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A grazing-incidence SAS measurement of Ge islands capped with Si

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Introduction

The structure of self-organized Ge islands capped with a Si layer has been examined by small-angle scattering measurements with grazing-incidence (GI-SAS).

Although the structure of semiconducting islands grown on substrates has been examined by direct methods such as scanning probe microscopy, GI-SAS has a merit that the structure of islands buried in a cap layer for protection or for confinement can be examined, in particular, as the macroscopic average. We conducted small-angle scattering experiments with grazing incidence with rather simple set-up. It was shown that the use of two-dimensional detector is quite useful and simple kinematical analysis applies when the islands are small enough and the scattering profile appears well above the critical angle.

Experimental

GI-SAXS experiment was performed at BL-15A with a sample rotation/height stage and the 9-inch II-CCD. A typical experimental setup is described in [1]. In order to set the angle of incidence slightly larger than the critical angle, trace of the specular reflection was used to calibrate the angle of sample stage. In the present measurements, a sample with one layer of Ge islands grown on Si substrate and capped with Si was examined.

Results and Discussion

Figure 1 shows a set of two-dimensional GI-SAXS patterns with the angle of incidence varying from just above the critical angle for Si to above that of Ge. It is seen that with the angle of incidence between the critical angle of Si and Ge (a), the SAS intensity is weak and no apparent SAS pattern originating from the island was observed. When the angle of incidence increased as shown in (b), well-defined SAS profile reflecting the shape of the island, and also the interference effect between islands was observed. The average size of the island was estimated to be about 9nm in radius from a Guinier approximation of the in-plane intensity. The Guinier radii was found to be the same when the direction of the incident beam with respect to the sample was rotated in the in-plane direction. This leads to a conclusion that the Ge islands examined in the present experiment is not facetted. From the peak distance in the in-plane component of the intensity, the average separation of the islands was found to be 44.2 nm. Since the distance between the neighboring islands are the same regardless of the crystallographic direction, the spatial distribution of the Ge island was isotropic in the present sample. Assuming a nearly close-packed distribution, the number density of the island was estimated to be 6.0×10^{-10} cm^2. It should be emphasized that the size and also the number density of the Ge island are evaluated without removing or destroying the capped layer in the present experiment. Present results suggest that GI-SAXS is quite useful in evaluating the structure of self-organized nanodots. Detailed analysis on the shape and distribution of the islands based on kinematical calculation is now under progress.

References

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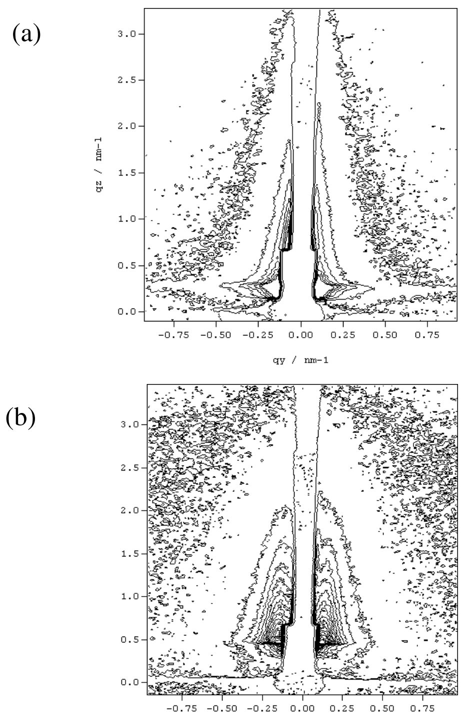

Fig.1 Two-dimensional GISAS profiles for α=0.3degree (a) and β=0.48 degree (b).