

MBE GROWTH OF NANODOT ARRAYS USING ANODIC ALUMINUM OXIDE TEMPLATES

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Recently, there have been increasing studies on the fabrication of quantum dots of nano-sized fine structures because of their unique physical properties in electronics, optics, and magnetism. For the maximum quantum dot effect, highly ordered nanodots with uniform size, shape, and composition are required. It is well known that anodic aluminum oxide (AAO) is useful for the growth of nanodot arrays because of its well ordered arrays of nanoholes of the pore sizes from 30 to 80 nm diameter. Therefore, AAO can be taken as a template for the fabrication of highly ordered nanodot arrays.[1,2] In this work, we have studied the MBE growth of nanodot arrays by using AAO as a masking template. Generally, freestanding AAO templates fabricated by anodizing Al foils are used for the MBE growth of nanodot arrays by attaching it on the substrate. With this way, well arranged pores can be obtained. However, it's not easy to handle and make a large area template with the freestanding AAO. Thus, we have directly fabricated the AAO templates on silicon substrates and grown nanodot arrays of GaAs, GaN and GaMnAs by using MBE.

Al layers of 200 nm thickness were deposited by a sputtering method on a silicon wafer. And after post-annealing at 500 °C for 30minutes in nitrogen ambient, the Al layers were oxidized by two step anodization process proposed by Masuda et. al.[3] An aqueous solution of 0.3M oxalic acid was used for an electrolyte at 10 °C with the anodic potential of 45V to control the inter-pore distance. A pore-widening process was carried out in an aqueous solution of 0.1M phosphoric acid at 30 °C for 45minutes to determine the final pore diameter. We have fabricated an AAO template on a silicon substrate having pore diameter of 60 ~ 65 nm and pore length of 200 nm, of which the aspect ratio is a proper condition of MBE growth to avoid the shadow effect. SEM images of the AAO templates fabricated are shown in fig. 1.

GaAs, GaN, and GaMnAs nanodot arrays were grown on AAO template respectively by varying the growth conditions such as substrate temperature, source flux, and growing time. The GaAs and GaMnAs nanodot arrays were grown by using the solid source, and the GaN nanodot arrays was grown by using a single precursor Et₂Ga(N₃) NH₂CH₃. The growth rate of GaAs nanodots was highly dependent on the Ga flux and the substrate temperature. In the temperature range of our experiments, 280 °C to 650 °C, it showed that the lower the Ga flux or the substrate temperature, the higher the growth rate of the GaAs nano-dots. At 650 °C, it showed no growth of nanodots, and at 620 °C as shown in the fig. 2, the upper end of the nanochannel is clogged with the GaAs particles, indicating that the shadow effect activated. The growth rate of GaN nano-dots also showed the same results as the GaAs case at the temperature range 500 °C to 700 °C, where at the lower source flux or temperature, it showed higher growth rate.

It suggests that the re-evaporation rate of the deposited GaAs or GaN nano-dots is higher than the deposition rate at higher temperature. And with higher flux of the sources, shadow effect prevents the GaAs or GaN particles from depositing through the nano channels. In case of the GaMnAs, the growth rate of nanodots also depends on the Mn flux. When the

temperature of Mn source was 930 , a secondary phase was found on the surface of the template, which was identified to be MnAs by x-ray diffraction method. Fig. 2 reveals the SEM images of the nanodots of GaAs, GaN and GaMnAs, respectively with the AAO templates on silicon substrate.

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Figures:

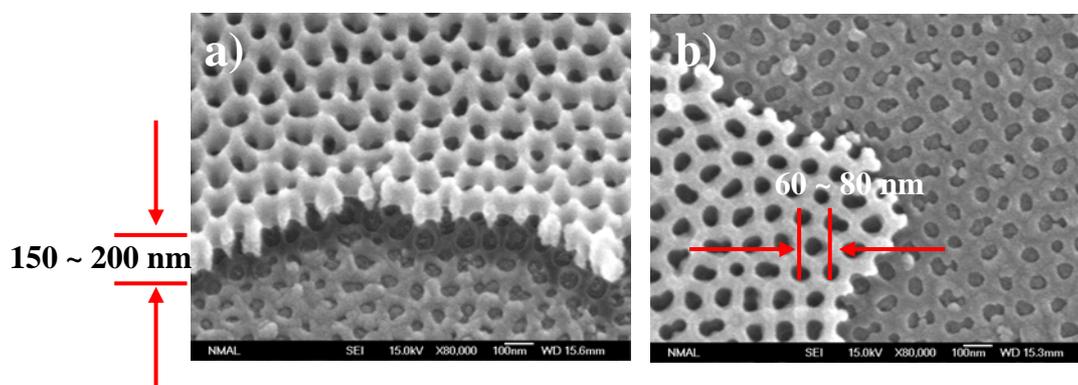


Fig. 1 SEM images of an AAO template(bright part) on a silicon substrate ; a) oblique view, b) top view.

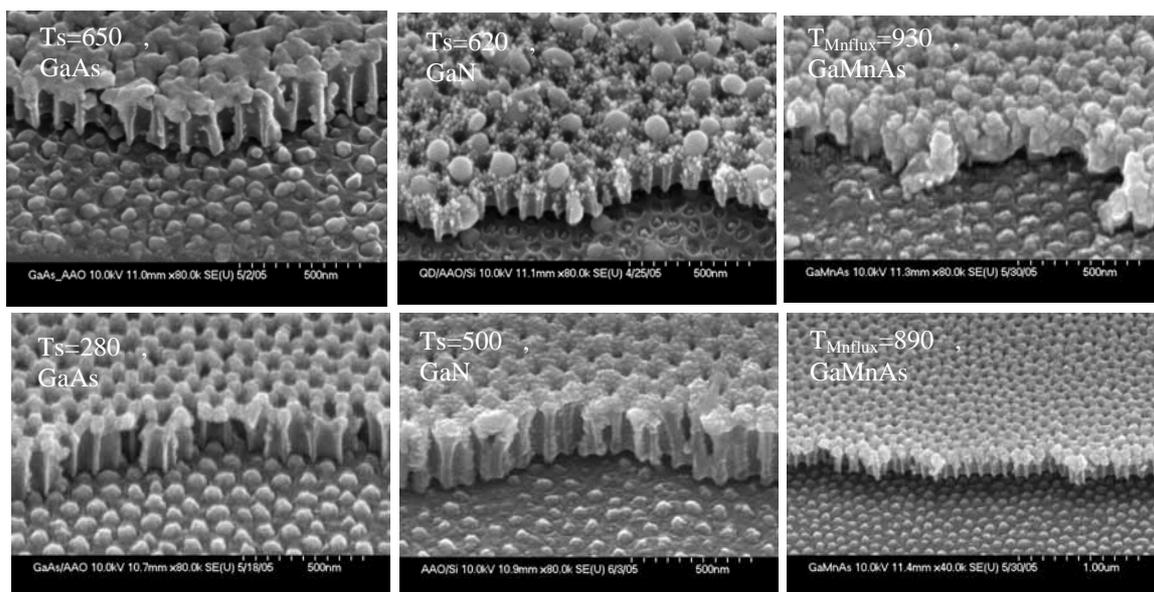


Fig. 2 SEM images of nanodot arrays of GaAs(left), b)GaN(center), and GaMnAs(right) with AAO templates.