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eSWIR antimonide detector structures grown in MOCVD!

MOCVD Growth of GaSb, InGaAsSb and AlGaAsSb

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Introduction

Semiconductors with antimony attract great interest due to their potential applications in solar cells, infrared emitters and detectors. This work share information about growth of GaSb, lattice matched InGaAsSb and AlGaAsSb on (100) GaSb substrates in Aix-200 horizontal MOCVD reactor, assisted by Reflectance Anisotropy Spectroscopy (RAS) *in-situ* monitoring.**[1]**, **[2]**.

The target layer structure to be developed is eSWIR barrier detector structure aimed at unbiased operation at 300K.

This kind of structures were grown in MOCVD by Wang**[3]** and Dutta et al.**[4]**, and in MBE **[5]**, **[6]**.

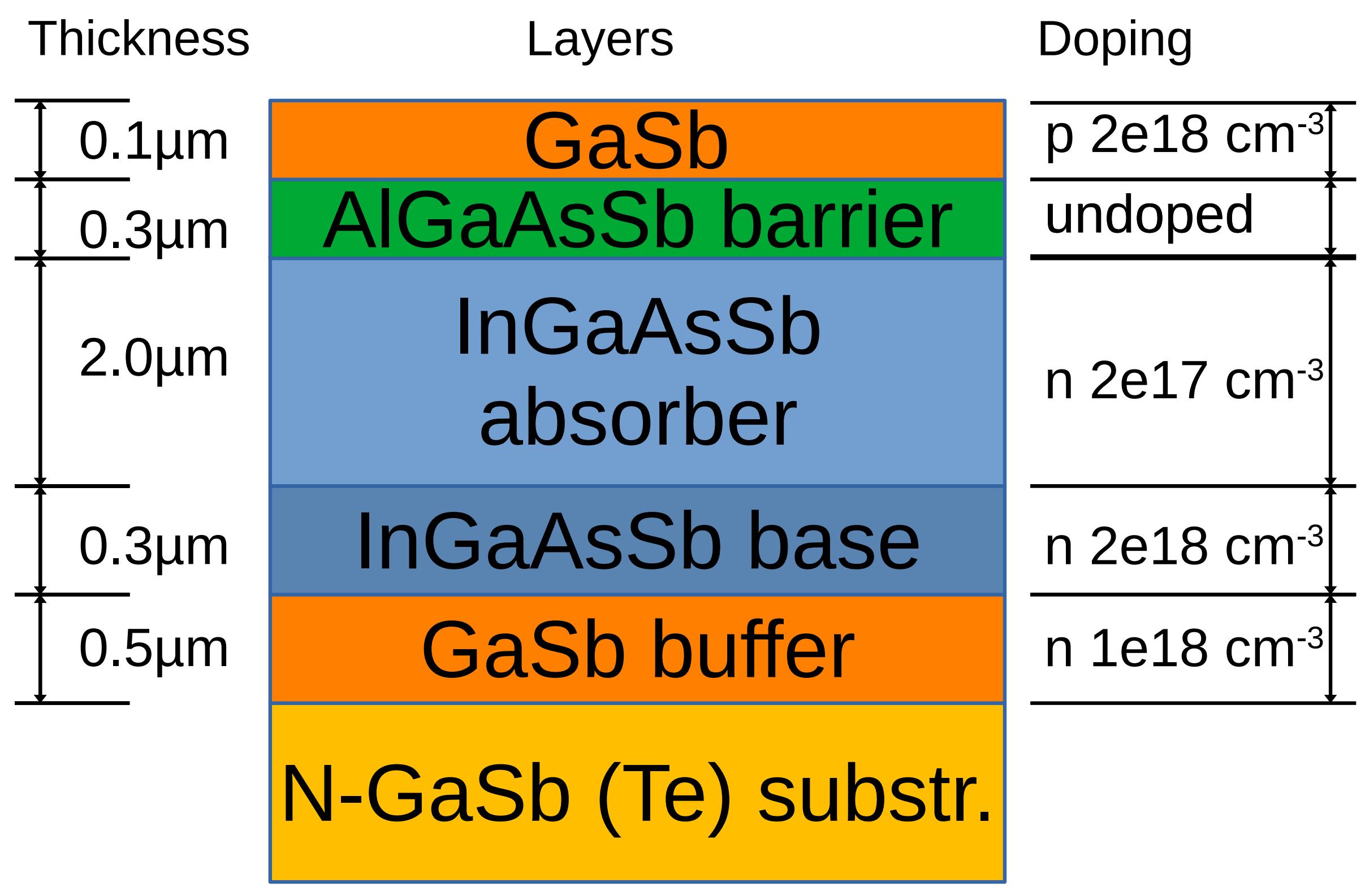

Figure 1: Target eSWIR detector structure

Experimental - Material Growth

The GaSb based structures were grown in an AIXTRON Aix-200 system horizontal quartz reactor with RF heater, non-rotating graphite susceptor and equipped with Laytec EPIRAS 200TT RAS and True Temperature measurement. The precursors we used were trimethylindium TMIn, triethylgallium TEGa, tris-tertiarybutylaluminium TtBAl, tertiarybutylarsine TBAs and triethylantimony TESb. Hydrogen was used as the carrier gas with the total flow through the reactor of 10 slpm during deoxidation as well as for the growth of all layers. The total pressure in the reactor was decreased to 150 hPa. Prior to the epitaxy, the oxide layer from substrates has to be removed. GaSb substrates were etched for 10 min in 35% HCl, then twice rinsed by isopropylalcohol, blowed off by N2 and directly loaded to the reactor. The deoxidation of GaSb substrates was carried out under hydrogen atmosphere with 1.5 µmol/min TESb flow at 560 °C for 10 min according to [4]. The growth temperature of GaSb layers was 540 and 560 °C, the later one was used for quaternaries, V/III ratio was kept between 1.8 and 2.5.

Results

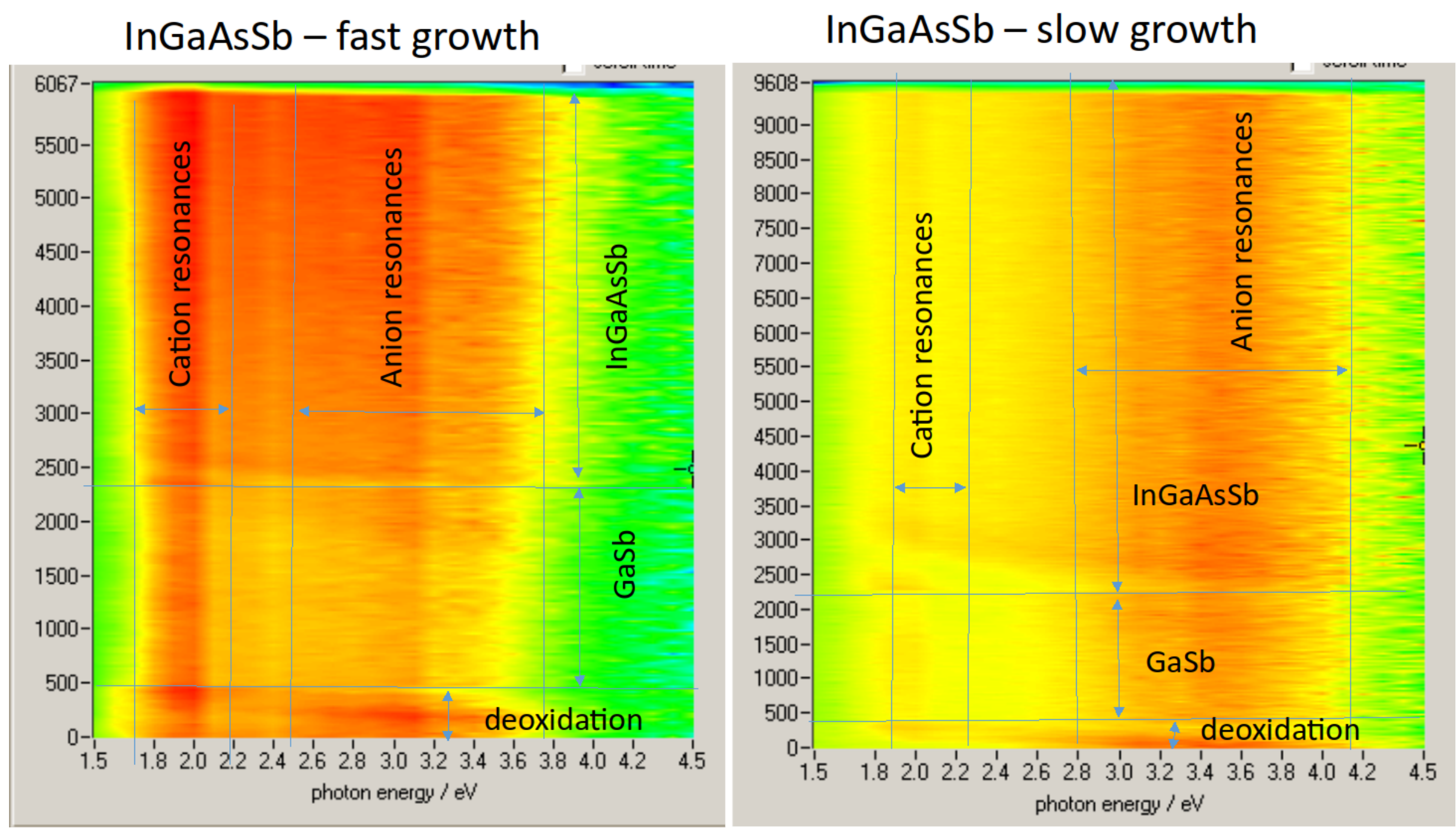
InGaAsSb – fast growth
InGaAsSb – slow growth

Figure 2: RAS spectra of sample grown faster (1µm/hour) and slower (0.5µm/hour).

The RAS spectra are influenced by growth rate(fig. 2), doping (fig. 3) and composition of quaternary layers. Growth rate influences the surface reconstruction similarly as in case of GaAs: at higher growth rate cation dimer resonances are the strongest, while for slow growth group V dimer formation is enhanced, with improved layer quality. It was checked, that lower growth rate helps to obtain better surface quality, and choosen approx. 0.5 µm/h for all layers. Similar growth rate limitation at 1.6µm/h was found by Moller et al. in RDS study of GaSb on GaSb epitaxy using TEGa+TESb **[7]**.

Similar differences between doped and undoped GaSb were reported in ref. **[8]**.

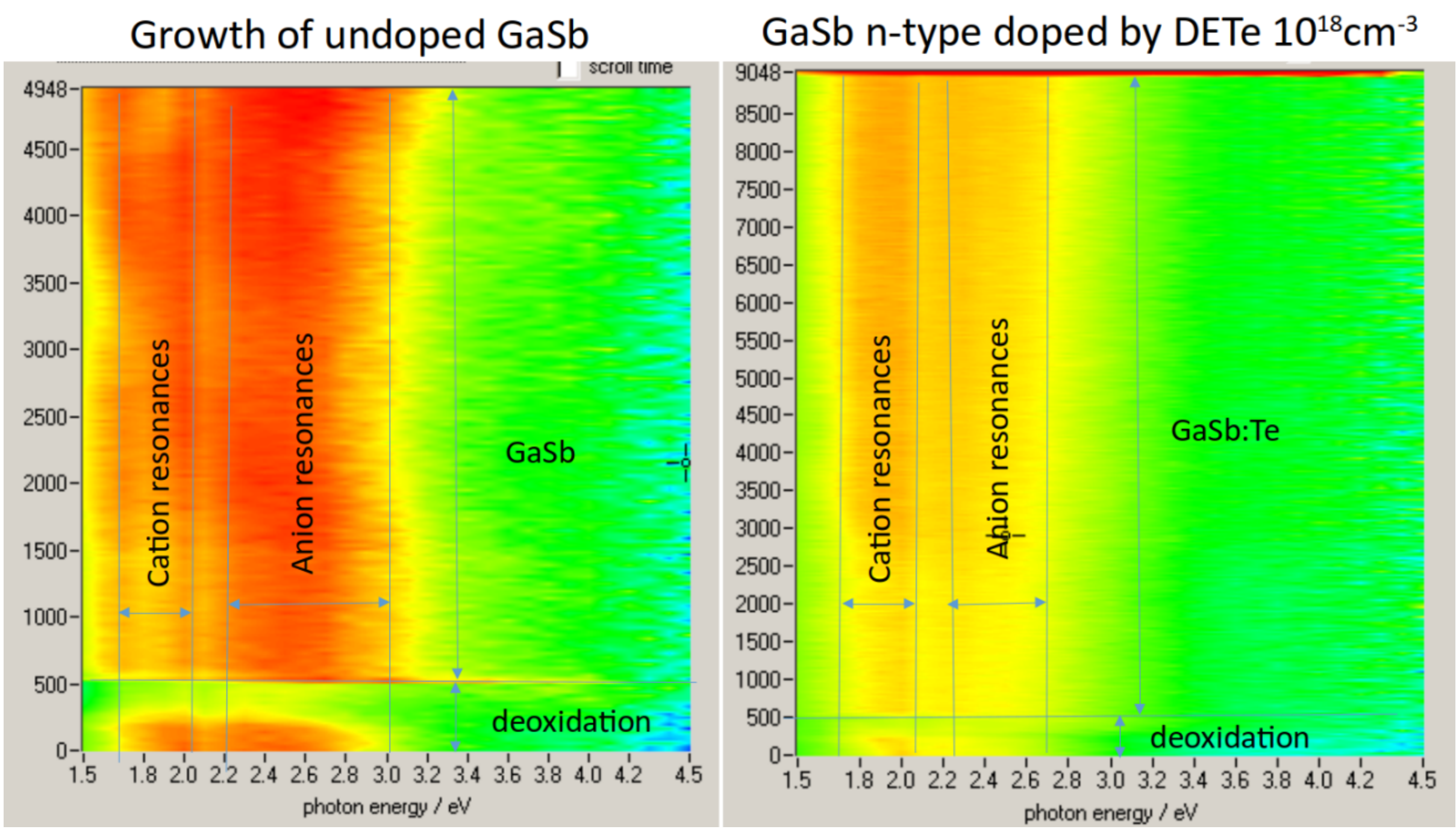
Growth of undoped GaSb
GaSb n-type doped by DETe 10^{18}cm^{-3}

Figure 3: RAS difference between undoped and Te-doped GaSb.

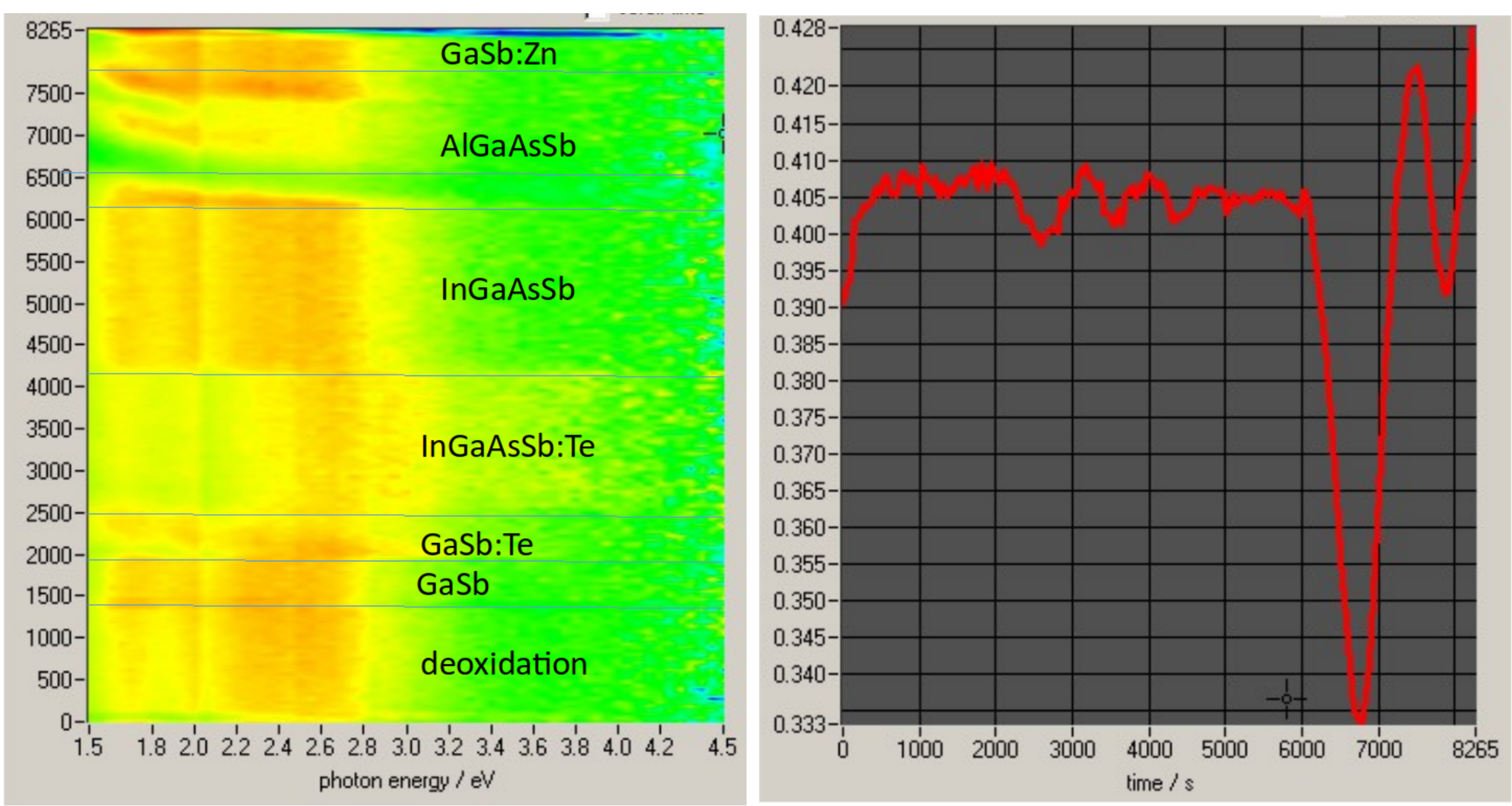

Figure 4: RAS and Reflectance during test growth.

Fig. 3 shows Te doping cause RAS signal at lower energy range decrease, and during the full structure growth there is shift of RAS signal maximum toward higher energy (fig. 4).

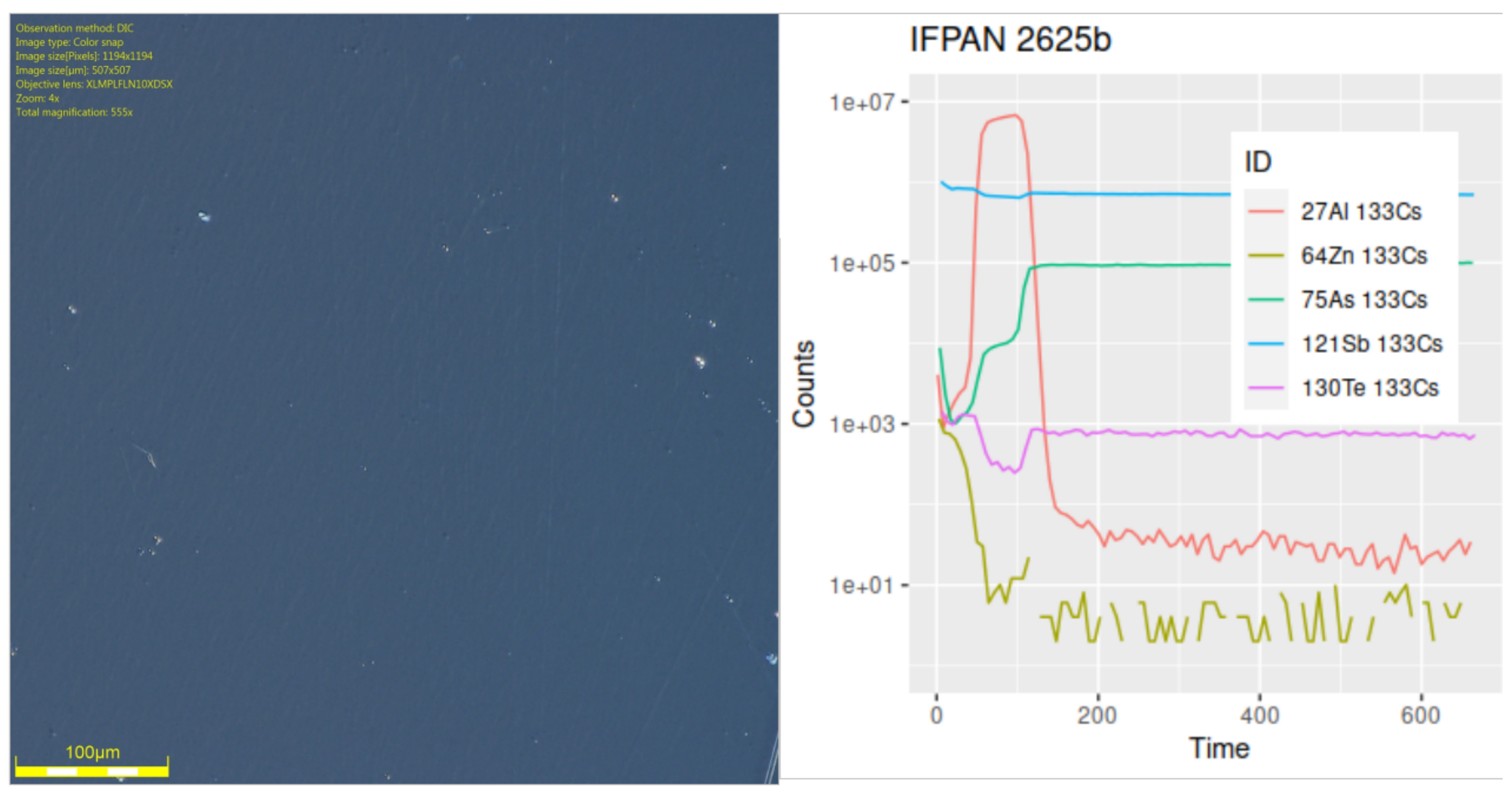

Figure 5: DIC Nomarsky picture of eSWIR structure surface (left(and SIMS measurement confirming proper barrier composition and doping profiles.

DIC Nomarsky pictures of grown full structure shows smooth surface, which confirm proper growth conditions (fig. 5a).

The SIMS measurement reveal proper Al composition profile and sharp Zn and Te doping profiles (fig. 5b).

Conclusions

1. Optimal technological conditions were found for the growth and doping of complex IR detector structure consisting GaSb, InGaAsSb and AlGaAsSb layers.
2. Our results may help to understand the RAS in situ monitoring in InAs-GaSb system
3. Processing and full characterization of grown eSWIR epi-structures are in progress
4. Developed technology is being transferred to other Photin Aix-200 reactor with Gas Foil Rotation and with ultrasonic precursor delivery devices to keep fixed III/V ratio during long runs.

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