Mg element has been reported as a good candidate for the band gap engineering of ZnO because of the similar ionic radius of the Zn$^{2+}$ and Mg$^{2+}$, which does not result in a significant misfit strain in the MgZnO/ZnO heterostructure\cite{1}. For this reason, MgZnO thin films have also become the subject of major scientific researches as more attentions have been focused on ZnO. The properties of the MgZnO thin films are extremely sensitive to its crystal perfection, which is decisively depended not only on growth processes but on post heat treatments such as thermal annealing\cite{2}. Although the annealing is an important way to improve the crystal quality and electrical properties of the MgZnO thin films\cite{3}, the experimental reports of the thin films concerned with the crystal structures during the annealing treatment relatively have been less compared to ZnO.

Our work, therefore, employed the in situ heating TEM study to directly observe the change of the crystal structures of the MgZnO thin films deposited on Si substrates. The results showed that the deposited MgZnO thin film had the layer of nano sized grains between the disordered columnar grains and Si substrate at RT (Fig.1a). This layer was analyzed that the cubic and hexagonal crystal structures were coexisted together based on the measurement of d-spacing values from the FFT pattern image (Fig.1b).

In the in situ heating TEM study, it was found that the change of crystal structures was not occurred up to at 400℃. However, the disappearance of the hexagonal structure was observed at 500℃ in the layer according to the d-spacing values measured from the FFT pattern image (Fig.2b) of the HRTEM image (Fig.2a).

Additionally, the core loss EELS spectra of Zn L-edge and Mg K-edge obtained at the RT (Fig.2.c) and elevated temperature of 500 ℃ (Fig.2d) were showed the decreased intensity of Zn L-edge meant the fewer amounts of Zn atoms compared to the RT one. This phase change process could be caused by the evaporation of Zn atoms in the MgZnO alloy system under high vacuum condition of the specimen chamber of the TEM. The Zn atoms could be a first evaporation element rather than the Mg atoms because the bond enthalpy of MgO is stronger than the one of ZnO\cite{4}.

On the basis of our experimental results, the phase change of MgZnO thin film was directly observed by the continuous thermal annealing method in the in situ heating TEM study. This phenomenon is prominent to enhance the crystallinity and control the microstructure of the MgZnO thin film with adjusting the thermal annealing temperature.

\begin{thebibliography}{9}
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\bibitem{2} J. Li et al., J.Cryst.Growth. 314 (2011) 136
\end{thebibliography}

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Fig. 1: A HRTEM image taken at RT in the region of nano sized grains (a) with the FFT pattern image (b).

Fig. 2: A HRTEM image taken at 500 °C in the region of nano sized grains (a) with the FFT pattern image (b) and core loss EELS spectra of Zn L-edge and Mg K-edge taken at RT (c) and 500 °C (d).