Structure Analysis of Semiconductor Electrode Surfaces by X-Ray Standing Wave Method

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Elctrochemical reactions at semiconductor surface have attracted much interest from the viewpoint of the control of etching process. In spite of the importance of the atomic-scale structures of the electrode surfaces, the lack of probing tool has been keeping us away from clear understanding. We show that a new type of X-ray standing wave method can be a unique probe to solve a problem related to the GaAs(001) electrode surface: Which of Ga and As forms the top layer after oxide layers on the GaAs(001) surface are removed by etching process? This is a fundamental issue that may affect the electrochemical reaction and the overlayer growth succeeding the removal of the oxide layers.

In the new method shown here, the modulation of surface X-ray diffraction intensity is measured while the Bragg diffraction corresponding to another reciprocal lattice point is simultaneously excited. This can be regarded as an extension of multiple-beam diffraction. Surface diffraction intensity under the Bragg condition can be calculated on the basis of the Darwin's dynamical diffraction theory. Fig. 1 shows the (0 0 0.29) surface diffraction intensity coinciding with 204 Bragg reflection. The profiles for the Ga- and As-terminated surfaces should be distinguishable.

The sample is a 10x10x0.5mm^3 GaAs(001) wafer mounted in a specially designed electrochemical cell for X-ray diffraction experiment. After oxide layers were etched in HCl, electrolyte was replaced with H_2SO_4, which does not react with GaAs. The incident X-ray beam were monochromatized to 10^{-5}Å and collimated to 2 arc sec using two Si(800) channel-cut monochromators arranged in the (+,+) setting.

Experimental result was so poor that we could not determine the atomic specie of the top layer. Owing to the design of the sample cell, the sample was so strained as to show more than 8 times wider reflection width than ideal one. In addition, the sample was drifting during the measurement. It is necessary to improve the electrochemical cell as well as to reduce the measuring time by utilizing a GaAs(204) monochromator of the parallel setting.

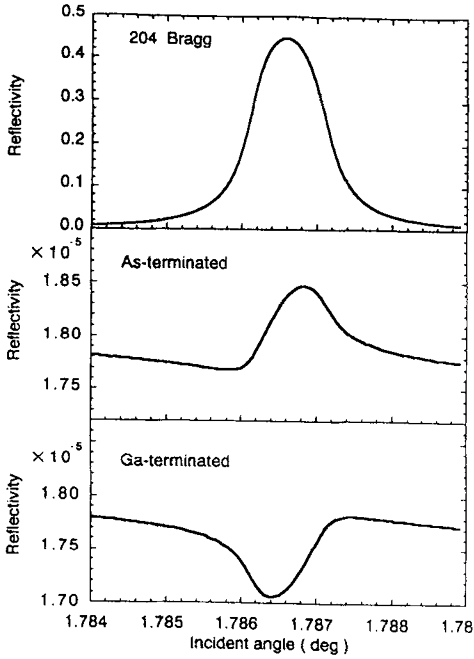

Fig. 1 Calculated profiles of 204 Bragg reflection and (0 0 0.29) surface diffraction intensities.