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Domain switching observation near fatigue cracks in PZT

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Introduction

Lead zirconate titanate (PZT) is the most commonly used piezoelectric ceramics for sensors and actuators. Its strength properties as well as piezoelectric properties should be guaranteed especially when used as actuators at high power. PZT has a perovskite structure of Pb(zr, Ti)O_3 and the crystalline structure is either tetragonal or rhombohedral structures at about equal fraction of zirconium and titanium [1]. Since PZT near this ingredient ratio shows the highest piezoelectric performance, both crystalline structures have been used. PZT is usually used after polarization. The polling treatment introduces the lattice strain and the switching of domain structure in PZT [2]. Moreover, the lattice strain and domain switching are also generated by external mechanical loading.

In the present study, microscopic observations near fatigue cracks and fracture surfaces were carried out. The behaviour of the domain switching due to fatigue crack propagation was investigated as a function of the distance from a tip of the fatigue crack. .

Experimental procedure

Material and specimen

The experimental material of PZT was pressureless sintered at 1503 K to have a tetragonal structure. The atomic fractions of Zr and Ti are 53 and 47 at %, respectively. The lattice constants of the tetragonal structure determined by X-rays are a=0.40410 nm and c=0.41087 deg. The specimen s were machined with #800 diamond grind wheel and annealed at 673 K for 10 min. After annealing, the specimens were poled at 373 K for 10 min in Silicon oil. The electric field of the direct current used for poling was 1.2 kV/mm for L (PL material) direction, and 1.9 kV/mm for S (PS material) and T (PT material) direction. A single edge notch was introduced after poling. The fatigue crack was introduced in each material.

X-ray measurement

The X-rays were irradiated at the notch root, fatigue crack tip, neutral plane of the specimen and near the back face of the specimen. The diffraction profiles were recorded by using an imaging plate. The wave length of the X-ray used was 0.2002 nm at BL-3A in PF. The ratio of the diffraction intensity I_{004}/I_{400} were evaluated. The diameter of the irradiated X-ray was 100 μm.

Results and discussion

Figure 1 shows the intensity ratio for each specimen. Strong fiber orientation can be seen in the PS material.

Figure 2 shows the change of the intensity ratio with a distance from notch root for PL material. The intensity ratio increases with increasing the distance from the notch root. When the poling direction is perpendicular to the loading direction, the domain switching takes place easily.

References

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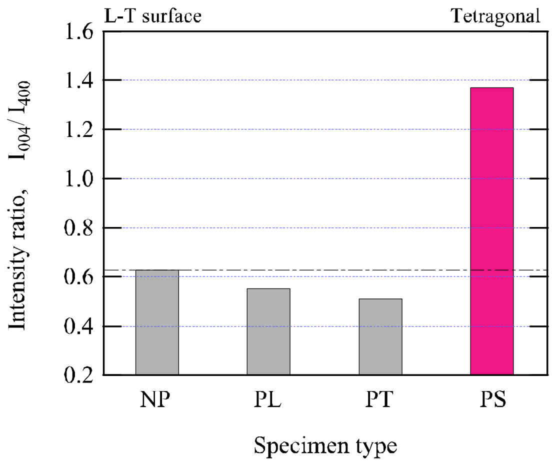

Fig. 1. Intensity ratio of poled specimen.

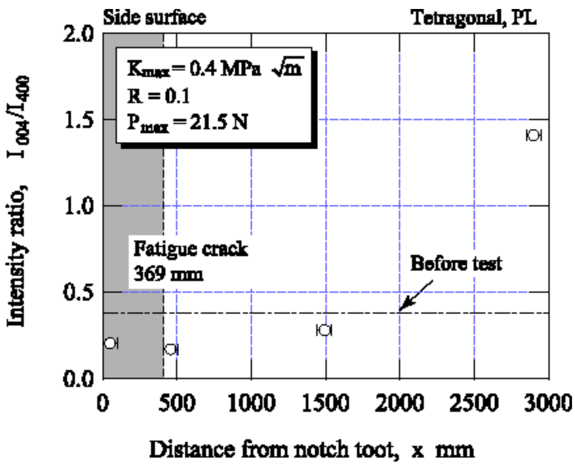

Fig. 2. Change of intensity ratio with distance from notch root.