7x6 inch MOCVD system for the production of VCSEL, HBT, HEMT

J. Hofeldt, B. Schineller, M. Heuken
AIXTRON AG, Kackertstr. 15-17, 52062 Aachen, Germany

Abstract: Experimental results (layer thickness, PL wavelength and doping uniformity) on GaAs/AlGaAs layers are presented. A new MOCVD production tool with a wafer capacity of 7x6 inch for production of e.g.VCSEL, HBT, HEMT is shown.

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1. Introduction

AIXTRON as the world‘s leading manufacturer of metal-organic chemical vapor deposition (MOCVD) equipment meets the demands of the III-V compound semiconductor industry by supplying the industry with multiwafer Planetary Reactors® with ever higher productivity. The productivity of an MOCVD system is primarily driven by the depositable wafer area, the uniformity across the wafers, the reproducibility from wafer to wafer and run to run, and the number of runs per day.

This paper elaborates on the achieved results for the material families of GaAs/AlGaAs, with a focus on electrical, optical and structural data. Van-der-Pauw Hall-effect measurements, non-contact sheet resistance mapping, room temperature photoluminesence (PL) mapping were used to quantify the results.

2. Experimental and results

GaAs-based VCSELs or electronic devices as HEMT and HBT require large area growth technologies with a focus on yield, reliability and uniformity. To meet these demands we have developed the AIXTRON Planetary Reactor®, which, in its 5×6 inch configuration, is already qualified and well proven for production. To increase the wafer area depositable per run the 7x6 inch configuration was developed.

Fig. 1 shows a schematic of the susceptor of the AIX 2600 G3 in the 5×6 inch (left) and the 7×6 inch (right) configurations. Fig. 2 shows a corresponding photograph of the reactor chamber.

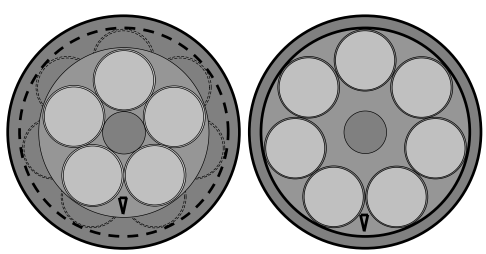

Fig. 1: Layout of the AIX 2600 G3 susceptor in the 5×6 inch (left) and 7×6 inch (right) configurations.

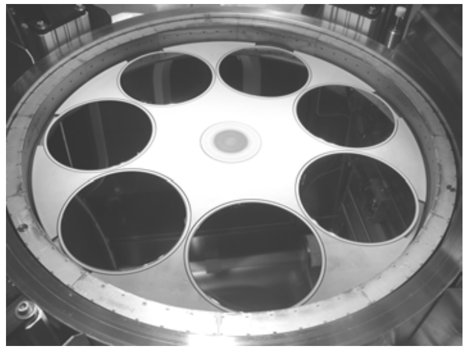

Fig. 2: Photograph of the reactor chamber of the AIX 2600 G3 in the 7×6 inch configuration.

To assess the performance of the system for the growth of VCSEL, p-HEMT and HBT structures we have investigated the p- and n-type doping uniformities of GaAs, and the n-type doping of $Al_{0.3}GaAs$ and GaInP. Fig. 3 shows the achieved on-wafer doping uniformities of GaAs on 6 inch of 1.24% and 1.1% standard deviation of the sheet resistance at carrier densities of 8×10^{17} cm^{-3} and 3×10^{19} cm^{-3} for n- and p-type, respectively. The corresponding wafer to wafer uniformities in the same run were of ±0.4% and ±0.7%, respectively. In analogous experiments n-type doping levels of 1×10^{17} cm^{-3} (σ_{onW} = 1.26%) and 1×10^{18} cm^{-3} (σ_{onW} = 3%) were achieved for $Al_{0.3}GaAs$ and GaInP, respectively. These results satisfy the demands of p-HEMT and HBT applications and guarantee excellent yield in mass production in the 7x6 inch configuration.

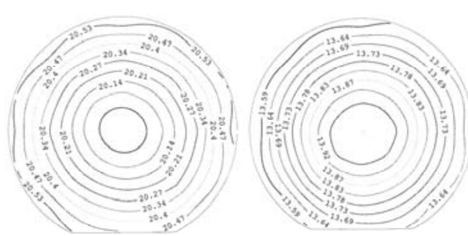

Fig. 3: Doping uniformities on 6 inch for n-type GaAs (left) and p-type GaAs (right).

Besides the need for excellent electrical data, the mass production of semiconductor devices demands the control of composition and thickness. Fig. 4 shows the thickness uniformity of a 2 µm thick $Al_{0.3}GaAs$ layer on a 6 inch GaAs wafer. The standard deviation was determined to be 0.17%.

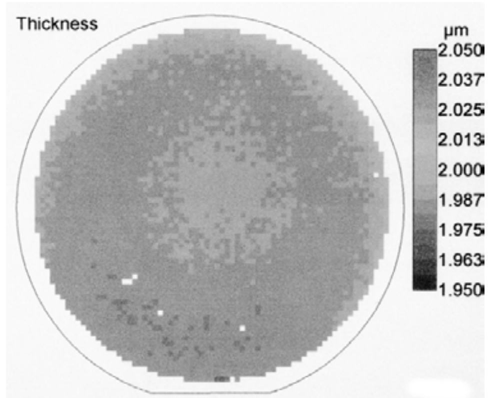

Fig. 4: Thickness uniformity of 6 inch $Al_{0.3}GaAs$.

Low cost of ownership is dependent on the efficient utilization of the precursor materials, notably the metalorganic sources. By changes of the total carrier gas flow the depletion profiles of all growth species can be precisely tuned in the reactor chamber. After rotating each wafer individually through this controlled depletion, outstanding uniformities together with extremely high precursor efficiencies can be obtained. To investigate thickness uniformity AlAs/GaAs distributed Bragg reflectors (DBR) were grown. In XRD profiles of a rotated 6 inch wafer the thickness interference fringes are equidistant across the wafer diameter indicating an excellent thickness uniformity of the layers. The wafer appeared green to the naked eye without any visible color changes and inhomogeneity. Reflectance measurements showed an average reflected wavelength of 552.4 nm with an overall standard deviation of 3.1 nm corresponding to 0.5%. The efficiency of the group-III precursors was found to vary with the carrier gas flow rate from 40% up to 54% with the highest values obtained at the low end of the carrier gas flow rate range.

3. Summary and conclusion

With the 7×6 inch layout a valueable configuration is added to the repertoir of AIXTRON's Planetary Reactor® concept. The excellent homogeneities and reproducibilities known from other configurations offer the device manufacturer the possibility to expand his production capacity without the need for extensive process adaptations.

MOVPE has established itself as the method of choice for mass production of modern compound semiconductor devices. The easy transferrability of process conditions from tool to tool, the hands-on control of processes by direct monitoring of the growing layer, the low cost of ownership, the high yield and the high volume throughput that the MOVPE growth technique offers are among the main deciding factors for the choice of MOVPE for the industry's production capabilities.