Ferroelectric Thin Films for Tunable Microwave Applications

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Modern wireless communication systems are based on microwave technologies. Ferroelectric devices with the electric field dependent dielectric properties and low dielectric losses at microwave frequencies are very promising. Capacitance tunability n_c, defined as the ratio of the capacitance at zero applied bias voltage to the capacitance at some desired applied voltage, is the key functional property of ferroelectric materials. In order to avoid losses arising from the domain wall motion, these materials are mainly used in their paraelectric phase. [1]

Device electronics and thin film technology have in last years triggered intensive research activities in the field. Thin films enable usage of low bias voltages and therefore low energy consumption, miniaturization of microwave components, and integration into electronic circuits. Requirements for thin film varactors (variable capacitors) are: low dielectric losses $tan\delta$, high tunability n_c, and the possibility of deposition on low-cost substrates. If all the requirements are fulfilled, ferroelectric thin films can be efficiently used as phase shifters, i.e. the active elements in electronically controlled antennas which are suitable for aeronautic applications. [2]

The ferroelectric – paraelectric phase transition temperature of the $K(Ta, Nb)O_3$ solid solution varies from 0 to 708 K, depending on the Ta / Nb ratio. In this respect it is analogous to the best known microwave ferroelectric material $(Ba, Sr)TiO_3$. However, literature reports on preparation and dielectric properties of this material in thin film form are scarce due to highly reactive reagents and demanding processing.

$K(Ta, Nb)O_3$ thin films on polycrystalline alumina were prepared by chemical solution deposition from potassium acetate and transition metal alkoxides in 2-methoxyethanol. The influence of the reflux time on microstructure and tunability of $KTa_{0.6}Nb_{0.4}O_3$ films after heating at 900 °C was studied. The films, prepared from the 24-h refluxed solutions, have a homogeneous microstructure and the tunability, measured at room temperature and 1 MHz, equal to 2.6. The films, prepared from the 1 h-refluxed solutions, have heterogeneous microstructure and a lower tunability value, i.e. 1.9. [3]

Further more, the influence of the Ta / Nb ratio on dielectric properties of the $K(Ta, Nb)O_3$ thin films, prepared from the 24 h refluxed solutions and heated at 900 °C, was studied. The tunability, measured at room temperature and 1 MHz, decreases with the increasing Ta / Nb ratio from 2.6 for the $KTa_{0.6}Nb_{0.4}O_3$ films to only 1.01 for the $KTaO_3$ films. On the other hand, dielectric losses at 9.7 GHz of $KTa_{0.6}Nb_{0.4}O_3$ and $KTaO_3$ decrease from 0.38 to 0.017, respectively.

References:

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