Liquidus Isotherms, Solidus Lines and LPE Growth in the Te-Rich Corner of the Hg-Cd-Te System*

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Liquidus isotherms for the Hg$_{1-x}$Cd$_x$Te primary phase field in the Te-rich corner of the Hg-Cd-Te ternary system have been determined for temperatures from 425 to 600°C by a modified direct observational technique. These isotherms were used to help establish conditions for the open-tube liquid phase epitaxial growth of Hg$_{1-x}$Cd$_x$Te layers on CdTe$_{1-y}$Se$_y$ substrates. Layers with $x$ ranging from 0.1 to 0.8 have been grown from Te-rich HgCdTe solutions under flowing H$_2$ by means of a horizontal slider technique that prevents loss of Hg from the solutions by evaporation. Growth temperatures and times of 450-550°C and 0.25-10 min, respectively, have been used. The growth solution equilibration time is typically 1 h at 550°C. Source wafers, supercooled solutions, and (111)-oriented substrates were employed in growing the highest quality layers, which were between 3 and 15 μm thick. Electron microprobe analysis was used to determine $x$ for the epitaxial layers, and the resulting data, along with the liquidus isotherms, were used to obtain solidus lines. In addition to EMP data, optical transmission results are given.

Key words: Hg$_{1-x}$Cd$_x$Te, liquid phase epitaxy, phase diagrams.

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Introduction

The Hg$_{1-x}$Cd$_x$Te alloys have a number of interesting physical properties as well as numerous potential device applications. These II-VI pseudobinary alloys can be tailored to cover a broad range of energy gaps and temperatures and their basic properties such as high electron mobility, high mobility ratio, relatively low dielectric constant, long minority carrier lifetimes and high electrooptic coefficients are very suitable for the development of complex devices. Among the well-developed semiconductor alloy systems, Hg$_{1-x}$Cd$_x$Te is unique because good quality material can be prepared with both high bandgaps (of interest for solar cells and for avalanche photodiodes operating at wavelengths in the vicinity of 1 μm) and low bandgaps (of interest for detectors and lasers operating in the vicinity of 10 μm and beyond). The lattice mismatch between HgTe and CdTe is only 0.3%, and Hg$_{1-x}$Cd$_x$Te layers can be precisely lattice-matched to CdTe$_{1-y}$Se$_y$ substrates. Furthermore, there is a good thermal expansion coefficient match between the substrates and the alloy layers.

Homogeneous bulk single crystals of Hg$_{1-x}$Cd$_x$Te are difficult to prepare by growth from stoichiometric melts because of the high vapor pressure of mercury and the large separation between the pseudobinary solidus and liquidus lines. This paper describes the growth of Hg$_{1-x}$Cd$_x$Te at relatively low Hg pressures by means of liquid phase epitaxial (LPE) growth from Te-rich solutions. Two other investigations of such growth have been reported.

Several other possible methods for obtaining Hg$_{1-x}$Cd$_x$Te epitaxial layers have been explored in the past. A close-spaced isothermal vapor-transport method using a HgTe source and CdTe substrate has been investigated. Cathodic sputtering deposition of Hg$_{1-x}$Cd$_x$Te films on single-crystal substrates of CdTe, NaCl, Ge, and sapphire have been reported. The Hg-ion bombardment of CdTe has been carried out, but epitaxial layers were not achieved. Polycrystalline layers of Hg$_{0.9}$Cd$_{0.1}$Te were obtained by a simple thermal evaporation method. The vacuum deposition of Hg$_{0.8}$Cd$_{0.2}$Te was studied using both flash evaporation and separate molecular beams of the components. Recently, an open-tube, vapor-phase deposition method using elemental sources and a variation of the close-spaced vapor-phase technique have