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Structural and optical study of the strain distribution in GaN/AlN superlattices

B.I. Tsykaniuk[1], O.F. Kolomys[1], V.V. Strelchuk[1], P.M. Lytvyn[1], Shibin Li[2,3], M.E. Ware[2], Yu.I. Mazur[2], M. Benamara[2], A.E. Belyaev[1] and G. Salamo[2]

[1] *V. Lashkaryov Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, Pr. Nauky 41, 03680 Kiev, Ukraine.*
E-mail: btsykaniuk@gmail.com

[2] *Institute for Nanoscience and Engineering, University of Arkansas, West Dickson 731, Fayetteville, AR 72701, USA.*

[3] *State Key Laboratory of Electronic Thin Film and Integrated Devices, University of Electronic Science and Technology of China, 610054 Chengdu, China*

Recently, GaN/AlN heterostructures attract much attention for application in high-power, high-frequency and high-temperature electronics, electrochemical and optoelectronic devices. However, important problem in designing devices based on GaN/AlN superlattice (SL) is to control the deformation of the material systems with large lattice mismatch parameter between GaN and AlN. The study of stress relaxation in GaN/AlN superlattices is important not only because of their influence on electrical and optical characteristics but also because of their zone engineering effects due to the large piezoelectric constants of nitride semiconductors.

The investigated GaN/AlN SLs with different number periods (5, 10 and 20) ware grown by MBE on GaN/Al_2O_3 template with GaN buffer layer. The nominal thickness of GaN quantum well (QW) and AlN barrier was 3 nm. The optical and structural study of strain distribution in GaN/AlN SLs was examined by confocal Raman, photoluminescence and TEM techniques. From high resolution TEM analysis determined the change of the lattice parameter of GaN QW and AlN barrier and calculated depth profile deformation in the SLs layers. Strong PL peak in the range 3.1-3.4 eV depend on penetration depth was observed. Observed red-shifted PL emission as a result of quantum confinement Stark and strain effects in these AlN/GaN MQW structures. Also determined that GaN QW is under compressive strain and AlN barrier under tensile strain. This fact is in good agreement with confocal Raman results. By increasing the number of SL periods the high-frequency (low-frequency) shift of the peak of the E2(high) of the GaN (AlN) phonon modes occurs related to with increase of the compressive and tensile strain in the QWs and barrier layers, respectively.