

A breakthrough in nanowire growth: Quantitative in-situ monitoring for process optimization

Nanowires (sometimes also called nanorods) are becoming more and more attractive for next generation LED and solar cell applications. One of the reasons is the fact that epitaxial III-V nanowire arrays combine 1-dimensional electronic states with additional degrees of freedom for strain relaxation and resonant electromagnetic interaction. The most critical parameters for nanowires' optical response are their length and diameter. Usually, time consuming and destructive ex-situ methods like scanning electron microscopy (SEM) are used for characterization before further processing. But now, LayTec and the Nanometer Structure Consortium at Lund University (nmC@LU) in Sweden have jointly developed a solution for real-time quantitative monitoring of III-V nanowire growth. The first results were presented by Martin Magnusson of Lund University at LayTec's in-situ seminar on June 3. The

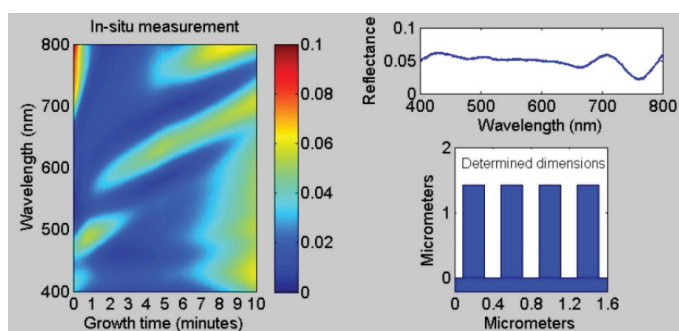


Fig. 1: LayTec software display after a complete nanowire growth run. In the color plot (left), the reflectance is given by the color.

team of Prof. Lars Samuelson used LayTec's spectroscopic in-situ reflectometer EpiR to monitor the nanowire epitaxial process in an AIXTRON 200/4 reactor. Fig. 1 shows an MOVPE run sequence where InP shells were grown on InP core nanowires (please find the whole run as video at www.laytec.de/nanowires).

The data of previous ex-situ analysis by SEM (see Fig. 2) and spectroscopic reflectance [1] were used by Nicklas Anttu of Lund University to develop numerical algorithms for deduction of the average length and diameters of the growing nanowire ensemble.

Together with these algorithms, the in-situ spectroscopic measurements by EpiR provide information on the evolution of nanowire length and diameter already during growth. According to Nicklas Anttu of Lund University, "The first results are very impressive. EpiR enables effective process optimization, speeds up development and paves the way to future process transfer for industrial nanowire growth. We are confident that in-situ metrology will be a must in nanowire applications in the near future."

[1] N. Anttu et al., Optical Far-Field Method with Subwavelength Accuracy for the Determination of Nanostructure Dimensions in Large-Area Samples, *Nano Lett.*, 2013, 13 (6), pp 2662–2667

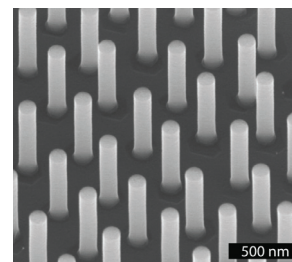


Fig. 2: SEM image of InP nanowires structured with gold particles by nanoimprint lithography. Courtesy: Lund University.

LayTec's in-situ seminar at EWMOVPE 2013: customers share their experience

On June 3, more than 100 customers attended LayTec's in-situ seminar in conjunction with the EWMOVPE XV in Aachen, Germany. This time our customers discussed these topics:

- Strain engineering in complex GaN structures on Si (C. Berger, Otto-von-Guericke University Magdeburg, Germany)
- Influence of GaN growth initiation on wafer curvature and electroluminescence (W. Lundin, Ioffe Physical-Technical Institute, Russia)
- Reflectance Anisotropy Spectroscopy (RAS) and wafer bow sensing for III-V concentrator photovoltaics (Th. Zettler, LayTec, presented recent results of Ioffe Institute, St. Petersburg, Tokyo University and Fraunhofer ISE, Freiburg)
- Semiconductor nanowire growth monitoring (M. Magnusson, Lund University, Sweden - see the article above)
- AbsoluT temperature calibration and advantages of LED

light source upgrade for CCS R&D reactors (T. SpringThorpe, National Research Council of Canada)

- RAS diagnostic of memory effect and surfactant of In and Sb atoms during III-V epitaxy (A. Hospodková, Institute of Physics, Czech Republic)

To download the talks on our website, please ask for the password via info@laytec.de.

You can meet us at the following workshops, conferences and trade fairs:

8 July 2013 | LayTec's in-situ seminar | St. Petersburg, Russia

25–30 August 2013 | 10th International Conference on Nitride Semiconductors (ICNS X) and LayTec's in-situ seminar | Washington DC, USA | www.icns10.org

30 September – 1 October 2013 | Deutscher MBE Workshop | Dresden, Germany | www.namlab.com (at the booth of our distributor EpiServe)