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Growth of thick epitaxial InAs layers by CSVT

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InAs epitaxial layers have been grow by Close Spaced Vapor Transport using water vapor as transporting gas. Growth rate is controlled by source, and substrate temperatures and the transporting gas pressure. The growth seems to be proportional to the transporting gas pressure. Growth rates as high as 1 ìm/min are easily obtained with layers showing mirror like surface. Double X ray diffraction spectra show FWHM typically 19arcsec, 1.7 K photoluminescence shown only near band gap transitions although corresponding to highly doped material. Sulfur incorporation in the epitaxial decreases as the substrate growing temperature increases. Layers as thick as 130 ìm have grown displaying the above mentioned properties.

Keywords: InAs; Epitaxy; Close Spaced Vapor Transport; DDX

1. Introduction

InAs is an interesting material for infrared optoelectronic devices as lasers, photodetectors and photodiodes, tunnel diodes. Most of the InAs infrared photodetectors need thick active layers [1]. Growing thick epitaxial layers using conventional techniques as Low Pressure Metalorganic Chemical Vapor Deposition (LPMOCVD), Molecular Beam Epitaxy (MBE) in any one its versions is something everybody tries to avoid because extremely long growing time and intensive precursors consumption. Above mentioned aspects, makes the growth of thick later by those techniques unaffordable. The Close Spaced Vapor Phase (CSVT) technique is a good candidate to grow thick layers since high growth rates have already been obtained for GaAs, InP, GaP, BN, CdTe, ZnSe and other semiconducting materials. All of these materials when grown by CSVT using water as transporting gas have displayed physical properties as interesting as when grown using conventional epitaxial techniques, which normally are complicated, expensive, time consuming and polluting. A detailed description of the close spaced vapor transport technique can be found elsewhere [2-4]. Here in this work we present a preliminary exploratory study of the growth of thick InAs epitaxial layers, using the technique of Close Spaced Vapor Transport (CSVT), with water vapor as transporting gas. We have initially focused on the dependence of the layers surface morphology dependence with the growth conditions as well as other layer physical properties. Epitaxial layer thickness targeted are higher than 100.0 µm.

2. Experimental details

The source and substrate materials were 15x15 mm^2 N-type, S doped, (100) oriented single crystals. Samples were ready to be used as substrates for the epitaxial growth, so called “epi-ready”. Prior to the introduction to the reactor, the surface samples were blown up with dry N_2 and immediately charged in the reactor. Once the chamber was pumped down, it was filled with the mixture of H_2 and the transporting gas, H_2O, to the atmospheric pressure at which all the layers were grown. The preliminary results that are presented here below were obtained using as source temperature 750 °C and the substrate temperature was varied between 730 and 640 °C. The effect of the water pressure on the growth and layers properties was explored over two decades. Epitaxial layers physical properties were studied by Secondary Ion Mass Spectroscopy, X ray Double diffraction (DDX) and low temperature Photoluminescence. Each time that the effect of a growth parameter was studied all others were kept constant.

3. Results and discussion

Figure 1 shows the obtained dependence of the growth rate as a function of the water vapor pressure. As it can be seen the growth shows a linear dependence with the water vapor pressure. That could mean that the water stochiometry coefficient in the chemical reaction that produces the transport is 1. To investigate the dependence of the sulphur incorporation in the growing layer, as a function of the growth conditions, we proceeded in the following way. Using two samples taken side by side from the same sulphur doped wafer, one was used as source material and the other as substrate. Then a grow was made at constant source temperature of; T= 750 °C, but using five different substrate temperatures from 680 °C to 600 °C by 20°C steps. Each substrate temperature was kept constant during 2 minutes. By this way we were able to assure that the growth of each layer took place exactly under the same conditions but the

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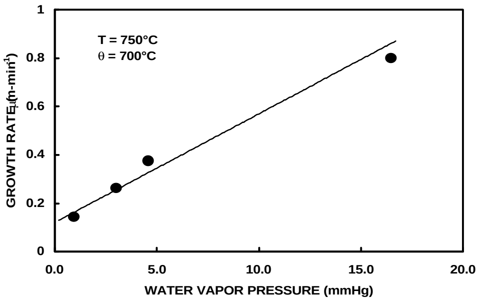

Figure 1. InAs growth rate a a function of the water vapor pressure, total chamber pressure 1 atm.

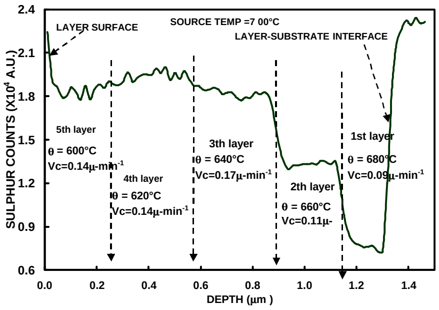

Figure 2. Sulphur concentration as a function of the substrate temperature at constant source temperature and water vapor pressure.

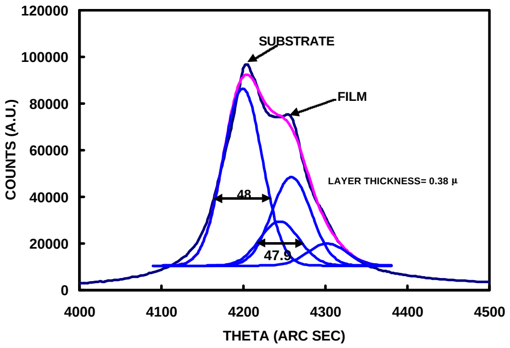

Figure 3. InAs-CSVT double X ray diffraction diagram

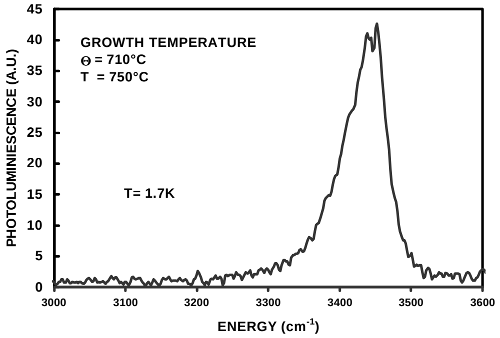

Figure 4. Low temperature photoluminescence of InAs-CSVT 0.3ìm thick layer

substrate temperature, particularly the water vapor pressure and the source sulphur concentration. Then, a SIMS sulphur profile was done through the entire layer.

The impurity profile obtained by this results to be self calibrated as the sulphur level signal beyond the layer substrate interface is the also the impurity Level at the source material. Figure 2 shows the SIMS obtained sulphur profile in the grown layer. As the growth rates for the different substrate temperatures used during this growth, result to be not too much different it can be concluded that the higher the substrate temperature is the lower the sulphur incorporation is. That means that the sulphur sticking coefficient during the growth of InAs is temperature dependent as well, as the substrate temperature increases its sticking coefficient decreases.

Layers crystalline quality was studied with a double crystal X ray spectrometer, typical width at half maximum (FWHM) of the rocking curve is 0.48 arc-sec, demonstrating their good crystalline quality, even for the higher growth rate. Figure 3 shows the x-ray diffraction diagram, as the spectrometer x-ray beam contains the Ká and K$_{â}$ emissions, the obtained diagram can be de-convoluted on four gaussian peaks, the first corresponds to the substrate and the second to the CVST epitaxil layer.

Concerning surface morphology, mirror like surfaces can be obtained at any growth rate, although not at each growth conditions. Low temperature photoluminescence (1.6 K) studies were realized, samples excitation was done with 10 mW Ar laser and analyzed by a Fourier Transform Interferometer BOMEN DA8. Typical spectra are shown in Fig. 4, where only near Band gap transition are observed. This photoluminescence spectra show that good quality material is been obtained, although containing a high impurity concentration, certainly because of the source material used.

4. Conclusions

This exploratory study has demonstrated that epitaxial InAs can be grown by CSVT using water vapor as transporting gas. The growth rate increases linearly with the water vapor pressure and growth rates ~1 μm are easily

achievable still having good layer surface morphology and physical properties as crystalline quality, low temperature photoluminescence. It was also found that sulphur incorporation decreases as the growth temperature increases. Indicating a possible way to obtain low impurity concentration epitaxial layers.

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