CHAPTER 6

Conclusions

In this dissertation, the growth and characterization of $Si_{1-x}Ge_x$, GaAs and ZnSe epilayers grown on Si (100) substrates are systematically studied. The mechanism of interface-blocking mechanism was proposed to reduce the threading dislocations in the $Si_{1-x}Ge_x$ and Ge epilayers on Si substrates. And the high-quality epitaxial Ge layers grown on a Si substrate were demonstrated. In this study, the growths of GaAs and ZnSe epilayers on Si were based on this novel $Ge/Ge_{0.95}Si_{0.05}/Ge_{0.9}Si_{0.1}$ buffer structure. The growths of high-quality GaAs and ZnSe epilayers on $Ge/Ge_xSi_{1-x}/Si$ were successfully demonstrated by using MOCVD and MBE equipment, respectively. The properties of nickel germanosilicide contact on $Si_{1-x}Ge_x$ were also investigated with improvement. The primary results obtained in this dissertation are summarized below:

(1) An interface-blocking mechanism was proposed to reduce the threading dislocations in the SiGe and Ge layers grown on Si(100) substrates. A method of growing high-quality Ge epitaxial layers on a Si substrate was also were demonstrated. The method mainly involves: (1) growth of three layers consisting of 0.8μm $Si_{0.1}Ge_{0.9}$, a 0.8μm $Si_{0.05}Ge_{0.95}$, and a 1.0μm top Ge layer, and (2) *in situ* 750℃ annealing for 15 min performed on each individual layer. By this procedure, many dislocations were formed at the $Si_{0.1}Ge_{0.9}/Si$ interface and at the lower part of the $Si_{0.1}Ge_{0.9}$ layer. Moreover, the upward propagated dislocation in the bottom layer were bent and terminated effectively by the interfaces of $Si_{0.05}Ge_{0.95}/ Si_{0.1}Ge_{0.9}$ and $Ge/ Si_{0.05}Ge_{0.95}$. The top Ge layer exhibited a low threading dislocation density and a smooth surface, while the total thickness of the epitaxial structure was relatively small.

(2) High-quality GaAs epitaxial layers successfully grown on $Ge/Ge_{0.95}Si_{0.05}/Ge_{0.9}Si_{0.1}/Si$ substrates by using MOCVD were demonstrated. The improvement of the crystallinity of the GaAs was demonstrated by using the $Ge/Ge_{0.95}Si_{0.05}/Ge_{0.9}Si_{0.1}$ buffer structure grown

on 6° off-cut Si substrate. It was shown that the GaAs epitaxial layers grown by this approach exhibited ultra-low threading dislocation densities. The suppression of Ge inter-diffusion into GaAs epilayers was also succeeded using the Si substrate with 6° off-cut toward the [110] direction.

(3) The growth of high-quality ZnSe epilayers on Si substrates using a $Ge/Ge_{0.95}Si_{0.05}/Ge_{0.9}Si_{0.1}$ buffer structure was demonstrated. The use of the large off-cut Si substrate improved the crystallinity of the ZnSe epilayer grown and successfully suppressed Ge diffusion into the ZnSe layers. The ZnSe epilayers grown on the large off-cut $Ge/Ge_{0.95}Si_{0.05}/Ge_{0.9}Si_{0.1}$ buffer layers also exhibited a low threading dislocation density. The PL spectrum of the large off-cut ZnSe sample showed intense FX with a narrow peak width. These results indicate that the use of the large off-cut Si substrate to suppresse the Ge interdiffusion through the heterointerface and help the growth of high-quality layers by reducing dislocation generation. The method of low temperature MEE and buffer layer growth with *in-situ* annealing can effectively suppress the formation of the deep-level emission in the $ZnSe/Ge/Ge_xSi_{1-x}$ structure was also demonstrated.

(4) We have demonstrated that in order to improve the sheet resistance, specific contact resistivity and junction leakage current of the nickel silicide contact on $Si_{1-x}Ge_x$ layer, a Si consuming layer with an appropriate thickness should be grown on the top of the $Si_{1-x}Ge_x$ layer for silicide formation. The silicidation film is uniform, smooth and free from Ge segregation nickel silicide formed on $Si_{0.8}Ge_{0.2}$. The morphological is also demonstrated stability was thermally stable after aging at 400℃ for 48 hours.