Topographic Studies of Domain Structure in Czochralski Grown Pr$_x$La$_{1-x}$AlO$_3$ Crystals

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Praseodymium lanthanum aluminium perovskite is a very interesting material in view of the complicated phase transitions, some of them ascribed to ion lattice coupling. It is perspective new material in visible light laser technology. The other possible interesting application is connected with the preparation of crystals with self-organized domain structure for in light guiding.

We applied the X-ray diffraction topographic techniques to a number of samples cut out from Czochralski-grown Pr$_x$La$_{1-x}$AlO$_3$ crystals with different values of $x$, as well as from the LaAlO$_3$ crystal, doped with 5 at. % of praseodymium.

The synchrotron white beam topographs usually reproduced the domain structure as a series of mutually displaced stripes corresponding to different orientation of the crystal inside the domains, which probably are of twin type. Different appearance of the domain structure has been observed in the samples differing in the chemical composition.

Fig. 1a. presents the back-reflection topograph of the Pr$_{0.4}$La$_{0.6}$O$_3$ sample. The topograph in Fig. 1b shows the whole diffraction pattern with great number of Laue spots. Each spot consists of two displaced parts, which correspond to the slightly misoriented grains. The images of the right grain are differently located in each spot.

Figure 1: (a) back-reflection projection topograph of the Pr$_{0.4}$La$_{0.6}$AlO$_3$ sample reproduced in two systems (D$_1$ and D$_2$) of narrow domains, (b) The synchrotron diffraction pattern of the same sample with a greater number of Laue spots - The right fragment of the topogram in Fig. 1a corresponds to a slightly misoriented grain, differently located with respect of the other part of the Laue spots. B$_1$, B$_2$ – misoriented grains, D$_1$, D$_2$ – domain systems, S – striations, X – projection of synchrotron radiation beam direction on the film.
Figure 2: White beam back-reflection projection topograph of the sample cut out from LaAlO$_3$ crystal doped with 5 at. % Pr. $B_1$, $B_2$ – diffraction contrasts of misoriented block; $S$ – striations fringes; $C$ – crystal core; $D$ – domain systems; $G$ – dislocations, $X$ – projection of synchrotron radiation beam direction on the film.

The topograph of LaAlO$_3$ crystal doped with 5 at. % Pr reveals large region of considerably good perfection (Fig. 2). Particular striation fringes and a core in the central part of the crystal one can see. Some short linear contrasts may be attributed to the individual dislocations of relatively small density. The longer linear contrasts should however be interpreted as the domains. Apart from these defects we have observed some large misoriented blocks with the straight boundaries.

Fig. 3 reports the representative synchrotron transmission section topographs of the same sample as in Fig. 2. We may observe five dash formed contrasts in Figs. 3a and 3c appearing on the upper and lower side of the main section image respectively (marked by $A$). These dashed contrasts are not visible in Fig. 3b, which most probably corresponds to the reflection coming from the crystallographic plane common for the domains and the matrix crystal.

Figure 3: A set of three transmission section topographs for the same crystal as in the case of Fig. 2 revealing the misorientation of the domain regions (a series of displaced stripes corresponding to different orientation of the crystal inside the domains marked by $A$).