In-situ Transmission Electron Microscopy Study on Nanodomains in PMN-PT ($Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$) Single Crystals

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Single crystals of PMN-PT ($Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$) with morphotropic phase boundary (MPB) composition are used for medical imaging devices because of the ultrahigh piezoelectricity [1]. Since domain structure plays important roles in ferroelectrics/piezoelectrics, domain structures of MPB-composition PMN-PT has been investigated. It has been revealed that domains are miniaturized down to nanometer scale, and hierarchical structure with microdomains and nanodomains is formed [2]. Although structural analyses have been well performed for static state, information is not very abundant for dynamic domain responses. In the present study, we present our recent results on real-time observations of nanodomain dynamics by applying external electric fields.

We have performed *in-situ* electrical biasing transmission electron microscopy (TEM) observations for commercially available PMN-PT single crystals with MPB composition. One is in-situ electrical biasing experiment [3], and the other is in-situ heating experiment. In-situ experiments have been performed using electrical biasing specimen holder (Model EM-Z00363T, JEOL Ltd.) and specially designed TEM specimen (Fig. 1 (a) and (b)).

Figure 2 (a)~(c) show the results on *in-situ* electrical biasing TEM observations. Three microdomains and much finer lamellarlike nanodomains within them can be observed in the TEM image in (a), which is before electrical biasing. When the electric fields exceeding a certain value are applied, the domains quickly respond (Fig. 2 (b)). The response includes reorientation of nanoscale domain walls (DWs) and movement of microscale DWs. Even under high electric fields, nanoscale domains still exist without largely altering their widths. This implies that nanoscale domains and DWs would be still important under the electric fields. On the other hand, number of microscale domains and DWs tend to be reduced, being closer to single-domain like state, which would be usually considered for normal ferroelectrics. The responses are reversible on the application and removal of the electrical biases; the domain structure has been recovered right after the removal of biases. Therefore, in the present study, response of nanodomains in PMN-PT by applying electric fields has been unambiguously visualized in real time. Further details will be introduced in our poster.

References

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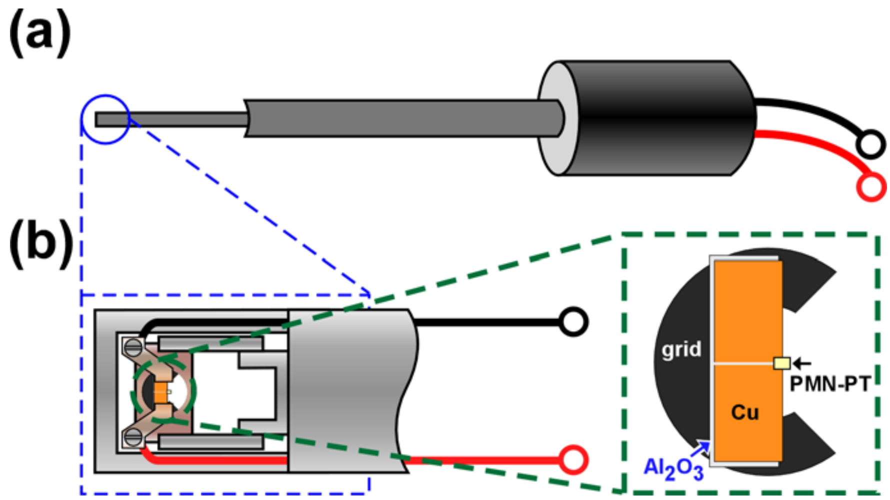

FIG. 1. (a) Schematic of *in-situ* electrical biasing TEM specimen holder (whole view). (b) Magnifications of the holder around the specimen loading part (left) and TEM specimen (right).

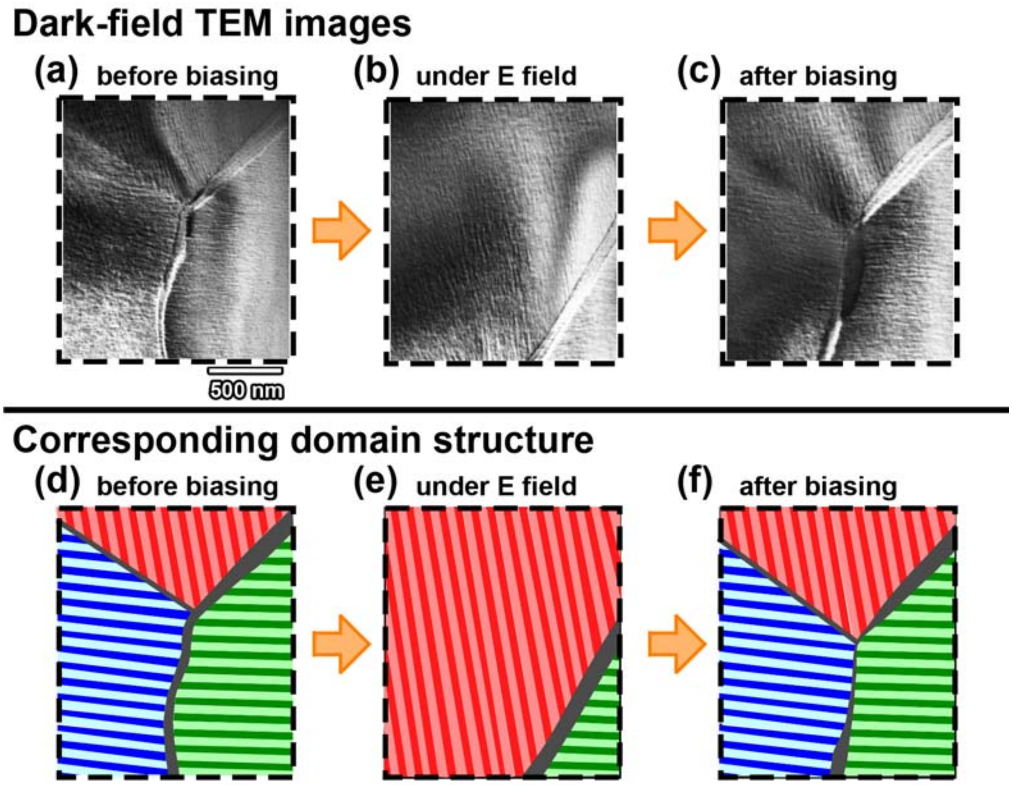

FIG. 2. Dark-field TEM images of PMN-PT single crystals (a) before, (b) during, and (c) after electrical biasing. Schematic of corresponding domain structure (d) before, (e) during, and (f) after electrical biasing.