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Fabrication of $Si/Al_2O_3/Si$ SOI Structures Grownf80by the UHV-CVD Method

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Si on insulator (SOI) structures have attractive features as a very fast logic device, a environment-hardened device such as a high temperature operated device, and a radiation-hardened device. We have reported epitaxially grown Al_2O_3 films on Si as an insulator material, SOI structures of $Si/Al_2O_3/Si$ and double SOI structures by low-pressure chemical vapor deposition (LPCVD) and Si_2H_6 gas-source molecular beam epitaxial growth. Using these materials, we also have reported that metal-oxide semiconductor field effect transistors (MOSFETs) were fabricated by polycrystalline-Si gate process on the double heteroepitaxially grown $Si(100)/Al_2O_3(100)/Si(100)$ SOI structures and were characterized by measuring electrical properties of the MOSFETs. From these result, it can be seen that electrical properties were similar to those obtained from SOS wafers. However, there are some problems remained such as a flatness of a grown film and reappearance control of a crystallinity.

In this work, to improve a flatness and reappearance of a crystallinity, an ultra high vacuum(UHV)-CVD with a hot wall heating system using an electric furnace was developed, and we present that the double heteroepitaxially grown $Si(100)/ Al_2O_3(100)/Si(100)$ SOI structures were fabricated by this UHV-CVD method. These SOI films were characterized by RHEED, ellipsometry, AES depth profile, and a replica electron microscope method.

Epitaxial Al_2O_3 films were grown on 2 in. Si(100) wafers by pyrolysis of N_2 bubbled $Al(CH_3)_3$ tri-methyl-aluminum (TMA) and N_2O at a pressure of 4×10^{-1}Pa in a vertical electric furnace. The substrate temperature of Al_2O_3 growth was 1000°C. The growth rate of the Al_2O_3 were 20Å/min, and the thickness of these films was 600Å. The thickness and the refractive index of the epitaxial grown Al_2O_3 films on Si were measured by ellipsometry. The refractive index of the Al_2O_3 films was ~1.9 at a wavelength of 6328nm.

To fabricate SOI structure, Si epitaxial growth was carried out on the $Al_2O_3(100)/Si(100)$ substrate by the UHV-CVD method. Si_2H_6 was used as the source gas. Substrate temperatures were 950°C. The growth rate of Si film was 400Å/min.

The growth conditions are summarized in Table I. The epitaxial relationship was $Si(100)// Al_2O_3(100)//Si(100)$.

Epitaxial Al_2O_3 film on Si(100) showed even interference color and flatness surface as shown in Fig. 1. The RHEED patterns from the 600Å thick Al_2O_3 film grown at 1000°C and the 4000Å thick Si film grown at 950°C were streaky as shown in Fig. 2(a) and 2(b), respectively. From the results, crystallinity of Al_2O_3 and Si films grown by UHV-CVD method is considered to be useful for device applications. Thickness in a sample was ranged in ±10%, which was superior to that grown by LPCVD.

By using UHV-CVD method, we will be more easily get the $Si(100)/Al_2O_3(100)/Si(100)$ structures available for SOI devices.

Table I(a). UHV-CVD growth conditions for Al_2O_3

Base pressure	2×10^{-6} Pa (at 700°C)
TMA(N_2 bubbled)	25 sccm (N_2)
N_2O(100%)	20 sccm
Substrate temperature	1000 °C

Table I(b). UHV-CVD growth conditions for Si

Base pressure	2×10^{-6} Pa (at 700°C)
Si_2H_6(100%)	10 sccm
Substrate temperature	950 °C

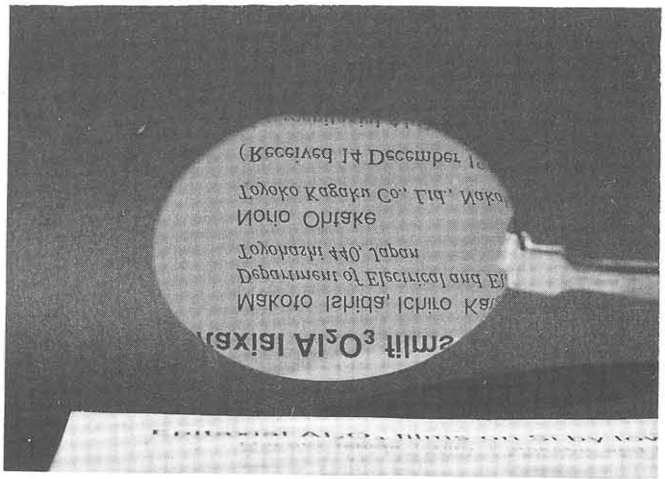

Fig. 1 Photograph of heteroepitaxially grown 600Å-thick Al_2O_3/2in. Si(100) wafer.

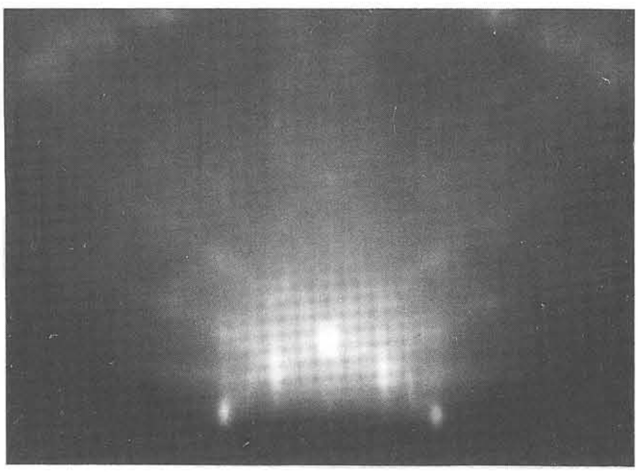

Fig. 2(a)RHEED pattern of 600Å-thick (100) γ-Al_2O_3 film grown on (100) Si at 1000°C by UHV-CVD. The electron beam is along the [110] azimuth.

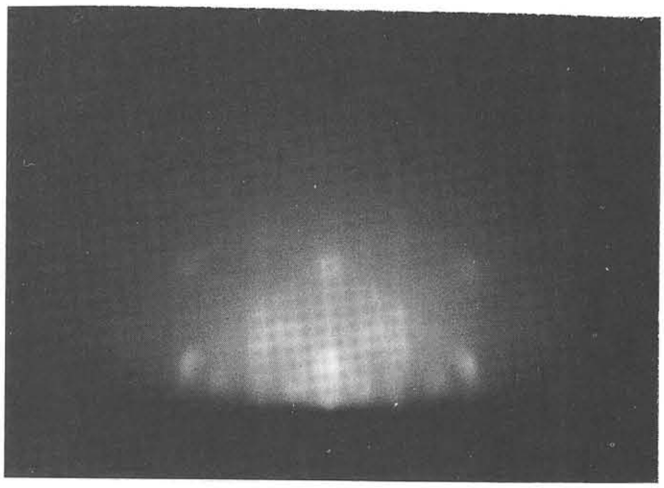

Fig. 2(b)RHEED pattern of the (100) Si grown epitaxially on the (100)Al_2O_3/(100)Si substrate. The electron beam is along the [110] azimuth.