Growth of bulk GaN by ammonothermal technique

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Gallium Nitride (GaN) is a very interesting material because of its applications in fabrication of optoelectronic devices operating in short wavelength region (blue and green light). Low dislocation bulk GaN seems to be good candidate for high-power laser optical systems. For example, GaN-based green light emitters are supposed to be more efficient and more compact then currently available second harmonic generation lasers. These lasers are desired to fill the green-gap, which is necessary for commercialization of red-blue-green (RGB) laser displays and pocket laser projectors of high pixel resolution.

This communication presents the properties of truly bulk GaN monocrystals, obtained by unique ammonothermal method (in so-called ammonobasic regime). The ammonothermal technology is regarded as an analogue of hydrothermal one, commonly used in industrial quartz production. In this method GaN feedstock is dissolved in supercritical ammonia in one zone of high pressure autoclave, then transported to another one via convection, where crystallization on GaN seeds takes place due to supersaturation of the solution. The crystal growth proceeds in temperature range T=500-600°C and pressure p= 0.1-0.3 GPa. GaN produced this way posesses the crystal features such as exceptionally low FWHM value of X-ray rocking curve (20 arcsec), large lattice curvature radius (R~100 m) and the lowest dislocation density (of the order of 10^3 cm^{-2}). The substrates of various crystallographic orientation – polar C-plane, semipolar and nonpolar M-plane can be machined. The two latter ones, due to the largely reduced electric fields, are the response of company to market demands for this type substrates for green optoelectronics purposes. The dimensions of commercially available substrates reach 2 inch in case of polar substrates and about 26mm x 26mm in case of non-polar and semi-polar ones, being the largest size of non- and semi-polar truly bulk material. The polishing progress results in epi-ready surface with clear visible atomic steps and RMS factor of the order of few Å in substrates of any orientation. The results of improved purity and transparency of ammonothermal GaN crystals will also be shown.

Finally, the examples of devices grown on ammonothermal substrates will be presented: light emitting diodes (LEDs), high-power laser diodes of outstanding parameters, proving their potential in blue and green optoelectronics. Moreover, possibility of large size (26mm x 26 mm) non- and semi-polar GaN substrates opens perspective of more efficient green laser production.