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窒素添加結晶化法による格子不整合基板上へZnOエピタキシャル成長—窒素酸素共添加多段バッファー層の効果—

Sputter epitaxy of single crystalline ZnO films on 18%-lattice-mismatched sapphire substrates using multiple ZnON buffers

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ZnO is a multi-functional material with a wide range of existing and emerging applications such as varistors, transparent conducting electrodes, surface-acoustic-wave (SAW) devices, and gas sensors. Recently, ZnO has also been recognized as a candidate material for high-performance light emitting devices and/or excitonic devices due to the high exciton binding energy. The most popular substrate for epitaxial growth of ZnO is sapphire that offers the advantages in terms of cost and wafer size. The large lattice mismatch of 18%, however, make single crystalline growth of ZnO challenging. In this context, we recently developed a new type of buffer layer fabricated using "nitrogen mediated crystallization (NMC) method" [1-5]. During NMC process, crystal nucleation and the growth are controlled via absorption-desorption behavior of nitrogen "impurities" [5]. By utilizing the films fabricated via NMC as buffer layers, single crystalline ZnO films were successfully fabricated on sapphire substrates [2,3].

Here we report effects of multi ZnON buffers fabricated via NMC at different Ar/N_2/O_2 flow rate ratio with the aim of further improvement of the crystal quality.

The ZnON buffers were fabricated on c-plane sapphire substrates by RF magnetron sputtering. The supplied RF power was 100 W and the deposition temperature was 735°C. The Ar, N_2 and O_2 flow rates were 24, 1, 0–5 sccm, respectively. The thickness of the ZnON buffer layers was 10–30 nm. Next, ZnO films were fabricated on the ZnON buffers by RF magnetron sputtering. The supplied RF power was 60 W and the deposition temperature was 700°C. The Ar and O_2 flow rates were 45 and 5 sccm, respectively. The thickness of the ZnO film was about 1000 nm.

Figure 1 shows the X-ray rocking curves for (101) plane of ZnO films fabricated on ZnON buffer layers. The full-width at half-maximum (FWHM) of the rocking curve drastically decreases from 0.73° to 0.32° by introducing a single ZnON buffer layer. Here the buffer layer was fabricated in Ar/N_2 atmosphere. Moreover, introducing another two buffer layers prepared in Ar/N_2/O_2 atmosphere, which were subsequently grown on the buffer layer prepared in Ar/N_2 atmosphere, leads to further improvement of the crystal quality. The FWHM for ZnO film on such multi ZnON buffers is significantly small of 0.21°. XRD analysis revealed that O_2 introduction into the sputtering atmosphere suppress the deviation of the lattice constants of ZnON buffer layers from that of bulk crystal. Thus, the improvement of the crystal quality brought by multi ZnON buffers is considered to be due to the decrease in residual distortion in ZnO thin films.

References

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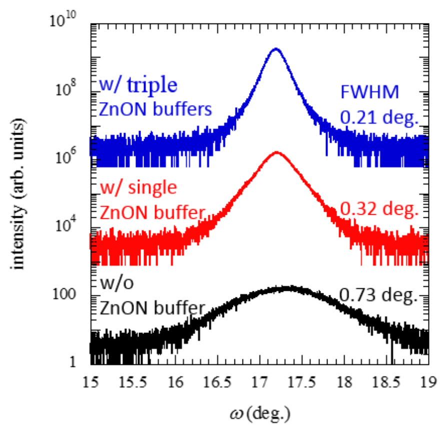

Fig.1. X-ray rocking curves for (101) plane of ZnO films fabricated on ZnON buffer layers.