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Grazing Incidence Small Angle X-ray Scattering studies of GeSi Quantum Dots

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Introduction

Semiconductor quantum dot structure have shown very promising application in optoelectronics and might become important for new architecture of computer. The performance of such Si-based optoelectronics device strongly depends on the shape, size and distribution of GeSi quantum dots(QDs). Thus the microstructure characterization is very important in GeSi QDs investigation. As the result of grazing incidence small angle x-ray scattering(GISAXS) composes the statistic information of QDs, and also has the advantage of investigating buried QDs, it is a complementary method compare to the direct observation method, such as Atomic Force Microscope(AFM). Because of this advantage of GISAXS, we have used GISAXS to investigate the GeSi QDs.

Experiment

The GeSi QDs samples were grown by S-K mode by Molecular Beam Epitaxy(MBE). The QDs sample was prepared as follows: a buffer layer with the thickness about 50 nm was grown before the deposition of Ge Dots on clean Si surface. First the deposition of Ge was carried out at the temperature of 680 °C with the growth rate about 0.01 nm/s. After 0.7 nm Ge layer was deposited, the sample was annealed for 5 min, and then 0.05 nm Ge layer was deposited. As the deposition of the Ge film was finished, a Si caplayer with nominal thickness of about 1.6 nm was deposited at the temperature of 700 °C.

The sketch of GISAXS was shown in Fig. 1 . The incidence x-ray impinge on the sample surface with a small angle near the critical angle. Before the image plate there is a beam stop to avoid the strong prime beam and the reflected beam.

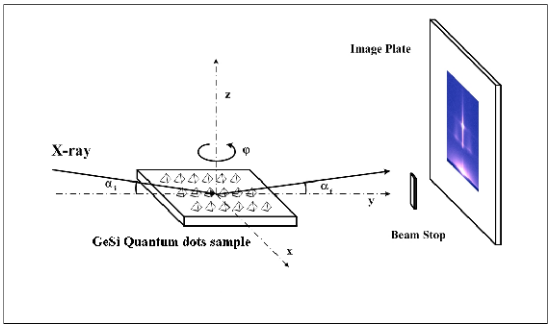

Fig. 1 Sketch of GISAXS

Results and Discussion

Fig. 2 shows the GISAXS results of GeSi QDs with incidence angle at 0.4 degree. Small angle x-ray scattering signal around the Yoneda peak and the reflected beam can be seen clearly. We attribute this scattering to the GeSi QDs distribution on the sample surface. The size and shape distribution usually affect the high q area, which seems to be immerged in the large back ground noise in the high q area in this experiment.

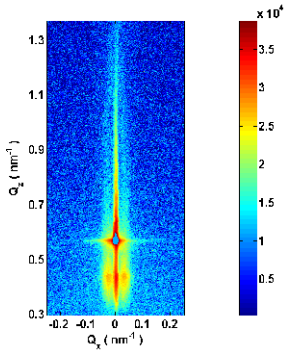

Fig. 2 GISAXS result of GeSi QDs

Fig 3 shows the horizontal cut in fig. 2 where the q_z equals 0.43nm^{-1}, the q_x ranges from 0 to 0.25nm^{-1} , and the first q_x maximum is 0.0322nm^{-1}. We could obtain the average distance between island from the equation:

$$D=2\pi/q_{xmax}$$

Therefore, the average islands distance on the surface is 195nm.

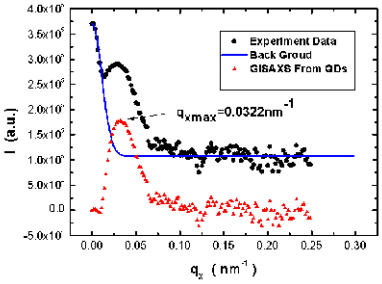

Fig. 3 Horizontal cut at q_z = 0.43nm^{-1} in fig.2

More accurate simulation of distance, shape and size distribution needs to employ more complicated DWBA theory.

References

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