Dielectric permittivity of ytterbia-stabilized zirconia cystals measured at high frequencies

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Zirconia (ZrO_2), due to its high dielectric constant, is a promising candidate for replacement of SiO_2 in MOS structures in microelectronic devices. It is well known, that adding of a trivalent oxide, such as yttria (Y_2O_3) or ytterbia (Yb_2O_3), can influence the phase composition (and dielectric constant) of the crystal. Depending on the amount of trivalent oxide, monoclinic, tetragonal or cubic phase can be stable at room temperatures. In this work ZrO_2 crystals with various concentration of Yb_2O_3 were investigated.

For microelectronic applications the dielectric constant in MHz-GHz frequency range is an important parameter. However, classical methods, such as C-V measurements or systems based on RLCG-meters or impedance analyzers, are usually designed for frequencies up to 1 – 10 MHz. At higher frequencies the parasitical inductance (connected with the length) of the wires becomes crucial.

We present a method of dielectric permittivity measurement based on a network analyzer working in the frequency range of 300 kHz – 3 GHz. The measured complex impedance of a wired sample is analyzed as a waveguide loaded by a capacitor. This approach makes possible to find proper values of dielectric constant in the frequency range typically up to 1 GHz.

Among measured samples the sample ZrO_2 + 3.3mol% Yb_2O_3 has the highest dielectric constant ($\kappa = 39$) and seems to be the most interesting candidate for application in MOS structures.