Interface roughness in InGaAs/InP heterostructures

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InGaAs/InP heterostructures present an important class of semiconductor materials with applications in infrared optoelectronics and ultra-high-speed devices. Moreover, a large g-factor found in these materials makes them promising in the field of spintronics and quantum information processing. A manipulation of the electronic properties (including g-factor engineering) important in device applications is possible in superlattices - structures consisting of periodic sequences of the layers made of two different semiconductor materials. However, the application of the InGaAs/InP heterostructures is limited by the interface roughness scattering which may dominate the mobility of the electronic devices. The requirement of lattice matching makes high-quality interfaces more difficult to achieve in comparison to the GaAs/AlGaAs heterosystem. In this work the interface roughness was studied in lattice-matched short-period InGaAs/InP superlattices grown by molecular beam epitaxy. The periodicity of the superlattices was proved by x-ray diffraction. In order to examine the interfaces the InGaAs/InP superlattices with different width of the wells ranging from 6 to 65 monolayers were grown. At well thicknesses smaller than 30 ML the interface roughness dominates scattering of carriers. In such case the mobility decreasing with the decreasing well thickness may be described by a theory which allows for determination of the interface profile (the height and the lateral size of the interface roughness). The experimental data obtained in the InGaAs/InP superlattices were compared with the results acquired in the GaAs/AlGaAs superlattices. In both heterosystems the metal-to-insulator transition induced by the interface roughness scattering was achieved with the decreasing well thicknesses. The nature of the metal-to-insulator transitions and the characteristics of the interface roughness are discussed.

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