WET CHEMİCAL ETCHİNG OF Si AND Zn DOPED GaAs AND UNDOPED SEMİ-İNSULATİNG GaAs WİTH CİTRİC ACİD/HYDROGEN PEROXİDE SOLUTİONS

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The surface roughness thickness of the Zn doped GaAs wafer was found to be generally higher and sharply increases as volume ratio citric acid/H_2O_2 increases. Behaviour is not surprising if one considers the the detrimental effects of mechanical polishing on the surfaces of the wafers. icroscope images revealed that square shaped dislocations are denser in Si doped GaAs wafers incomparison to Zn doped ones.

In general, there are two classes of etching processes: (i) wet etching where the material immersed in liquid etchant solution ; (ii) Dry etching where the material exposed to sputtering or reactive ions or a vapor phase etchant. Wet etching have numerous advantages over dry etching: Wet etching produces negligible damage on the material; is highly selective; is inexpensive; easy to implement. Wet etching methods are frequently used for defect analysis, crystal polarity/polytype identification and device fabrication. One of the essential processing needs for fabrication of next-generation electronic and photonic devices is new selective etching solutions [1]. Wet etching is regarded as more promising than the dry one due to the ion-induced damages produced by dry etching which lead to degradation of the performance of various devices.

A number of studies have been published on selective removal of GaAs over $Al_xGa_{1-x}As$ using citric acid/hydrogen peroxide solution [2-4]. To best of our knowledge, neither of these studies investigate electroless etching of GaAs wafers with different resistivities and dopings. In this work, Zn doped (with a density of ~10^{18} cm^{-3}), Si doped (~10^{18} cm^{-3}) and undoped semi-insulating GaAs (100) wafers were etched at room temperature by citric acid/hydrogen peroxide solutions with volume ratios of 1:1, 2:1, 2.3:1, 2.5:1, 2.7:1, 3:1 and 4:1. H_2O_2 is the oxidizing agent of the GaAs surface whereas the citric acid is the dissolving agent of the oxide. The reactive molecules in the etching solution break the bonds at the GaAs surface and the surface become oxidized. Subsequently oxides dissolves into the etching solution. The potential of H_2O_2 in the solution supplies the holes required for the oxidation by depleting the valence band electrons in the GaAs. Etching is possible if the redox potential is higher than the potential of the GaAs in equilibrium with its ions in the solution. Besides, the etch rate is primarily determined by the position of energy band of GaAs relative to the energy levels of the redox couple in the solution [5].

The citric acid solution was prepared by dissolving 1:1 weight ratio of citric acid monohydrate with deionized water, stirred for half an hour and waited for 1 day at room conditions. Etching times were fixed to 2 mins except for the volume ratio of 4:1 where 1 min etching time was prefered.

The GaAs wafers were cut into small rectangular shapes with dimensions of about 1 x 2 cm which were thoroughly cleaned with standard degreasing methods before immersing them into etching solution. The wafers are constantly shaked during the etching processes. The wafers were properly masked in order to produce etch steps and the heights of the steps were measured with a stylus profilometer.

The measured etch rates for various volume ratios of citric acid/hydrogen peroxide are shown in Figure 1. The etch rates of wafers doped with Zn and Si are few A/s up to a volume ratio of 2.5. At this critical volume ratio etch rates sharply increase but this increase appears much weaker up to volume ratio of 3. Beyond this ratio the etch rates tend to decrease. In other words, the etch rates of Zn and Si doped GaAs wafers were found to become maximum at a volume ratio of 3. This behaviour suggests that oxidation and dissolution reactions are balanced in the etching solution at this volume ratio. The etch rates of Si doped wafers are obtained to be insistently slightly larger than Zn doped wafers at volume ratios larger than 2.3. However, up to this volume ratio the etch rates of the Zn an Si doped wafers are not distinguishable. On the other hand, the etching dynamics of undoped semi-insulating GaAs wafer exhibits a different behaviour. First, the sharp increase in the etch rate similarly appears but at a lower volume ratio between 1 and 2, as shown in Figure 1. The etch rate is lower than those for doped ones at volume ratios of 1, 3 and 4. Between volume ratios of 2 and 2.3, an interval discovered where undoped semi-insulating GaAs is selectively etched over GaAs wafers doped with Zn and Si.

The surface roughness of the etched surfaces are examined by phase modulated spectroscopic ellipsometry. Spectroscopic ellipsometer measures the change of polarization of polarized light upon reflection from a sample surface. The changes in the polarization state of the reflected light reflects the change on surface properties of the GaAs wafers at hand. The surface roughness of the samples are modelled in the frame of effective medium approximation and with 50% percentage volume ratios of GaAs and void.

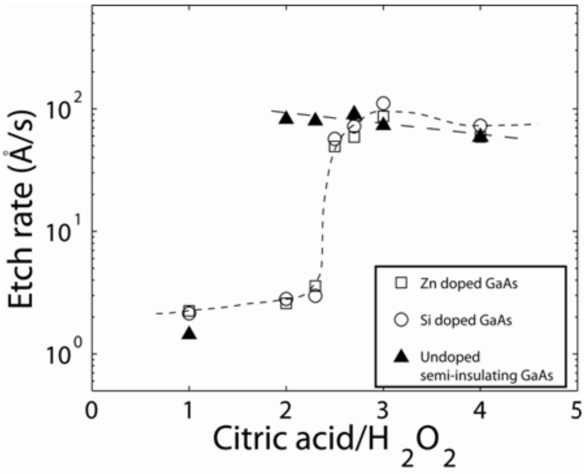

Fig.1. Etch rate of GaAs wafers as a function of volume ratio of citric acid/H_2O_2

The surface roughness thickness of the Zn doped GaAs wafer was found to be generally higher and sharply increases as volume ratio citric acid/H_2O_2 increases. In addition, it is possible to observe slight increase of surface roughness in the initial stages of the etching and then the roughness thickness slightly tends to decrease. This behaviour is not surprising if one considers the the detrimental effects of mechanical polishing on the surfaces of the wafers.

In addition, the surface of the etched wafers and particularly the transition regions around the steps on the surfaces are studied with an optical microscope. Microscope images revealed that square shaped dislocations are denser in Si doped GaAs wafers incomparison to Zn doped ones. Besides, it is observed that the steps are more observable for larger volume ratios. In the initial stages of the etching the effects of mechanical polishing on the surfaces are easily noticed as long scratch like, long linear patterns.

ACKNOWLEDGMENTS: This work is supported by Turkish of Prime Ministry State Planning Organization Project number 2001K120590 and Gazi University Scientific Research Project(BAP),FEF.05/2005-48,05/2006-05 and 05/2006-12.

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Received: 10.02.2007