1975
doi:10.1017/S143192761501065X Paper No. 0986
Microsc. Microanal. 21 (Suppl 3), 2015
© Microscopy Society of America 2015

Analysis of GaAs Compound Semiconductors and the Semiconductor Laser Diode using Off-Axis Electron Holography, Lorentz Microscopy, Electron Diffraction Microscopy and Differential Phase Contrast STEM

Hirokazu Sasaki[1], Shinya Otomo[1], Ryuichiro Minato[1], Kazuo Yamamoto[2], Tsukasa Hirayama[2] Jun Yamasaki[3] and Naoya Shibata[4]

[1.] Furukawa Electric Ltd., Yokohama and Japan.
[2.] Nanostructure Research Laboratory, Japan Fine Ceramics Center, Nagoya and Japan.
[3.] Osaka University, Osaka and Japan.
[4.] Institute of Engineering Innovation, The University of Tokyo, Tokyo and Japan.

In order to develop and manufacture semiconductor devices which are key components of the optical telecommunication products, such as the semiconductor laser diode, it is essential to confirm whether it is manufactured as designed. Electric potential distributions of the semiconductor devices are designed in nanoscale, so two dimensional methods to evaluate the electrical potential in the semiconductors with a high spatial resolution are necessary for product management.

The observation of the gallium arsenide (GaAs) model specimen and the analysis of the semiconductor laser diode were carried out by using the electron holography, which is one of the methods of the transmission electron microscope, and Lorentz microscopy. In the observation using the electron holography, not only pn junction but also interfaces which are in different dopant concentration regions of the $1x10^{19}$ and $1x10^{18}$ cm^{-3} regions and the $1x10^{18}$ and $1x10^{17}$ cm^{-3} regions could be observed [1]. Then, the analysis example for the semiconductor laser diode was introduced and described that these methods have been used practically.

For other semiconductor electric voltage evaluation methods by TEM, electron diffraction microscopy [2] which is one method of phase reconstruction method, differential phase contrast [3] (DPC) which is one method of STEM are also effective and possible to be utilized complementarily with the electron holography. We will discuss about these method applied for semiconductor in this presentation.

References:

[1] H Sasaki *.et al*, Microscopy, 63（2014）, 235.
[2] J Yamasaki *.et al*, Appl. Phys. Lett., 101（2012）, 234105.
[3] N. H. Dekkers & H. de Lang, Optik 41, 452 (1974).

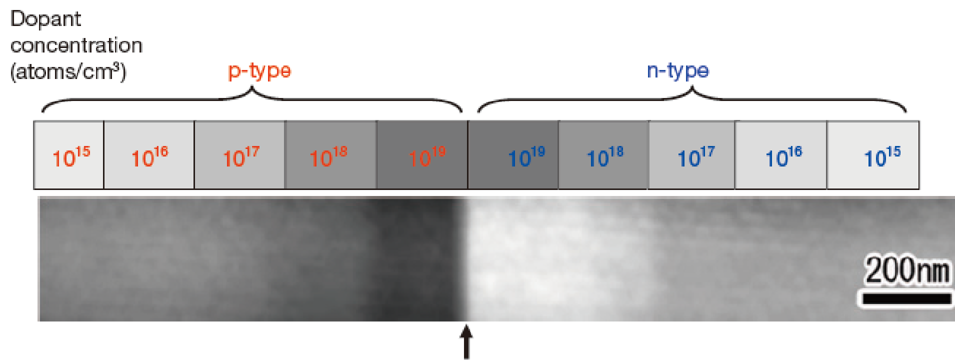

Figure 1. Phase image of the GaAs specimen reconstructed by the phase-shifting method.

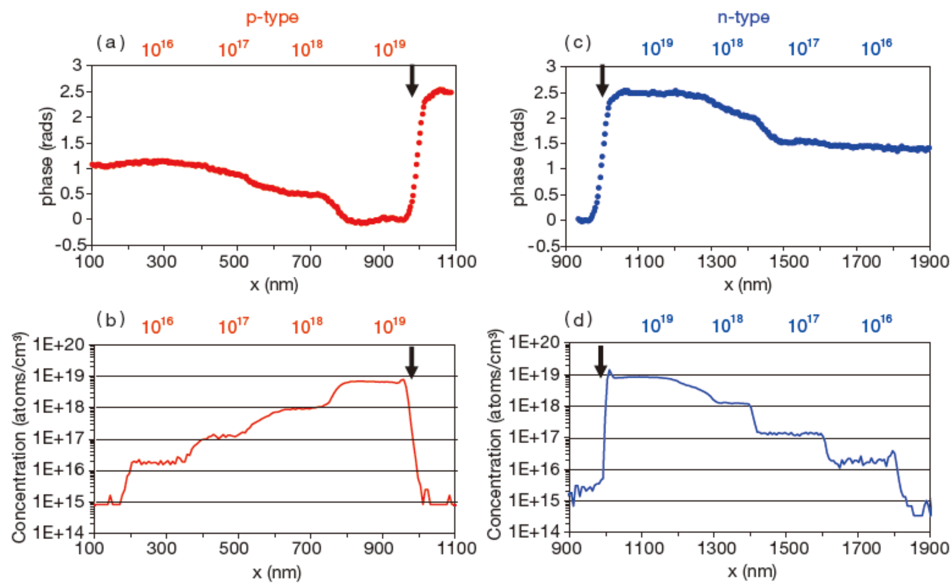

Figure 2. （a） Line profile of the phase image in the p-type region. (The arrows indicate a p-n junction.) （b） Zn SIMS profile. （c） Line profile of the phase image in the n-type region. （d） Si SIMS profile.