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Coaxial Impact Collision Ion Scattering Spectroscopy System for the in-situ Monitoring of Molecular Beam Epitaxy

N.Sugiyama, A.Hashimoto, M.Tamura.
Optoelectronics Technology Research Laboratory
5-5 Tohkodai, Tsukuba, Ibaraki 300-26, JAPAN

We have both designed and constructed a coaxial impact collision ion scattering spectroscopy (CAICISS) system which has an off-axis ion source and deflecting electrodes for the incident beam. In-situ observations of the epitaxial surfaces of AlAs and GaAs have been performed using this system, revealing that it is one of the best methods for surface monitoring of the initial stages during epitaxial growth.

CAICISS[1)] has attractive advantages over conventional ISS. The coaxial arrangement of the detector to the incident beam line, which realizes the largest scattering angle (=180deg.), allows a simple analysis of the surface structure. Time-of-flight (TOF) measurements enable energy analyses of not only charged particles, but also neutral particles that are scattered by the target. In our system, the ion beam extracted from an electro-bombardment-type ion source is accelerated and chopped at the chopping-plate with a pulsed application of the electric field. The chopped ion beam is deflected at a prism comprising a static electric field and impinges on the sample. Scattered particles passing through the aperture on the prism are detected by a micro-channel-plate (MCP) placed on the coaxial line of the incident beam. A gated operation of the prism permits the straight flight of scattered ions through the prism. The flight time of the particles is measured by a time-to-digital converter (TDC) with the applied pulse on the chopping plate used as a starting trigger and the counting pulse from MCP is used as a stop trigger. Data from TDC are stored and converted to the TOF spectrum in a personal computer.

AlAs and GaAs crystals grown on n-type GaAs wafers of (001) orientation were observed by CAICISS. Neon ions of 3 keV were used for probe beams, and the incident angle was along the <001> axis on the crystal. Figure 1 shows the changes in the TOF spectra, depending on the coverage of the GaAs layers on the AlAs layer. In the case of AlAs

(Fig.1 (a)), only the particles scattered by As atoms were detected, since the energy loss of neon ions upon collision with Al atoms is large, and the scattered particles are too slow to be detected within the measuring time. The peak of particles scattered by Ga atoms becomes larger as the growth thickness of the GaAs layer is increased (Fig.1. (b)~(d)). A 1-monolayer GaAs on an AlAs layer is detectable (Fig.1 (b)), and the sampling depth of the analysis is about 2~3 monolayers, since there is no significant change in the spectra when the GaAs layer is grown to be over 4 monolayers. The ion dose required for taking one spectrum is less than 10^{12} ions/cm^2, and the damage is so small that the influence on the analysis is negligible using this method. This technique has been demonstrated to be an excellent method for in-situ observation of the surface structure during MBE growth, particularly during the initial stages of growth.

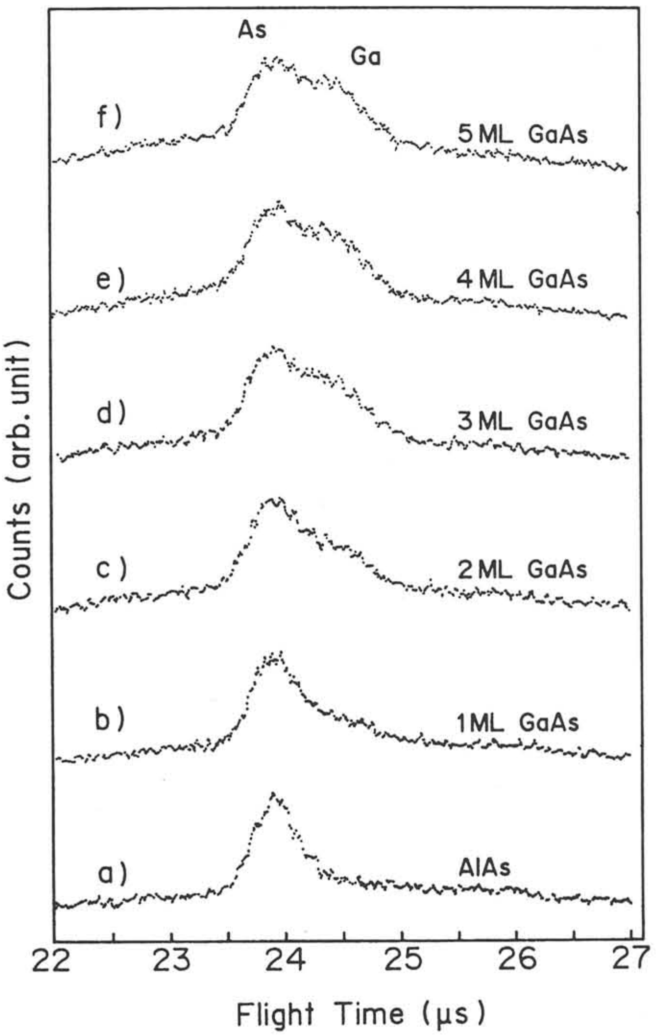

Fig.1. TOF spectra of AlAs (a) and GaAs on AlAs (b~f). The probe beam comprises neon-ions of 3 keV chopped by 100 ns, and impinges on the n-GaAs crystal along the <100> axis.

Ref.1) M.Katayama, E.Nomura, N.Kanekama, H.Soejima, and M.Aono: Nucl. Instr. and Meth. B33 (1988) 847.