Evaluation of processing characteristics of anisotropic aluminum-assisted chemical vapor etching

Reo Kometani[1,2], Masato Okuno[2], Shin'ichi Warisawa[1,2]
[1]*Graduate School of Frontier Sciences, The University of Tokyo*
5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8561 Japan
[2]*Graduate School of Engineering, The University of Tokyo*
7-3-1 Hongo, Bunkyo, Tokyo, 113-8656 Japan
kometani@edu.k.u-tokyo.ac.jp

Metal-assisted chemical etching has attracted attention as a key technology for a low-cost and high-speed nanofabrication. Fabrication of Si nanostructure such as nanowire[1] using Au was reported. It was a powerful technique for fabrication of Si nanostructures. On the other hand, a processing of SiO_2 had not been researched enough although SiO_2 is a very useful material for various devices. Therefore, we has been researching on metal-assisted chemical etching of SiO_2. Thus far, we found that Al [2] and Ti [3] enables metal-assisted chemical vapor etching. Especially, Al induced strong anisotropic chemical etching. However, its processing characteristics and mechanism have not been sufficiently clarified. Therefore, we evaluated Al-assisted chemical vapor etching in this study.

In this experiment, Al-assisted chemical vapor etching was carried out by using commercially available chemical vapor etching equipment (Hydrogen fluoride (HF) vapor phase etcher, idonus), as shown in Fig. 1. 50 wt% HF was used. And etching sample was heated at 40 deg. C. Al pattern for metal-assist etching was fabricated on SiO_2 by using electron beam lithography and lift-off process. Figure 2(a) shows a scanning electron microscope (SEM) image of Al pattern and SiO_2 layer before etching. And, Fig. 2(b) shows a SEM image of SiO_2 nanostructure after etching. SiO_2 under Al is etched, and etching proceeds so that Al is embedded into SiO_2. We evaluated etching characteristics. Figure 3 shows oxygen content dependence of etching speed as a result of etching characteristics evaluation. Although relationship between oxygen content and the etching speed did not show clear correlation, etching using aluminum which had high purity was faster. And, etching with Al (Al : O = 1 : 0.0038) was approximately 16.9 times faster than etching without Al, as shown in Fig. 3. This relationship may be useful for the investigation of mechanism of Al-assisted etching process. Furthermore, this etching technique was applied in order to fabricate various nanostructures. Figure 4 shows an example of application of this etching technique. This etching technique will enables fabrications of various devices such as photonic devices and fluidic devices. Etching properties, mechanism and applications of Al-assisted chemical vapor etching will be reported in detail.

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[1] Z. Huang, H. Fang, and J. Zhu, Adv. Mater. 19, 744 (2007).
[2] R. Kometani, *et. al.*: Abstract of MNE2016, Thu-A9-74 (2016).
[3] R. Kometani, *et. al.*: Abstract of MNC2016, 10C-6-2 (2016).

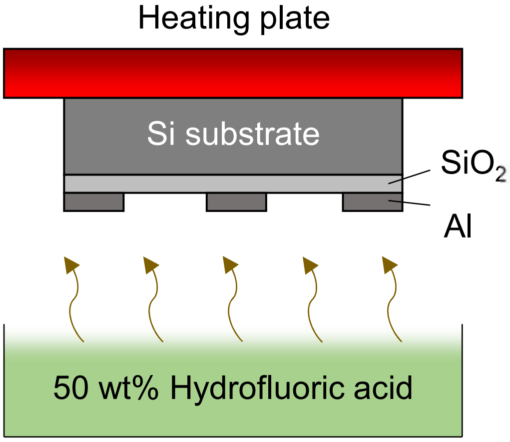

Figure 1 Schematic of Al-assisted chemical vapor etching

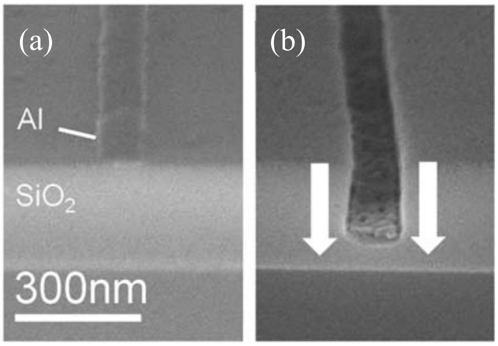

Figure 2 SEM images of SiO_2 nanostructure (a) before and (b) after Al-assisited chemical vapor etching for 90 sec

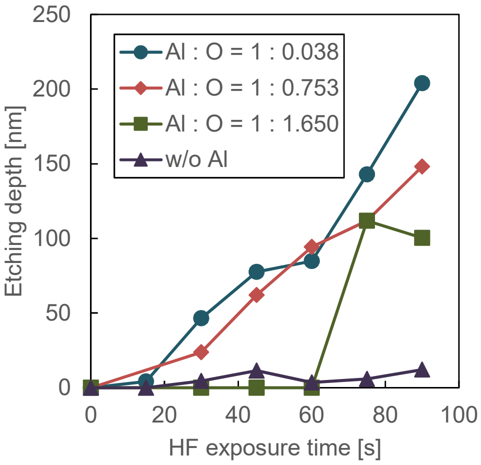

Figure 3 Oxygen content dependence of etching characteristics of SiO_2 on Al-assisted chemical vapor etching

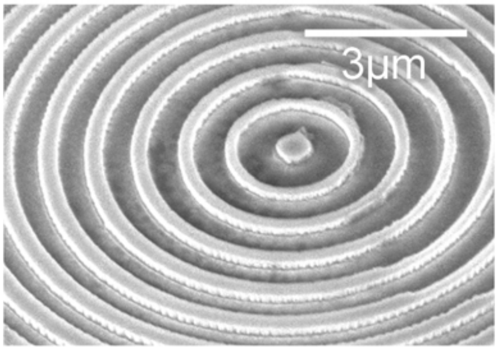

Figure 4 SEM image of a bull's eye nanostructure fabricated by Al-assisted chemical vapor etching