Abstract

Due to the dependence of their dielectric properties on an external electrical field, ferroelectric materials proof to be of interest for a number of modern radio-frequency (rf) applications. Especially for their integration into frequency-tunable rf-devices (i.e. for mobile communications) the linear and nonlinear dielectric properties of thin ferroelectric $SrTiO_3$-films are of interest.

Therefore, in this work the structural as well as the dielectric properties of thin $SrTiO_3$-films are being examined. The lattice strain of the epitaxial deposited $SrTiO_3$ films is proven to strongly effect the dielectric properties. Correlations of the dielectric constant, the rf loss, the dielectric tunability and the structural properties are demonstrated. The results are explained in terms of a thermodynamic model that describes the influence of lattice strain on the polarization of the $SrTiO_3$ films.

Experimental determination of the intermodulation distortion (IMD) proofs to be an ideal tool for the examination of the nonlinear dielectric properties of the films. IMDs are generated by applying two fundamental rf-signals of slightly different frequencies to systems with nonlinear properties. Two different origins of IMD-signals are being verified for our $SrTiO_3$-films: the nonlinear behaviour of the dielectric constant and the onset of conductivity at extremely high fundamental rf-powers. The coaction of both mechanisms leads to a rather unusual dependence of the IMD signals on the power of the fundamental signals. Furthermore, the nonlinear dielectric constant generates IMD signals of higher orders i, i.e. i = 3, 5, 7, 9.

Finally, the influence of the geometry of integrated ferroelectric elements upon the performance of any device is examined. Different varactor designs are analyzed theoretically and experimentally. It turns out that the properties of complex varactors with structured dimensions down to 4µm can be described in terms of an improved model of parallel capacitors. Via this analysis, novel varactor geometry for the integration in tunable rf-devices is presented. In comparison with the standard planar capacitor, the tunability of the device is improved by about 300% and the rf losses are reduced by about 50%. The quality factor of exceeds $K \geq 50$ (i.e. sufficient for most applications) already at extremely low operating voltages of $U_{dc} < 20V$. The standard planar capacitor and the new vertical capacitor are well described by the model of parallel capacitors.