Sn influence on MBE growth of GeSiSn/Si MQW

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Abstract. Temperature and composition dependencies of the critical thickness of transition from two-dimensional to three-dimensional growth for GeSiSn films on Si(100) with a lattice mismatch of 1 – 5% were experimentally determined. To understand the Sn influence on growth of SiGeSn/Si multi-quantum wells, the phase diagram of surface superstructures during the growth of pure Sn on Si(100) was created. A possibility of synthesizing multilayer structures by molecular beam epitaxy was shown, and the crystal lattice constants were determined using high-resolution transmission electron microscopy. We obtained GeSiSn/Si MQW structures which demonstrated photoluminescence for the Sn content in GeSiSn layers of up to 6%.

1. Introduction

The interest in GeSiSn materials is associated with the ability to create a direct bandgap semiconductor, as a double compound GeSn [1], and a ternary compound GeSiSn [2]. These compounds can be grown directly on a silicon wafer, providing the ability to create silicon photonics and optoelectronics devices operating in the IR spectrum. In recent years, a lot of articles on the creation of emitting devices and photodetectors, based on GeSiSn materials, have been published [3-6]. The structures, which were obtained in these studies, were grown on a silicon wafer using a 1 μm thick Ge buffer layer.

In the present work, we suggest to use pseudomorphic elastic-strained GeSiSn films grown directly on Si rather than relaxed layers. The principal advantage of pseudomorphic films against thick relaxed layers is that they are free of dislocations and coherent to the substrate. GeSiSn films are more thermostable than GeSn [7], their lattice constant and bandgap can be individually controlled as dependent on the composition.

In this work, GeSiSn multi-quantum wells (MQW) structures were grown directly on Si(100) substrates by molecular-beam epitaxy (MBE). The data about the initial growth stages of ternary compounds Ge-Si-Sn on Si(100) have been earlier obtained [8]. Using the reflection high-energy electron diffraction (RHEED) method [9], the kinetic diagrams of growth of $Ge_{1-x-y}Si_xSn_y$ on Si(100) in a wide temperature range (150 – 500°C) and at different lattice mismatch (1 – 5%) between a GeSiSn film and a Si substrate were determined (figure 1). Based on the temperature dependencies of 2D-3D transition, the growth temperature and thickness of GeSiSn layers were chosen to achieve a pseudomorphic growth. The GeSiSn layer thickness was 2 – 3 nm and the growth temperature of GeSiSn layers was 150 – 200°C. GeSiSn layers act as quantum wells which are covered by a Si layer