ELECTRIC POTENTIAL DISTRIBUTION IN AN INDENTATION-PRE-CRACKED$BaTiO_3$ SINGLE CRYSTAL

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Summary *In-situ* potential mapping over the (001) surface of an indentation-pre-cracked $BaTiO_3$ single crystal exhibits the higher potential distribution zone along the crack. The potential peak occurring in each horizontal scanning along the [001] direction increases with the crack length. The highly concentrated potential distribution is induced by the (113) indentation crack in air at room temperature, whereas an applied electric field along the [100] direction has trivial influence on the surface potential profile.

INTRODUCTION

In fracture study of ferroelectric ceramics, it is extremely important to understand the role of electric field in the fracture behavior under mechanical and electric loading. Electrically permeable and electrically impermeable cracks are two extremes in the theoretical treatment of electric boundary conditions along electrically insulating cracks [1, 2]. Experimental clarifying the electric boundary condition is substantial to the research on the fracture behavior of ferroelectric ceramics. Schneider *et al*.[3] measured electrical potential difference across an indentation crack in a poled PZT ceramic under an applied electric field and determined the dielectric constant of the crack interior to be 40. The results are tremendously significant to piezoelectric fracture because they indicate that the indentation crack is electrically permeable. Fracture tests on electrically insulating cracks are usually conducted in air at room temperature. Screen charges may be adsorbed on the pre-crack. The experimental results [3] might provide a clue of the adsorption of screen charges. In this paper, we report the measurement results on the surface potential distributionin a pre-cracked $BaTiO_3$ single crystal and the results show that the pre-crack does adsorb screen charges.

EXPRIMENTAL RESULTS AND DISSCUSION

Figure 1 (a) is a topographic image of the indentation-pre-cracked (001) surface without any applied electric field, while Fig. 1 (b) is the corresponding potential image. Fig.1 (c) is the potential image under applied electric fields of 8 V/mm. These images show that the crack region has much higher electric potential than others and this difference increases when an electric field is applied.

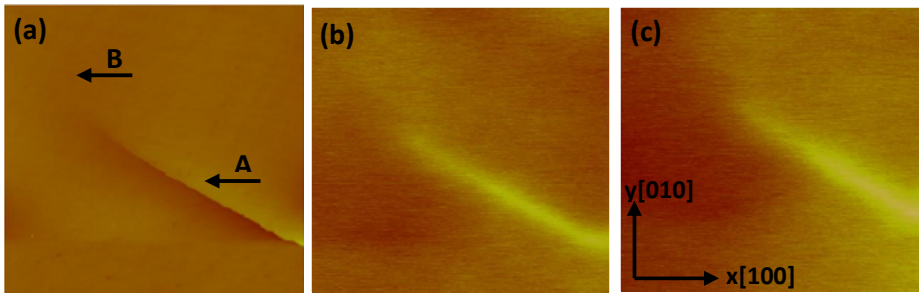

Fig. 1.(a) Topographic image, surface potential images under applied electric fields of (b) E= 0 V/mm, and (c) E= 8 V/mm.

Fig.2 (a) shows surface potential profiles parallel to the electric field along the arrow A in Fig. 1 (a) under applied electric field strengths of 0, 1, 5, and 8V/mm, indicating that the entire profile with a peakon the crack is higher if the applied electric field is stronger. The fact that higher potential shows up along the crack might be attributed to the

segregation of screen charges along the crack. Fig. 2(b) shows that both potential peak and crack opening displacement along the crack increase with the crack length. Starting from the crack tip region and long the crack line, the potential peak increases first and reaches a local maximum exactly at the crack, then decreases to a local minimum, and then almost monotonically increases with the crack length.

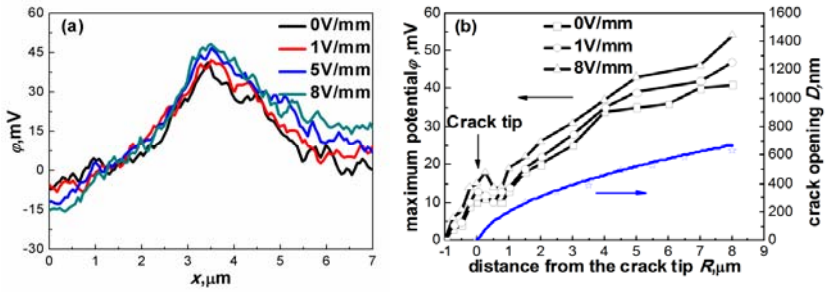

Fig. 2. (a) Surface potential profiles parallel to the electric field direction, and (b) The peak potential distribution and crack opening displacement, *D* along the crack

Excluding the original potential from the measured potential, the tip potential, φ_{tip}, induced by the applied electric field along the arrow A in Fig.1 (a) is shown in Fig.3, which does not exhibit any peaks. This means that the observed high potential along the crack is original, almost independent of the applied electric field, induced by the crack itself in air at room temperature. The observed phenomenon is significant to the study of fracture of ferroelectric/piezoelectric ceramics because such original electric field has not been considered yet. If the crack is electrically impermeable, electric field strength will approach infinity at the crack tip. However, Fig. 3 shows that the tip potential is almost a constant, although the value of the constant increases with the applied electric field. The experimental result confirms that the crack is electrically permeable.

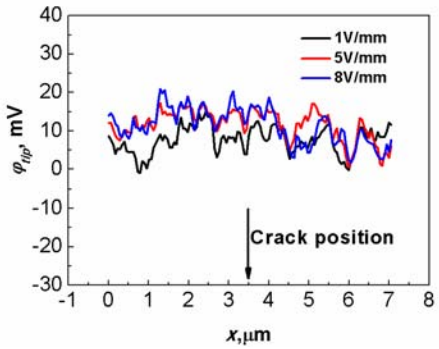

Fig. 3. The potential excluding the original value along the arrow A in Fig. 1(a)

CONCLUSIONS

There exists a higher potential distribution zone along the indentation cracksof $BaTiO_3$ single crystal. The higher potential is original, and almost independent of the applied electric field.

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