We investigated lattice distortion effects and their thickness dependence on the excitonic transitions in Cu$_2$O thin films recrystallized in a small gap between paired MgO plates. Recently, Yoshioka et al. reported the importance of exciton trapping into shallow potential minima for realizing the excitonic Bose-Einstein Condensation (BEC) in Cu$_2$O and it was also reported that uniaxial stresses are very useful to form the exciton trapping potentials.[2] In our investigation, we adopt Cu$_2$O thin films sandwiched by MgO plates because a small lattice mismatch between Cu$_2$O (4.273 Å) and MgO (4.210 Å) is expected to introduce compressive stresses in the Cu$_2$O thin films, which form the trapping potentials for the Cu$_2$O excitons.

Figure 1 shows a schematic diagram of the cross section in our samples and the variation of the compressive stresses (horizontal arrows). As shown in this figure, compressive stresses due to the lattice mismatch are considered to relax gradually departing from the interfaces of MgO plates. Since it is expected that the degree of the lattice distortion effects varies with the sample thickness, we investigated thickness dependence of the excitonic spectra in Cu$_2$O thin films to clarify the lattice distortion effects and the formation of the exciton trapping potentials.

Figure 2 shows the thickness dependence of the band gap energy shifts of the yellow excitonic system in Cu$_2$O thin films from that in bulk crystals. In thick films B, C, and D, the red-shifts of the band gap are rather small. On the other hand, in a thin film A, one can recognize a larger red-shift. Consequently, by controlling their thickness, we can form an operative trapping potential for the yellow excitons to realize the excitonic BEC in the Cu$_2$O thin films.

Fig. 1: A schematic diagram of the cross section of the Cu$_2$O thin film sandwiched by MgO plates.

Fig. 2: Thickness dependence of the band gap energy of Cu$_2$O thin films sandwiched by MgO plates.