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Evaluation of diffuse x-ray scattering from misfit dislocations in heteroepitaxial layers

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Diffuse x-ray scattering from heteroepitaxial layers with misfit dislocations is studied experimentally and theoretically. The theoretical analysis presumes the dislocations to be located at the interface between one layer and the substrate and to be distributed randomly, as appropriate in the majority of cases. The profiles of the x-ray diffraction peaks and the reciprocal space maps of the intensity are measured and simulated for several heteroepitaxial structures in a wide range of dislocation densities. At large dislocation densities, the peak position is governed by the mean distortions and the peak width is due to the mean square variations of the distortions. The peak widths calculated for uncorrelated distribution of dislocations exceed the widths of the peaks measured on the heteroepitaxial structures with large mismatch. It is shown that the spatial correlations of the dislocations reduce the peak width and explain the discrepancy. For small dislocation densities, the coherent and the diffuse components of the intensity are measured and simulated. It is shown that the position of the coherent peak does not follow the mean distortions. Satellites of the diffuse peak are observed and explained.