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ANNEALING OF DAMAGE IN GaAs AND InP AFTER IMPLANTATION OF Cd AND In

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ABSTRACT

The removal of damage and the electrical activation after heavy ion implantation of ^{111m}Cd and ^{111}In was investigated using the perturbed angular correlation technique (PAC) and Hall measurements. After implantation at 90 K and subsequent annealing the removal of structural disorder in the vicinity of the probe atom ^{111}In was observed around 300 K in GaAs and InP. The annealing behavior in the high temperature regime (500 K to 1100 K) of GaAs implanted with ^{111m}Cd and ^{111}In was investigated as a function of total implantation dose. After annealing at 600 K part of the Cd probe atoms are located in a slightly perturbed environment, the remainder in a heavily perturbed one. For Cd annealing above 900 K leads to outdiffusion of Cd located in heavily perturbed sites and electrical activation occurs. In contrast to Cd all In probe atoms are located in a slightly perturbed environment and no In is lost by outdiffusion. The differences and similarities of results obtained after Cd and In implantation are discussed in terms of extended defects and their interactions with the probe atoms.

1. Introduction

Most of the investigations concerning the recovery of III-V compound semiconductors on a microscopical scale were performed after irradiation of these materials with electrons, protons [1], or neutrons [2]. The situation after heavy ion implantation is different and up to now not well understood. Ion implantation is leading to a much higher defect concentration, creating amorphous regions in the material already at small doses [3]. Studies of high temperature annealing of implantation damage above 600 K in III-V materials mostly look at the electrical activation of dopants [4] and supply no direct information on the annealing mechanisms. The basic defect reactions were investigated at lower temperature by Rutherford backscattering [4], emission channeling (EC) [5], positron annihilation [2], and Mößbauer measurements [6]. As it was already shown, PAC is also able to supply information on the annealing behavior of implanted dopants [7,8,9]. The extension to different probe atoms (^{111}In and ^{111m}Cd) and the variation of implantation temperature and dose allow a more detailed discussion of the obtained PAC data in this work.

2. Method

The PAC technique is sensitive to electric field gradients (efg) present at the site of the probe atom, in our case ^{111}In ($t_{1/2}$ = 2.8 days) or ^{111m}Cd ($t_{1/2}$ = 48 min), both decaying via the same intermediate nuclear state. The interaction of the efg with the quadrupole moment Q of this state is detected via the modulation of the anisotropy in the angular correlation of the two consecutively emitted γ rays.