Epitaxial Growth and Luminescence Properties of Thin Films and Quantum Wells of Partially Ordered Zn$_{0.5+y}$Cd$_{0.5-y}$Se alloys*

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Traveling along the [001] direction of a zincblende binary compound one finds cation and anion atoms in alternate layers. In the case of Zn$_{1-x}$Cd$_x$Se ternary alloys we will find Se layers alternating with Zn$_{1-x}$Cd$_x$ layers; the cation fcc sublattice consists of a random distribution of Cd and Zn atoms and most of the optical, structural and electronic properties are correctly described by the virtual crystal approximation (VCA). In the particular case of Zn$_{0.5}$Cd$_{0.5}$Se we will find in each cationic (001) layer the same amount (in average) of Zn and Cd atoms. However, we can build another ternary alloy with the same chemical composition but with a different crystalline order along the [001] direction, only Cd or Zn atoms in each cation layer with the sequence Zn-Se-Cd-Se..., i.e., a Zn$_{0.5}$Cd$_{0.5}$Se ordered alloy, or more properly, the ordered ZnCdSe$_2$ tetragonal semiconductor. Changes in the material properties due to changes in symmetry and short range order, such as band gap reduction, valence band splitting, polarization dependence of optical transitions, changes in vibrational spectrum and others may be expected; the VCA approach cannot be employed to describe the ordered Zn$_{0.5}$Cd$_{0.5}$Se alloy [1, 2]. In this work, we present the results of our current efforts towards the growth by atomic layer epitaxy (ALE) of films and quantum wells (QWs) of the ordered Zn$_{0.5}$Cd$_{0.5}$Se alloy. In principle, the alternate deposition of CdSe and ZnSe monolayers (ML) by ALE could be expected to produce the ordered alloy, however, due to the unavoidable Zn-Cd chemical interaction, that results in the substitution of Cd atoms by Zn atoms and then the desorption of Cd atoms [3], the Cd content is lower than 0.5 and the resulting alloy presents a composition Zn$_{0.5+y}$Cd$_{0.5-y}$Se where $y$ can be as high as 0.2. In order to minimize the effects of the thermally activated Zn-Cd interaction we have grown QWs at relatively low substrate temperatures (~220 °C) and reduced the exposure times to Zn during the Zn-Se ALE cycles. The samples have been characterized by low temperature photoluminescence (PL) and we have observed that, at lower substrate temperatures and lower exposure times to the Zn effusion cell flux, we are closer to the nominal Zn$_{0.5}$Cd$_{0.5}$Se alloy composition; however, the excitonic emission of the QWs broadens indicating a increase in alloy disorder and structural defects caused by the reduced diffusion at the surface of the impinging atoms. A comparison of the electronic band structure of the ordered and disordered alloys will be presented and the degree of disorder of the samples will be described in terms of an order parameter.

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