29p-F1-6

Growth of Morphology-Controlled Ga_2O_3 Nanowires by High Temperature Glancing Angle Deposition

高温斜め蒸着法によって形態制御された Ga_2O_3 ナノワイヤの成長

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ABSTRACT

Nanowires have attracted considerable attention as novel material for nanodevices. Because conventional nanowire growth method is performed in high pressure (~1 Pa), it is difficult to control deposition conditions (amount, flux, incident angle of atoms). In order to investigate detailed relationships between growth modes of nanowires and deposition conditions, sophisticated growth technique is required. On the other hand, we have found that nanowires of various elements are grown by high temperature glancing angle deposition (HT-GLAD) [1, 2]. Because HT-GLAD is performed in low pressure (~10^{-3} Pa), we can control deposition conditions in detail. Recently, we have succeeded in growing Ga_2O_3 nanowires by HT-GLAD, which have never been grown by HT-GLAD. In this study, we investigated relationships between growth modes of Ga_2O_3 nanowires and deposition conditions, to try to control morphology of Ga_2O_3 nanowires.

SiO_2 was deposited on Si substrate up to 50 nm and then Au was deposited up to 3 nm. On the substrate with Au islands, Ga was deposited up to 50~150 nm in average thickness at substrate temperature of RT–750 °C. Flux of Ga was 0.1~2.0 Å/sec. Deposition angle was set at 85°. During deposition of Ga, O_2 gas blew the center of the substrate directly. Flux of O_2 at center area (O_2 was directly supplied) was about 10 times higher than that at the surrounding area (O_2 was supplied from atmosphere) of the substrate. Pressure was 1.7×10^{-3} Pa.

Fig.1 shows SEM images of samples prepared with different flux of Ga and O_2. Substrate temperature was 500 ºC and the amount of deposited Ga was 50 nm in average thickness. Arrows show incident directions of Ga vapor. Ga_2O_3 nanowires are grown in all samples. Fig.1(a) is a SEM image of a sample on which Ga flux of 2.0 Å/sec and direct flux of O_2 was supplied. All the nanowires have thin branches at the same intervals. Interestingly, branches are grown only at one side of trunk nanowires, which faces to incident direction of Ga vapor. This suggests that growth direction of branches is influenced by incident direction of Ga vapor. However, these branches are disappeared and nanowires become long when flux of Ga was 0.1 Å/sec as shown in Fig. 1(b). On the other hand, when flux of Ga was 2.0 Å/sec and O_2 was supplied from atmosphere (Fig.1(c)), nanowires have branches like Fig.1(a), where nanowires become shorter and thicker than those of Fig.1(a). Consequently morphology of the Ga_2O_3 nanowires can be controlled by flux of Ga and O_2. The detail of the relationships between growth modes of nanowires and deposition conditions will be presented.

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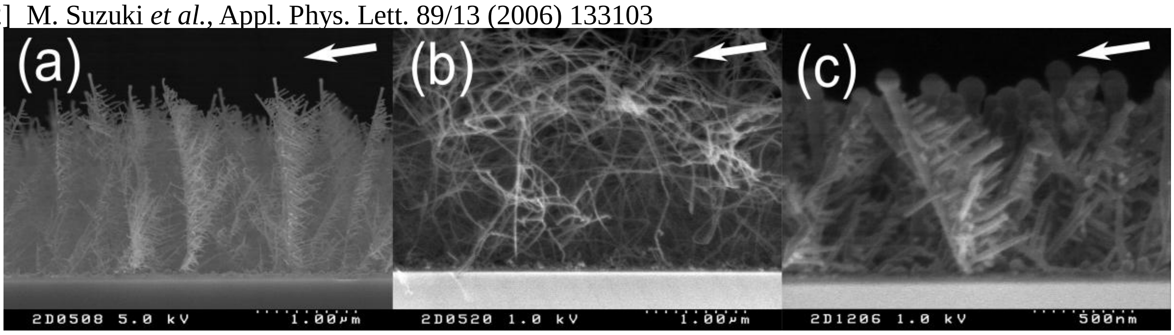

Fig.1 SEM images of the samples deposited at substrate temperature of 500 ºC, and the amount of deposited Ga was 50 nm in average thickness. (a) Flux of Ga was 2.0 Å/sec, direct O_2 flux was supplied. (b) Flux of Ga was 0.1 Å/sec, direct O_2 flux was supplied. (c) Flux of Ga was 2.0 Å/sec, O_2 was supplied from atmosphere.