Functional Materials 10, No.2 (2003)

Microdefects in semiconducting silicon

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Problems of grown-in microdefect formation in semiconducting silicon have been considered. It has been shown, using the transmission electron microscopy, that at high growing rates, both interstitial and vacancy microdefects coexist in silicon grown by the floating zone technique and by the Czochralski one. The microdefect formation, growth, and transformation mechanism in semiconducting silicon is proposed.

Рассмотрены вопросы образования ростовых микродефектов в полупроводниковом кремнии. С помощью просвечивающей электронной микроскопии показано, что при высоких скоростях выращивания в кремнии, выращенном методами бестигельной зонной плавки и Чохральского, сосуществуют межузельные и вакансионные микродефекты. Предложен механизм образования, роста и трансформации микродефектов в полупроводниковом кремнии.

The problem of microdefects is associated mainly with the absence of runoffs for point defects in dislocation-free single crystals. During almost 40 years, various experiments were performed to elucidate the reasons and conditions for the formation of microdefects, their effect on the crystal electrophysical parameters, and efforts were made to construct different theoretical models of the microdefect formation and growth. Since the electrophysical parameters of silicon crystals are structure-sensitive, the control of defect formation processes and production of silicon with the preset structure are very actual tasks of the modern electronic materials science. At present, the term "microdefect" means any local distortions in a periodic crystal structure having a size from several tens Angstrom units to several tens micrometers and being a transition class between point defects and linear ones.

The growth defect classification is rather complicated and confusing. This is associated with the fact that it is based mainly on data obtained using the selective etching of silicon single crystals in longitudinal and transversal sections [1, 2]. This resulted, in particular, in that the same term (D-microdefects) is used for quite distinct defects formed in silicon produced by the floating zone technique (FZ-Si) and by the Czochralski one (CZ-Si). In our opinion, the physical nature of the grown-in microdefects (the crystal lattice strain sign) is to be known along with the thermal growth conditions to establish the regularities of the microdefect formation. In the last case, it is just the transmission electron microscopy (TEM) that is the main information source. It allows to disclose the defects of as small size as 3 nm and provides various means to determine the strain sign caused by defects of different shapes and sizes. Using the classification of microdefects in FZ-Si and the available experimental data, it is possible to propose a classification taking into account both the microdefect distribution pattern and the growth thermal conditions (the crystal growth rate V, mm/min) as well as the microdefect concentration (N, cm^{-3}) determined from the TEM images, etc. (see Table 1). The microdefect classification in CZ-Si has been developed in the same manner basing also on the available literature data (Table 2).