Domain wall observations on surface of ferroelectric crystals using AFM

Using a scanning probe microscope, it is possible to observe domain wall structures on the surface of ferroelectric crystals with a high magnification, and to control the polarization direction directly on the crystal surface. In the present report, a method of the observation for the domain wall structure on the etched surface of ferroelectric crystals using an atomic force microscope is presented.

■ Introduction

It is known, in the case of ferroelectric materials, that the rate of dissolution for an acid strongly depends on the polarization direction on the surface. This makes it possible to express a ferroelectric domain wall pattern as a topographic image, where the contrast of it can be adjusted with an etching time and pH control. Using this method, it is possible to observe the domain wall structure by means of an atomic force microscope (AFM).

■ Sample preparation

First of all, the surface of the ferroelectric material with a certain orientation was polished to an optical grade, using lapping sheets with alumina powders. Lapping sheets with powder sizes of 10-0.3 □m were adopted in our experiment. In general, many ferroelectric crystals are very soft in comparison with the silicon wafer, and the domain wall structure easily changes due to an external strain. It is important that excess strains are not applied to the sample when polishing. In our experiment, to decrease excess strains when polishing, a small tool made of glass shown in Fig. 1 was used. A polished sample was etched by an acid after being washed in acetone using an ultrasonic cleaner. In the case of $Pb(Zn_{1/3}Nb_{2/3})O_3$- $PbTiO_3$ (PZN-PT) crystal, an aqueous solution of HF and NH_4F was used as an etching acid.

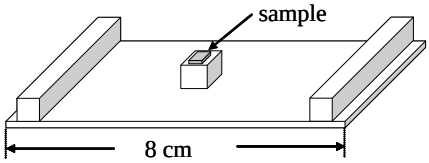

Fig. 1 Handmade tool for polishing.

■ Observation

The topographic image on the (111) surface of PZN-PT with the tetragonal symmetry by AFM and the schematic diagram of it are shown in Figs. 2 and 3, respectively. It was found that domain wall structures in ferroelectric materials can be clearly observed on the etched surface using AFM. We were also able to explain the polarization direction in the domain wall structure of the PZN-PT crystal surface.

This method of the etched-surface observation using AFM would make it possible to obtain a lot of informations not only from the ferroelectrics but also from any other material as a versatility tool.

【Courtesy of Graduate School of Engineering, Nagoya Institute of Technology】

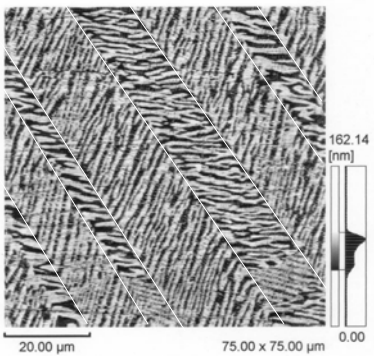

Fig. 2 Topographic image on ferroelectrics by AFM.

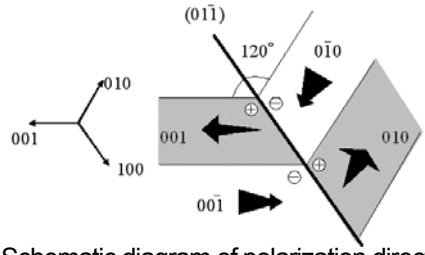

Fig. 3 Schematic diagram of polarization direction.

Reference:

Makoto Iwata, Kohei Katsuraya, Shinichi Tachizaki, Jiri Hlinka, Ikuo Suzuki, Masaki Maeda, Naohiko Yasuda and Yoshihiro Ishibashi: Japanese Journal of Applied Physics 43 (2004) pp. 6812-6820.