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Influence of the Microstructure on the Surface Potential of Ferroelectric Thick Films

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For the application of ferroelectric films in an electrostatic printing technique informations about the magnitude and the stability of the surface potential are necessary. In this paper the influence of film inhomogeneities on the electrostatic surface potential is discussed for ferroelectric PZT thick films ($d \approx 100$ μm) deposited on metallized ceramic Al_2O_3-substrates. The surface potential was measured with an electrostatic voltmeter. The potential contrast in the SEM could be correlated to the surface topology and stoichiometry comparing film observations in SE- and BSE-mode. A x-y-scan of the depth profile of the polarization was measured with the thermal wave method (LIMM). At different depths inhomogeneities were found which could be correlated to the toner decorated image failures at the film surface.

I. INTRODUCTION

The switchable polarization is a property of ferroelectric materials which is used in several applications in the field of information storage. An electrostatic printing technique is a special application, where ferroelectric films are used as permanent masters for multicopy printing [1].

Imaging is done by poling, where the stored information is erasable either electrically (by switching of the polarization) or thermally (by heating above T_C). The latent image of polarization is developed by a liquid toner consisting of charged particles, which are attracted by the electric field at the surface of the film at the polarized image points.

II. EXPERIMENTAL PROCEDURE

The investigated ferroelectric thick films ($d \approx 100$ μm) consist of a low sintering $Pb[Zr_{1-x}Ti_x]O_3$-$PbMg_{1/3}Nb_{2/3}O_3$-material (PZT-PMN), deposited on a Pt-metallized Al_2O_3-substrate (50×50 mm^2) and sintered at T = 950 °C [2,3]. The thick films are characterized by a dielectric constant ε of 1500 at 1 kHz, a remanent polarization P_R of 10...12 μCcm^{-2} and a coercive field E_C of 0.8...1 kVmm^{-1} (50 Hz sinus).

The electric surface potential was measured with an electrostatic voltmeter (ESVM) [6]. The sample was scanned with a motor driven x-y-table with the sensor of the ESVM being fixed above the sample surface in a distance of about 100 μm.

To record x-y-scans of the pyroelectric coefficient over a plane in a distinct depth below the surface, the LIMM technique [7] has been extended to a pyroelectric tomography procedure [9]. For the measurements Al-electrodes (thickness 50 nm, diameter 2 mm) were evaporated on the film surface. The electrode was exposed to a laser beam (laser diode with λ = 830 nm) which was intensity modulated sinusoidally in the frequency range from 10 to 2×10^6 Hz. The absorbed thermal energy generates a thermal wave which penetrates into the film. The attenuation and therefore the penetration depth of this thermal wave decreases with increasing frequency. Due to the pyroelectric effect the local temperature change in the film causes a pyroelectric current between ground and top electrode which was measured phase sensitive by a lock-in amplifier.

The usual LIMM procedure is a one-dimensional technique [7]. The electrode is illuminated homogeneously, and a plane thermal wave is generated. In this case the thickness dependence of the polarization P(z) can be calculated from the measured frequency dependence of the pyroelectric current I(ω) [8]. For the recording of pyroelectric tomographs, the intensity modulated laser light is focused on a small spot (2 μm diameter) of the electrode area. The heated spot is scanned over the electrode area using a laser-scanning-microscope, and the pyroelectric signal is recorded as a function of the location [9]. In addition, the penetration depth of the thermal wave is varied by a variation of the modulation frequency. As in the one dimensional case, the component of the pyroelectric current which is 45 degrees phase shifted with respect to the modulated intensity, is particularly appropriate for the reconstruction of the pyroelectric distribution [8].

III. RESULTS AND DISCUSSION

At first the films were polarized homogeneously with a field strength of 2 kVmm^{-1} in such a way that the polarization is oriented towards the ground electrode (background polarization). After this a surface potential of $\approx$ 20 V can be measured [4]. Charging by a corona dis-