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Physical Property Change of the Gapless Semiconductor $PbPdO_2$ Thin Film by Ex-situ Annealing

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We have studied lead-based gapless semiconductors, $PbPdO_2$, which is very sensitive to external parameters such as temperature, pressure, electric field, etc[1]. We have fabricated pure $PbPdO_2$, Co- and Mn-doped $PbPdO_2$ thin films using the pulsed laser deposition. Because of the volatile element of Pb, it is very difficult to grow the films. Note that in case of MgB_2, Mg is also volatile element. So in order to enhance the quality of MgB_2, some experiments are carried out in annealing with Mg-rich atmosphere [2]. This annealing process with volatile element plays an important role in making smooth surface. Thus, we applied such process to our studies of $PbPdO_2$ thin films. As a result, we found the optimal condition of ex-situ annealing temperature ~650^{o}C and time ~12 hrs. The ex-situ annealing brought the extreme change of surface morphology of thin films. After ex-situ annealing with PbO-rich atmosphere, the grain size of thin film was almost 100 times enlarged for all the thin films and also the PbO impurity phase was smeared out. And from X-ray diffraction measurements, we determined highly crystallized phases after annealing. So, we measured electrical and magnetic properties. Because of reduced grain boundary, the resistivity of ex-situ annealed samples changed smaller than no ex-situ sample. And the carrier densities of thin films were decreased with ex-situ annealing time. In this case, oxygen vacancies were removed by ex-situ annealing. Furthermore, we will discuss the transport and magnetic properties in pure $PbPdO_2$, Co- and Mn-doped $PbPdO_2$ thin films in detail.

Keyword: Annealing

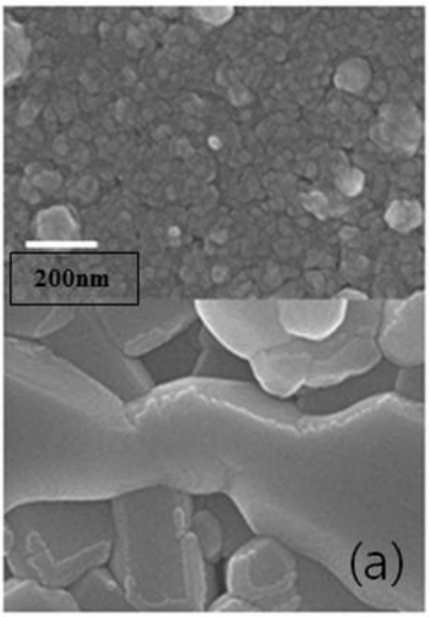

Fig (a) SEM image of two different samples