Low temperature growth of magnesium gallate crystalline films

Qixin Guo[1]*, Junya Tetsuka[1], Zewei Chen[1], Makoto Arita[2], Katsuhiko Saito[1], Tooru Tanaka[1]
*guoq@cc.saga-u.ac.jp
[1] Department of Electrical and Electronic Engineering, Synchrotron Light Application Center, Saga University, Japan
[2] Department of Materials Science and Engineering, Kyushu University, Japan

Wide bandgap oxide semiconductors offer the possibility of fabricating power devices, short wavelength deep ultraviolet (DUV) diodes and DUV photodetectors. It is well known that the ternary systems have the advantage of two cation sites enabling higher degree of freedom for doping. Magnesium gallate ($MgGa_2O_4$), one of the ternary oxide semiconductors, has large optical bandgap, good mechanical properties, and high radiation hardness, suggesting it is suitable for high power density electronic devices and DUV diodes and photodetector applications. Pulsed laser deposition has many advantages due to completely compositional consistency between a target and a deposited film. We have demonstrated that epitaxial growth of $(AlGa)_2O_3$ films and full color tunable light emitting diodes based on rare earth doped gallium oxide films obtained by pulsed laser deposition [1-3]. In this work, we report on the successful low temperature growth of $MgGa_2O_4$ films by the pulsed laser deposition.

The $MgGa_2O_4$ films were grown on (0001) sapphire substrate. A KrF excimer laser (λ = 248 nm) with a pulse of 2 Hz and energy level of 240 mJ was used to ablate a magnesium gallate ceramic target. The growth chamber was kept at 0.1 Pa by controlling the flow rate of the oxygen with a mass flow controller. The thickness of the films was determined by a step profile analyzer. Structural properties were characterized by X-ray diffraction (XRD). Optical transmittance spectra were measured by a spectrophotometer.

Three diffraction peaks observed around 18.5, 37.6, and 57.8 degrees in the XRD pattern of the $MgGa_2O_4$ film grown at a substrate temperature of 200℃, can be assigned as the (111), (222), and (333) planes of the $MgGa_2O_4$, respectively, by comparing the data with the known diffraction peaks listed in the International Center for Diffraction Data catalog. The lattice constant for this $MgGa_2O_4$ film is estimated to be 8.31 Å, which is close to the value of the bulk. The transmittance of the film is above 80% in the visible and UV regions. From the transmittance spectrum, sharp absorption edges are clearly observed around wavelength of 230 nm, implying that the films exhibit direct transition. Based on the relation between absorption coefficient (α) and incident photon energy ($h\nu$) in the form of $\alpha h\nu = C(h\nu - Eg)^{1/2}$ for the direct gap material, where C is a constant and Eg is the bandgap, the bandgap of the $MgGa_2O_4$ film is determined to be around 5.4 eV, which has reasonable agreement with the value of $MgGa_2O_4$ bulk. These results indicate that pulsed laser deposition is a promising method for low temperature growth of the $MgGa_2O_4$ crystalline films.

References

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