Spectrometric Monitoring Method for Concentration of Hydrogen Peroxide in a Chemical Etching Solution of GaAs

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Introduction

Several etching techniques are employed for the fabrication of laser diodes and microwave devices. Wet chemical etching is preferable because it causes less damage to the etched surface, processes compositional selectiveness, and forms a highly non-isotropic profile. We have reported that tartaric acid (C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}) + hydrogen peroxide (H\textsubscript{2}O\textsubscript{2}) aqueous solutions are suitable for selective etching of GaAs and fabricating fine structures\textsuperscript{1)}.

In this study, the etching mechanism of GaAs in C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} + H\textsubscript{2}O\textsubscript{2} aqueous solutions is reported, and a spectrometric monitoring method for the concentration of hydrogen peroxide in tartaric acid is proposed to control the etching rate of GaAs.

Experimental

The undoped GaAs (100) wafers employed for the experiment were cut into rectangular specimens (30 mm x 50 mm). The mirror-finishing surface of the specimens was covered with a square-patterned photore sistant film. The etching solutions were prepared by mixing 50 wt% tartaric acid (C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}) aqueous solution and 30 wt% hydrogen peroxide (H\textsubscript{2}O\textsubscript{2}) aqueous solution. The chemical etching rate was obtained by measuring the different levels between the covered area (top) and the etched area (bottom) with a surface profilometer (Alpha step). UV spectra were measured with a UV-VIS-NIR spectrometer (JASCO V-570), that detects wavelengths between 190 nm and 2500 nm.

Results and Discussion

Figure 1 shows the effect of C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} concentration in etching solutions on the etching rate of GaAs. In this case, the concentration of H\textsubscript{2}O\textsubscript{2} was kept constant at 0.5 wt%. The etching rate increased sharply with the addition of C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}, and the rate was almost constant at about 1 nm s\textsuperscript{-1} above a 5 - wt% concentration of C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}. Figure 2 shows the effect of the H\textsubscript{2}O\textsubscript{2} concentration in etching solutions on the etching rate of GaAs. The C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} concentration was kept at 50 wt%. GaAs is not chemically etched in 50 wt% C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} aqueous solution without H\textsubscript{2}O\textsubscript{2}. The etching rate increases linearly with increased H\textsubscript{2}O\textsubscript{2} concentration. This shows that C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} does not react with GaAs directly and apparently dissolves oxidation products such as Ga\textsubscript{2}O\textsubscript{3} and As\textsubscript{2}O\textsubscript{3} formed by the H\textsubscript{2}O\textsubscript{2} into the etching solution. In the C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} and H\textsubscript{2}O\textsubscript{2} mixed solution, the successive oxidation and dissolution of GaAs is performed during chemical etching. Figure 3 shows the relation between the concentration of H\textsubscript{2}O\textsubscript{2} in the etching solution and the absorbance of UV light, observed at 280 nm and 290 nm. The C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} concentration is kept at 50 wt%. The absorbance spectra observed below 250 nm were not influenced by the concentration of H\textsubscript{2}O\textsubscript{2}. The absorbance observed between 250 nm and 320 nm increases as the H\textsubscript{2}O\textsubscript{2} concentration grows, absorbance observed at 280 nm is the most sensitive to changes of H\textsubscript{2}O\textsubscript{2} concentration. Figure 4 shows the relation between the absorbance of UV light, observed at 280 nm, and the etching rate of undoped GaAs in the etching solution with different concentration of H\textsubscript{2}O\textsubscript{2}. The etching rate of GaAs in the etching solution is proportional to the absorbance. This shows that the etching rate of undoped GaAs in a C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} - H\textsubscript{2}O\textsubscript{2} aqueous solution system is monitored by the observation of UV absorbance spectra and controlled by the addition of H\textsubscript{2}O\textsubscript{2} into the solution.

Reference


Fig.1 Effect of C\textsubscript{4}H\textsubscript{6}O\textsubscript{6} concentration on etching rate of undoped GaAs in C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}-H\textsubscript{2}O\textsubscript{2} aqueous solution systems.

Fig.2 Effect of H\textsubscript{2}O\textsubscript{2} concentration on etching rate of undoped GaAs in C\textsubscript{4}H\textsubscript{6}O\textsubscript{6}-H\textsubscript{2}O\textsubscript{2} aqueous solution systems.

Fig.3 Relation between concentration of H\textsubscript{2}O\textsubscript{2} in etching solution and absorbance of UV light observed at 280 nm and 290 nm.

Fig.4 Relation between absorbance of UV light observed at 280 nm and etching rate of undoped GaAs.