Studies on the Solute-Feeding Czochralski Method and the Growth of GaInSb Bulk Alloy

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In recent years, device fabrication techniques for alloy semiconductors have been extensively developed. However, the available alloys are under the restriction of close lattice-matching conditions with a compound crystalline substaracte substrate having a certain lattice constant. If an alloy substrate controlled in its lattice constant can be realilzed, designing of alloy semiconductor devices will be released from this limitation.

In this thesis, a pulling technique of homogeneous GaInSb bulk alloys has been developed by improving "the solute-feeding Czochralski (CZ) method".

In the method, two conflict conditions should be realized simultaneously; non-equilibrium for stable CZ-mode growth and near-equilibrium for keeping the composition constant in both of grown alloy and growth solution are required. For this purpose, a two-chamber crucible, in which a growth region was separated from a source region by a wall with a small hole, was developed. The hole limits the rate of solute supply from the source region to the growth region to realize the suitable conditions of CZ-mode growth under solute-feeding.

The pulling of GaSb from Ga-Sb solution with this type of crucible made it clear that the hole operated as expected and the high rotation rate of a seed crystal was effective to eliminate compositional supercooling. On the basis of these experimental results, the pulling of GaInSb alloys was carried out using a GaSb seed. The pulled alloy had a uniform composition of 3.2 mol% InSb, indicating that the solute-feeding operated successfully during the growth. In order to obtain an alloy with higher InSb content, the composition of pulled alloy was increased step by step from the GaSb seed. After three steps, the composition of 10 mol% InSb was achieved. Crystalline quality and uniformity in the grown alloys were conformed by the measurements of electron probe micro-analysis, X-ray diffraction, phtoluminescence and hall effects.

Thus, GaInSb bulk alloys with a desired composition can be grown by the solute-feeding Czochralski method.