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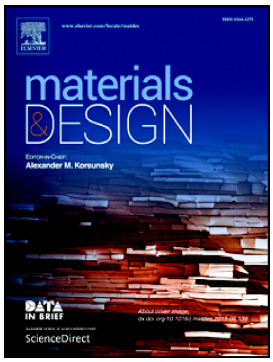

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Strain relaxation in GaN/AlN superlattices on GaN(0001) substrate: combined superlattice-to-substrate lattice misfit and thickness-dependent effects

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Abstract

The relaxation of built-up strain in the heteroepitaxial GaN/AlN superlattices (SLs) leads to defect-related undesirable changes of the optical and electrical properties of SL-based devices. In the present study, the influence of lattice misfit between the GaN/AlN SL and GaN(0001) substrate on the mechanism of strain relaxation in the SLs is comprehensively analyzed. A strain/thickness-dependent effect on the densities of threading dislocations (TDs) and cracks in the SLs is observed. At the initial stage of growth of the SLs with relatively small lattice misfit, the formation of TDs dominates over the post-grown cracking triggered by the thermal stress during the sample cooling. Cracking during the growth is the main mechanism of strain relaxation for the SLs with large lattice misfit. It is established that for the GaN/AlN SLs with thicknesses > 115±15 nm, which corresponds to a SL relaxation degree > 40±5%, the density of defects drastically decreases. This result offers an essential guidance for excluding the strong influence of the substrate on generation of a large number of defects in the SLs. The quantitative interpretation and discussions of the presented results are important towards the design of a high-quality heteroepitaxial GaN/AlN SLs.

Keywords: GaN/AlN superlattice; XRD; microstructure; strain relaxation; dislocations; cracks.