Analysis of the Optical Properties of the Superlattice Quantum Well

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Abstract: As an artificial material made by thin film growth technology, superlattice quantum wells have wide application prospects. Based on this material, this paper discusses three aspects: first, the type of Superlattice Quantum Well, second, the experimental material and sample preparation, and finally, the analysis is carried out according to the experimental phenomenon, hoping to enlighten people in some aspects.

1. Introduction

In this paper, the optical properties of superlattices are studied. The main purpose is to provide more diversified means for the study of electronic structure of superlattices. In addition, the spectral study also makes the optical properties of superlattice quantum wells present in a more systematic and accurate form, which also provides strong support for the optimization of experiments on which the new device principles rely.

2. Type of Superlattice Quantum Well

Quantum well refers to the electron and hole potential well formed by arranging two kinds of semiconductor materials between phases, both of which have quantum restriction effect. Superlattice refers to the coupled multiple quantum well. If the barrier layer is thin and the well has strong coupling, it will lead to the formation of multilayer structure, that is, superlattice.

2.1 Component Superlattices

Generally speaking, the application direction of superlattice materials is mainly the fabrication of planar imaging array. The common superlattice types include component superlattice, doping superlattice and semiconductor energy band. Among them, there are significant differences in the band gap width of the constituent superlattices, and the band gap can not be avoided. According to the difference of electron affinity, the discontinuous energy value can be determined, and then the band gap width can be considered to determine the corresponding discontinuous value of the valence band.

2.2 Doped Superlattices

The semiconductor superlattice is formed by changing the doping type alternately. At first, in order to avoid the change of microstructure when doping impurities into semiconductors, researchers strictly restricted the concentration of impurities. With the change of doping impurities, the performance of doped super crystals also changed, and the indirect band gap appeared.

2.3 Semiconductor Energy Band

If the semiconductor material of superlattice has two different band gaps, the selection rule of each quantum well is easy to affect the charge movement. The band structure of semiconductor materials is shown in Figure 1, where φ corresponds to electron affinity; EO corresponds to vacuum energy level; EC corresponds to bottom of conduction band; EV corresponds to top of valence band; K corresponds to wave vector; Z (k) corresponds to electron energy.

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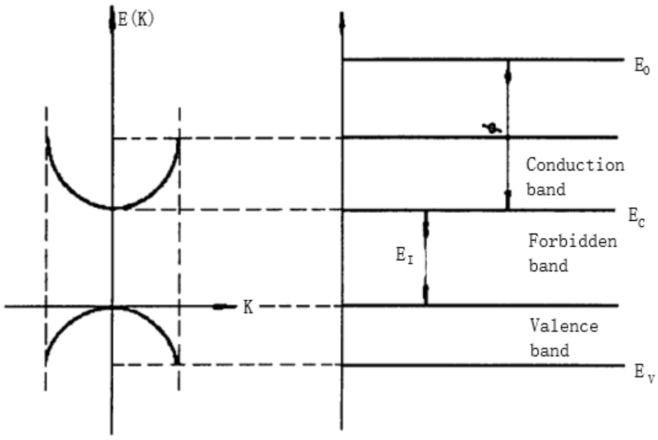

Fig.1 The Energy Band Structure of the Semiconductor Material

3. Experimental Materials and Sample Preparation

3.1 Preparation of Materials

3.1.1 Molecular Beam Epitaxial

Superlattice refers to the use of two materials with good lattice matching degree, through the alternate growth of periodic structure, to obtain materials with a thickness of no more than 100 nm. Electrons oscillate in the process of moving along the growth direction, which is usually used to manufacture microwave devices. The key to realize the above idea is molecular beam epitaxy. Molecular beam epitaxy (MBE), which refers to the beams of atoms and neutral molecules moving in a specific direction in a vacuum system, it has been widely used in the preparation of superlattices. MBE, as a vacuum evaporation method, has the following characteristics: first, epitaxial growth can be realized only in a vacuum system; second, the transport form of evaporation is mostly atomic beam and molecular beam [1]. The working principle is as follows: the substrate and molecular beam source furnace are placed in the vacuum system, and the compound elements and dopant elements are placed in the jet furnace. By means of heating, the atoms / molecules are ejected to the substrate surface according to the specific beam intensity and thermal movement speed, and the interaction occurs, so as to achieve the effect of epitaxial growth of single crystal film.

3.1.2 Atomic Layer Extension

The requirement of ultra-high speed devices for thin film structure is that the thickness of thin film can be controlled in a single layer, which is the background of three-dimensional structure. In order to give full play to its function, it is necessary to optimize the epitaxy technology and ensure that the film structure can meet the requirements of high uniformity and the characteristics of single-layer control. The crystal in the atomic layer epitaxy needs to be grown on the basis of the reaction of collision material and adsorption layer material, and the factors that determine the growth thickness are mainly the surface coverage of the adsorption layer. Therefore, to ensure the growth thickness is consistent with the expectation, the key is to control the temperature, flow rate and partial pressure.

3.1.3 Chemical Beam Epitaxial

The chemical beam epitaxy takes the molecular beam obtained by the element source evaporation as the core, and the characteristic of the chemical beam epitaxy is mainly expressed in the following aspects: firstly, the problem of the active film is not present; secondly, the ultra-thin layer and the abrupt hetero-section can be naturally generated; and thirdly, a plurality of instruments can be used for detecting the property of the epitaxial layer; And 4, the degree of cooperation with other processes is high, for example, ion implantation, metal evaporation, and the like. The practice has proved that the chemical beam epitaxy can be used to grow and component compound and epitaxial layer, and the target of batch production can be realized by multiple pieces of production.

3.2 Sample Preparation

3.2.1 Clean the Surface of the Substrate

The natural oxide film is often formed and the carbon in the atmosphere is adsorbed on the substrate exposed to the atmosphere. For GaAs, carbon is a pollutant to be removed. The commonly used removal method needs to form the oxide film first, and then put it into the related device. In addition, using ion beam to irradiate the surface of the sample can also achieve the effect of carbon removal, but this is easy to damage the lattice, so it is necessary to pay attention to the supply and demand of post-treatment.

3.2.2 Superlattice Doping

The doping method of the superlattice is two, one is to make uniform doping of the potential well and the potential well, and the other is to modulate and dope the specific semiconductor layer. Because the object of the modulation doping does not include the GsAs layer, the electron mobility can be improved by the fact that the coulomb scattering effect is reduced.

3.2.3 Preparation of Superlattice Samples.

As an ultra-high vacuum system, molecular beam epitaxial (MBE) not only needs good sealing, but also needs regular maintenance to reduce the residual amount of harmful gases and reduce pollution. The process of preparing superlattice samples is as follows: first, the glass plate is polished with coarse fine steel sand, washed with clean water after the angle appears, and then the rough surface is observed; secondly, the samples are polished with fine steel sand, the samples and grinders are washed, and their roughness is observed; finally, cerium oxide is used for final polishing, and the brightness of polishing surface can reach the standard.

4. Optical Experimental Analysis

The continuous development of electronic industry has laid the foundation for the promotion and use of electronic products. Superlattice materials have emerged. In recent years, more and more perfect crystal preparation technology has made the research on superlattice structure more in-depth. Based on the experiments on the optical properties of Superlattice Quantum Wells, the following text analyzes the experimental results for the reference of relevant personnel.

4.1 Photocurrent

On the surface of the sample to be etched, the upper electrode and the lower electrode are engraved, and the lead wire is used for measuring the photocurrent of the sample. The interference and reflection of the electron wave in the superlattice interface usually form an electron state, which is a starting point for calculating the electronic state of the superlattice, and the comparison of the experimental results shows that the peak width, height and position of the photocurrent formed by the electrons in the discrete energy level are calculated. And the method for obtaining the specific numerical value of the micro-strip bandwidth has good accuracy.

4.2 Raman Scattering

If the superlattice is doped with GaAs, the well layer doped with the atoms can be formed to form a plasma, good external conditions can be provided, the mutual coupling occurs and the Raman scattering is led out.

4.3 Photoluminescence

One side of the material is generated, the inclined surface is etched, and the photoluminescence measurement is carried out by means of a fluorescence spectrometer, The results of the actual measurement and the theoretical calculation results are taken into account, and if the two are the same, the occurrence of the light-emitting peak is indicated, which is mainly influenced by the recombination of the electrons and the holes.

4.4 Exciton Spectrum

The exciton spectra corresponding to quantum wells mainly have the following characteristics: First, if the temperature of quantum wells is low, free exciton absorption and fluorescence usually dominate; Secondly, the factors that may affect Bohr radius and exciton binding energy, including hole well depth, width and so on; Thirdly, the subbands formed by holes usually exist independently. Finally, if the quantum well is at room temperature, the absorption spectrum of the quantum well shows exciton absorption peak, which is often very obvious. In addition, it also includes saturated absorption: if the light intensity is small, the light absorption coefficient is not closely related to the light intensity, which is usually called "linear optical absorption"; if the light intensity is large, the relationship between the absorption coefficient and the light intensity is negative, which is called "Nonlinear absorption".

5. Conclusion

From the above description, it can be seen that the significance of superlattice quantum wells is very important both in theory and in practice, mainly because the periodicity of superlattice quantum wells can be changed according to the requirements, which makes it have properties different from natural materials, and it is precisely because of this that superlattice quantum wells are widely used in the fields of optoelectronics, material science, semiconductor physics and so on.

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