OMEE

Book of Abstracts

International Conference on

Oxide Materials for Electronic Engineering – fabrication, properties and applications

OMEE-2021

September 28 – October 2, 2021
Lviv, Ukraine

Ministry of Education and Science of Ukraine
Lviv Polytechnic National University

Book of Abstracts

International Conference on Oxide Materials for Electronic Engineering – fabrication, properties and applications

OMEE-2021

September 28 – October 2, 2021
Lviv, Ukraine

Lviv
Lviv Polytechnic Publishing House
2021

Materials with High Permittivity Based on Ferroelectric and Ion-Conducting Systems

T.O. Plutenko, O.I. V'yunov, L.L. Kovalenko, O.P. Fedorchuk and A.G. Belous

V.I. Vernadsky Institute of General and Inorganic Chemistry of the NAS of Ukraine, Palladina ave., 32/34, Kyiv - 03142, Ukraine

The miniaturization and high degree of integration of electronic devices and printed circuit boards is one of the strategies of "system in a box" technology and requires the development of dielectric capacitors based on materials with a high dielectric constant ($\varepsilon \geq 1000$). Several types of such materials are being developed. At first, these are solid solutions based on barium titanate, which large dielectric constant at room temperature associated with the ferroelectric properties. Partial reduction of titanium and an increase in the average grain size during sintering leads to an increase in dielectric losses and a relaxation contribution to the dielectric constant. The additives of 3d metal oxide MnO_2 to ceramics can prevent partial reduction of Ti. The AST (Al_2O_3 - SiO_2 - TiO_2) additive helps to reduce sintering temperature. It is interesting to study dielectric materials obtained using these additives. Secondly, a high dielectric constant was observed in $La_{0.67}Li_xTi_{1-x}Al_xO_3$ system, where a high dielectric constant can be associated with a barrier layer capacitor effect at the grain boundary. Nevertheless, dielectric properties of ceramic samples were investigated only for the orthorhombic structure, which is formed during fast quenching after sintering. Whereas materials obtained by slow cooling still remain unstudied.

Thereby, the aim of this work was to investigate the effect of MnO_2 and AST (Al_2O_3 –SiO_2–TiO_2) additives on the electrical properties and formation of $Ba(Ti,Sn)O_3$ solid solutions, as well as to study the effect of structure of partially substituted $La_{0.67}Li_xTi_{1-x}Al_xO_3$ (where $0.15 \leq x \leq 0.3$) solid solutions on their electrical properties.

The solid solutions of barium titanate stannate $Ba(Ti,Sn)O_3$ have been investigated. The sequence of phase transformations during the synthesis of the solid solution with the formation of intermediate barium orthotitanate (Ba_2TiO_4) and tetratitanate ($BaTi_4O_9$) has been established. Crystallographic and microscopic studies of ceramics based on $Ba(Ti,Sn)O_3$ have been carried out. It was found that the grain size does not change with the addition of manganese and grows with the addition of AST. It was found that the addition of manganese oxide and a low-melting additive AST can improve the dielectric parameters and reduce the sintering temperature of ceramics. Ceramics obtained at 1100 °C are characterized by high values of dielectric constant ($\varepsilon \sim 7000$) at 1 MHz and low dielectric values $tg\,\delta \sim 0.05–0.06$ at room temperatures.

$La_{0.67}Li_xTi_{1-x}Al_xO_3$ solid solutions ($0.15 \leq x \leq 0.3$) have been synthesized by solid-state reaction technique. To obtain the samples, they were sintered at 1200 ºC, single-phase solid solutions were formed for all x values. The samples had rhombohedral perovskite-related structure symmetry (space group R-3c, no. 167), while the properties for samples with perovskite-related orthorhombic symmetry are already known. Light-optical microscopy showed that the grain size of the $La_{0.67}Li_xTi_{1-x}Al_xO_3$ ceramics slightly increases with the concentration of lithium. Solid solutions $La_{0.67}Li_xTi_{1-x}Al_xO_3$ exhibit a high dielectric constant $\varepsilon' > 10^4$ in a relatively wide frequency range ($10^{-2} \leq f \leq 10^4$ Hz) without an explicit dependence on x. An impedance spectroscopy study indicates three semicircles in the Cole-Cole diagram that can be attributed to electrically different regions of the ceramic grain.

Comparing materials based on ferroelectric and ion-conducting systems we can conclude that both materials exhibit high dielectric permittivity in wide frequency range ($1 \leq f \leq 10^5$ Hz) but at the same time the dielectric properties of barium titanate are temperature dependent while the dielectric properties in lithium lanthanum titanate are thermally stable.