Real-Time Composition Control of InAlAs Using Spectroscopic Ellipsometry

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Spectroscopic ellipsometry (SE) was shown to be an accurate in-situ method for determining the composition and thickness of III-V semiconductor layers during growth [1]. For instance, in-situ SE was used to control the growth of resonant cavity enhanced photodetectors [2]. In this communication, we present the acquisition and parametrization (both composition and temperature) of a fully dynamic database and its use in the real-time composition control of InAlAs near lattice matched to InP. Since SE is very sensitive to the growing film's surface, it has been found that one cannot use a database acquired on non-growing films to adequately control real-time growth. Fig. 1 shows the high resolution X-ray diffraction (HRXRD) pattern obtained from a sample consisting of 5 InAlAs layers grown on InP. During the growth of these layers, the SE signal was acquired while the growth temperature was maintained at 500°C through the use of diffuse reflection spectroscopy (DRS) [3]. The layer compositions are assessed by fitting the HRXRD pattern with a simulation based on dynamical diffraction theory. 2 additionnal similar samples were grown at different temperatures and used to obtain the dynamic database. In order to improve the smooth behavior during real-time control, the database was parametrized using a tranfer function model [4]. The parametrized database was then used, in real-time, during growth to control the InAlAs film composition. Fig. 2 shows the results obtained using feedback control of the Al cell temperature in real-time. The composition, as measured by SE, is compared to the true film composition as determined from post-growth HRXRD measurements and simulations. The agreement is excellent and shows a degree of control of ±0.003 mole fractions in the In composition.

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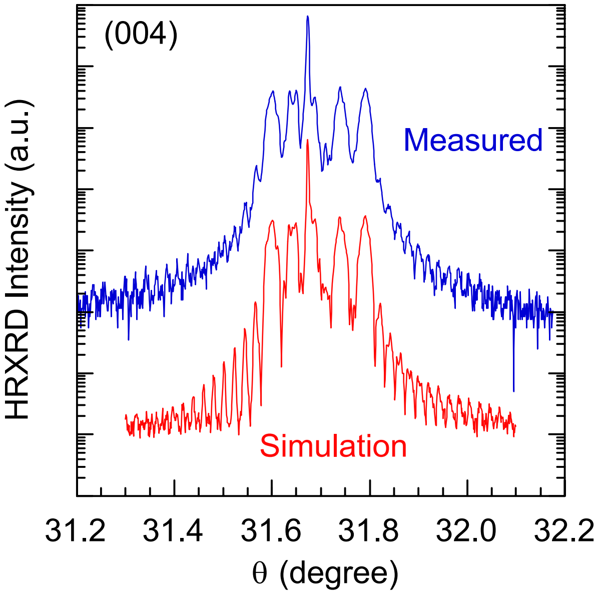

Figure 1: High resolution X-ray diffraction pattern of a structure consisting of 5 InAlAs films grown on InP. The bottom pattern is from a simulation using dynamical diffraction theory and is shifted down for clarity. These patterns are used to determine the film compositions used in the acquisition of the optical constants database.

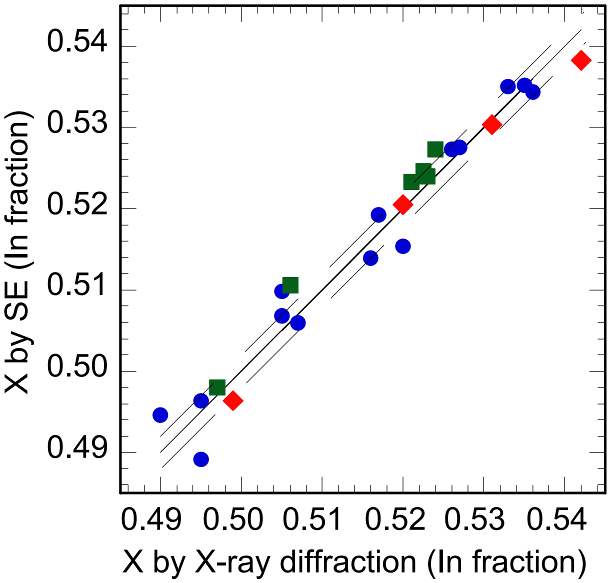

Figure 2: Comparison of SE and XRD determined In fraction in InAlAs. The control is within ±0.003 In mole fractions in real-time using the parametrized database.