INFLUENCE OF Mn, Mg, Zn DOPING ON THE DIELECTRIC PROPERTIES AND QUALITY FACTOR OF FERROELECTRIC Ba$_x$Sr$_{1-x}$TiO$_3$ FILMS

A.A. Semenov$^1$, A.I. Dedyk$^1$, S.F. Karmanenko$^1$, T. Inushima$^2$, V.I. Sakharov$^3$, and I.T. Serenkov$^3$

$^1$Electrotechnical University, 197376 St.Petersburg, Russia
$^2$Tokai University, 1117 Kitakaname, Hiratsuka 259-1292, Japan
$^3$A.F. Ioffe Physico-Technical Institute RAS, 194026 St.Petersburg, Russia

Among the dopants that are able improving a quality factor at microwaves of ferroelectric Ba$_x$Sr$_{1-x}$TiO$_3$ (BSTO) films rather effective influence is caused by such elements as Mn, Mg, Zn. We investigated the effect of these dopants on dielectric characteristics of BSTO films grown in the process of RF reactive cathode sputtering of powder targets. The sintered MnO$_2$, MgO or ZnO powders was added to BSTO ($x = 0.55$) powder. Then target surface was flatted and placed at bottom position in vacuum chamber. The dopant contents in BSTO targets were as follows: Mn - from 0.1 up to 2.0 mol.%; Mg - from 0.1 up 8.1 mol.% and Zn in quantity from 0.3 up to 0.9 mol.% that was added accompanied with Mg. Temperature dependencies of capacitance $C$ and $\tan \delta$ using BSTO planar varactors were investigated at frequency 1 MHz. along with voltage capacitance characteristics and current-voltage characteristics. Element composition and structural orderliness of BSTO films were investigated by means of Medium Energy Ion Back Scattering (MEIS) and transmission electron microscopy techniques. The results of film diagnostics included temperature $T_m$ corresponded to maximal capacitance of BSTO varactor. The $T_m$ value of BSTO films doped by Mn displaced to lower temperature, and BSTO:MgO films were distinguished by higher $T_m$ value in comparison with BSTO samples without dopants. The best dielectric properties were obtained on BSTO films with (1.8–2.0) mol.% of Mn, and the films containing 0.3 mol.% Mg and 0.9 mol.% Zn. These samples had $\varepsilon \approx 1500$; $\tan \delta < 0.003$, tunability $K \approx 1.5$ (at $E = 5$ V/µm); quality factor $Q = 10000$. Physical model of the influence of such dopants on BSTO film properties was proposed.