Correlation of structure and magnetic properties of MOVPE grown (MnGa)As clusters in GaAs

K. Volz [1)] , M. Lampalzer [1)] , W. Treutmann [1)] , W. Stolz [1)]

1) Materials Sciences Center, Philipps University Marburg, Hans−Meerwein−Strasse, D−35032 Marburg, Germany

Diluted magnetic semiconductor materials, e.g. (GaMn)As, based on III/V materials have attracted increasing interest recently due to the possibility of combining magnetic properties with existing electronics and optics based on GaAs. These materials have been grown by MOVPE (metal organic vapour phase epitaxy) using triethylgallium and tertiarybutylarsine as more efficient group III and group V precursors. As Mn source bis(methylcyclopentadienyl)manganese has been applied. Under certain growth conditions the formation of (MnGa)As clusters in the GaAs matrix is observed. Hexagonal (MnGa)As clusters are formed when the substrate temperature is chosen between 500 and 600°C and the Mn/Ga ratio in the gas phase during growth is high. These clusters are responsible for the ferromagnetic coupling in the samples up to temperatures exceeding room temperature. Depending on the growth temperature and the annealing as well as overgrowth conditions, different magnetic characteristics of the (MnGa)As cluster containing films have been found. These magnetic properties can be correlated to the structure and shape of the (MnGa)As clusters and their heteroepitaxial relationship to the GaAs matrix. High resolution transmission electron microscopy investigations show that clusters, which have been grown at high temperatures have only one distinct heteroepitaxial relationship of the clusters with respect to the matrix – in contrast to those grown at lower temperatures. This results in an anisotropy of the ferromagnetic coupling, which might be very important for device applications. Furthermore, these clusters can be overgrown heteroepitaxially with (AlGa)As. A model correlating the structure of the clusters with the magnetic measurements will be presented.

These investigations show that it is possible to grow (MnGa)As by MOVPE which fulfills important prerequisites for device applications, namely the possibility to be overgrown and a single heteroepitaxial relationship to the substrate.