Measurement of the electric field distribution inside ferroelectric multilayer structures during the poling process

Ralf Steinhausen, Azamat Kouvatov, Christoph Pientschke, Horst Beige, Hans Theo Langhammer, Hans-Peter Abicht
Martin-Luther-University - Germany

Abstract

We studied the time-dependence of the electric field distribution in a ferroelectric multilayer structure during the poling process. This work is essential to understand the poling process in Functionally Gradient Materials. Wong [1] had shown that the electric field in each layer of a multilayer system changes in time due to the electrical conductivity of the material. Here, we investigated ceramics from the system Ba(Ti,Sn)O3 (BTS). The ferroelectric properties like coercive field strength, maximum and remanent polarization strongly depend on the content of tin. A high-impedance electrometer was used to measure the voltage in a single layer during the poling process. To contact the single layers, two types of structures were investigated. First, single BTS ceramics sheets with different Sn content were connected electrically by a short wire. Second, electroded sheets were glued and the inner electrodes were contacted at the side surface. We estimated the influence of the mechanical clamping by comparison the results. We found the dependence on time of the electric field in each layer predicted by [1]. In the simplest system of two layers with 7.5 and 15 mol% Sn, respectively, the electric field in one layer (7.5 mol% Sn) increased and in the other decreased during the poling process with a DC-voltage. After few minutes both fields reached a stable value. By comparison with the modeling of this process, the electrical conductivity of the ceramics was calculated as 2E-9 1/(Ohm$*$ m). The polarization of the ceramics increases with increasing field and causes a better poling degree and higher piezoelectric coefficients, respectively. The difference of polarization of the layers is compensated by free charges collected at the interface. We found that these charges are stable after turn off the applied voltage.

[1] Wong et. al, J. Appl. Phys., 93 (7), 2003, 4112-4119