Fabrication of Line Pattern of InP by metal-assisted chemical etching under UV irradiation

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Micro/nano structures formed on semiconductor substrates have been applied in various devices such as electronic devices and biosensors. In particular, Metal-assisted chemical etching using noble metals such as Au, Pt, and Ag as etching catalysts is promising as one of the micro-/nano- fabrication techniques of semiconductors [1-2]. Previously, we reported fabrication of InP with micro bump and micro line pattern by combination of metal assisted chemical etching and UV irradiation [1]. In the present study, we investigated the effects of content and morphology of metal catalyst (e.g., thickness, interval, and coverage) on the rate of metal assisted chemical etching. In addition, scale down of regularly-arrayed line pattern was intended.

n-type InP (100) was used as a substrate. To form a metallic catalyst pattern on the InP substrates, a line pattern of resist with 4 - 120 μm of space at a regular interval of 8 – 200 μm was prepared by photolithography as a deposition mask (Fig. 1a). Metal films were deposited on the InP substrates through the line pattern mask by ion sputtering (Fig. 1b). The photoresist mask was removed by ultrasonic cleaning in toluene (Fig. 1c). Subsequently, the specimens were immersed in an etchant, *i.e.*, a mixture of H_2SO_4 and H_2O_2, at 20 °C under UV irradiation (Fig. 1d). The ordered geometric pattern formed on the InP substrates was evaluated by scanning electron microscopy.

First, InP substrate with 25 or 120 μm of catalyst line at regular interval of 200 μm line pattern was etched. The etching depth of low coverage was 2.3 μm and that of high coverage was 3.2 μm respectively. The InP substrate was oxidized locally by the diffusion of h^+ injected from the catalyst. Thus, as the coverage of metal catalyst increased, the etching quantity increased. This resulted in the increase in hole (h^+) generation by the reduction of H_2O_2 on metal catalyst. In addition, either end of the etched substrate under the metal film was also etched.

Next, the line pattern was scaled down from 120 μm of space at an interval of 200 μm to 4 μm of space at an interval of 8 μm. Namely, it was successfully minimized to one thirtieth as shown in Fig. 2. The shorter periodicity of catalyst line pattern showed higher catalytic effect for etching depth and etching rate as well as aspect ratio. The InP line pattern was effectively etched when metal catalyst coverage of line pattern is more than 50 %.

[1] H. Asoh, T. Yokoyama, S. Ono, *Jpn J Appl Phys.*, **49**, 46505 (2010).
[2] H. Asoh, F. Arai, S. Ono, *Electrochimica Acta*, **54**, 5142-5148 (2009).

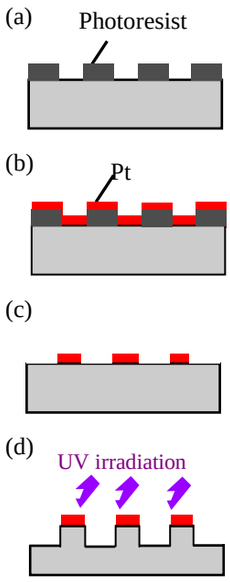

Fig. 1 Schematic representation of metal assisted chemical etching process: (a) formation of photoresist mask on InP substrate, (b) Pt sputtering, (c) removal of mask, (d) metal-assisted chemical etching under UV irradiation.

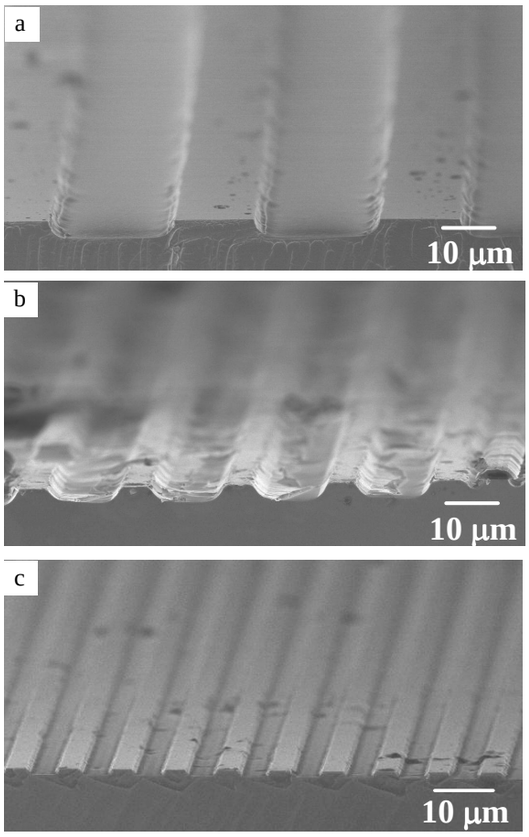

Fig. 2 Cross-sectional SEM images of InP line pattern formed by metal-assisted chemical etching under UV irradiation using Pt catalyst. Periodicity: (a) 40 μm, (b) 20 μm, (c) 8 μm.