Formation of ultrahigh density Ge nanodots on oxidized Ge/Si(111)

April 27 2004

Yoshiaki Nakamura et al. present their work in Journal of Applied Physics (Vol. 95, No. 9, pp. 5014–5018). They grew Ge nanodots with a typical size of ~4 nm and ultrahigh density (>10^{12} cm^{-2}) on ultrathin Si_xGe_{1-x} oxide films made by oxidizing Ge wetting layers grown on Si (111)–(7×7) surfaces. This is a promising result for the application of SiGe-based optoelectronics because of the ultrahigh density of Ge dots in addition to their small dot size.

Considerable efforts have been made to fabricate quantum dots with a size on the order of 10 nm because of the potential to modify the physical properties of the material through the effects of quantum carrier confinement. To use the quantum confinement phenomena, the dots in nanostructures have to be smaller than 10 nm for SiGe-based electronics. However, three-dimensional (3D) Ge islands fabricated by a self-organization process of strained Ge layers on Si substrates are larger than 30 nm because the surface morphology is formed through unstable intermediate phases. In addition to dot miniaturization, another requirement is that the dots be formed with a high density.

Yoshiaki Nakamura et al. achieved 4 nm dots with ultrahigh density by replacing SiO_2 films with oxidized Si_xGe_{1-x} films. The density of the nanodots was independent of the Ge deposition rate, indicating that the chemical reaction between Ge atoms and the oxide films determined the nucleation of Ge nanodots. The size and density of Ge nanodots grown on the ultrathin Si_xGe_{1-x} oxide films depended on the growth temperature and deposition amount. These dependences indicate that

they can form the Ge nanodots with ultrahigh density controllably by using ultrathin Si_xGe_{1-x} oxide films.