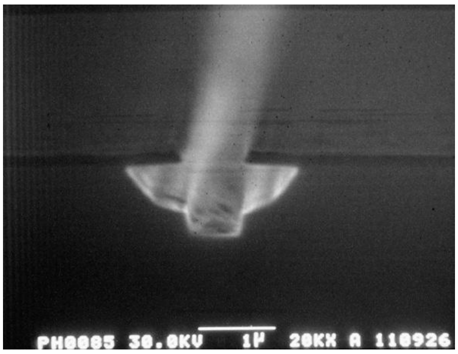


Fig. 3 SEM image of Si-microchannel by Ar/F_2 vapor etching and Cl_2-ICP etching process.

and an SEM image of a microchannel fabricated by Ar/F_2 vapor etching process, respectively. The Ar/F_2 flow rate was 100 sccm and the process pressure was kept at 1×10^3 Pa. The gap of resist mask pattern was 200nm. The etched depth was about 1.7μm. It is found that the resist mask of upper side of microchannel was warped up due to the stress.

Figure 2 shows an optical microscope image (Top View) of Si microchannel fabricated by Ar/F_2 vapor etching. The flowing direction of pure water was from left to right. The resist gap was 0.7μm and 0.8μm. Pure water was introduced by capillary forces. Despite the gap on the top of the microchannel, it is found that water flows from left to right without flowing out. We think that the proposed microchannel can be applied to mixing micro fluidic devices between vapor and liquid. This proposed manner is a simple technique without process for covering on the microchannel.

3. Fabrication of Step type Si-Microchannel by Plasma Etching Process

Figure 3 shows an SEM image of Si-microchannel by Ar/F_2 vapor etching and Cl_2-ICP etching process. We used a reactive ion etching system (Samco RIE-101ip) and Cl_2 as an etching gas. ICP/Bias RF power was 300/20 W, Cl_2 flow rate was 2 sccm. It is found that the resist mask was remained on the Si-microchannel and narrow vertical microchannel was formed in the cylindrical microchannel. We think that this microchannel structure is useful for isolation of bacterial cells.

4. Conclusions

We demonstrated the fabrication of Si based multistep microchannel without cover plates by Ar/F_2 vapor etching and Cl_2-ICP etching process. We think that the proposed microchannel would be also useful for single bacterial cell analysis.

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