Switching processes in ferroelectric superlattices

A.S. Sidorkin[1], L.P. Nesterenko[1], Y.Gagou[2], P.Saint-Gregoire[3],
A.Yu. Pakhomov[1], E.V. Vorotnikov[1], N.G. Popravko[1]

[1]*Voronezh State University, 394018, Voronezh, Russia*
sidorkin@phys.vsu.ru

[2]*Universite de Picardie Jules Verne, 80039 Amiens Cedex, France*

[3]*ICGM, C2M, 34095 Montpellier Cedex, France; University of Nimes, 30021 NIMES Cedex 01, France*

In present work the studies of switching processes were carried out on perovskite ferroelectric superlattices with alternating $BaZrO_3$/$BaTiO_3$ (BZ/BT) layers with a superlattice period of Λ = 13.32 nm that was layered by pulsed laser sputtering.

To study repolarization processes of samples by switching currents, we used rectangular shape stimulating switching signal with amplitude from 50 mV to 8 V at 10 kHz. We used an arbitrary form signal generator Waveform Generator 2571 to apply the same duration equally spaced bipolar rectangular periodic voltage pulses with a rise time of the switching voltage of not more than 10 ns to the samples.

Similarly to ferroelectric films, the full switching curve in superlattices has two sections – the initial, so-called activation section or region of “weak” fields, where the indicated dependence of the switching current on the applied field strength is close to the exponent, and the subsequent linear section, region of “strong” fields, or section slip, in which the dependence of the maximum switching current is proportional to the field $i_{max} \approx const\, E$.

The boundary between the regions of activation and nonactivation modes of switching, the so-called threshold or critical field of E_{crit}, determined by switching currents, approximately corresponds to the coercive field, determined by the dielectric hysteresis loop. The threshold field decreases as the ferroelectric phase transition temperature is approached.

A detailed study of switching currents under the action of rectangular field pulses in weak fields less than the coercive field showed that the integral characteristics of the switching do not obey the strictly exponential dependence on the field strength. This leads to the appearance of a dynamic indicator μ for the power dependence of the switching current on the electric field strength, the magnitude of which is less than unity. The selection of the power index μ for the activation region shows that in the superlattices compared to ferroelectric films, this indicator has a much smaller value and is practically independent of temperature.

Tilt angle of the switching current field dependence in the area of strong fields decreases with increasing temperature, which indicates a decrease in the mobility of the domain boundaries as the transition temperature to the non-polar phase decreases, apparently due to an increase in the switching time here.

The presence of an activation region in the regularities of switching ferroelectric superlattices indicates that repolarization processes here are most likely carried out by moving the domain boundaries.