BZN THIN FILM CAPACITORS FOR MICROWAVE LOW LOSS TUNABLE APPLICATIONS

Jaehoon Park, Jiwei Lu*, Susanne Stemmer*, and R. A. York

Department of Electrical and Computer Engineering, University of California Santa Barbara, Santa Barbara, CA 93106-9560 U.S.A
*Materials Department, University of California Santa Barbara, Santa Barbara, CA 93106-5050 U.S.A

Thousands of modern electrical applications require miniaturized and low-loss components such as phase shifters, tunable filters, and electro-optic modulators and the demands on these components have stimulated researchers to find higher dielectric constant and lower-loss materials such as Bismuth Zinc Niobate (BZN) that is introduced in this paper. One of the representative candidates so far is BST thin film. However, the strong function of thin film thickness is its permittivity, which is 20~50 times lower than that of bulk, and other factors such as polarization effect and film non-stoichiometry affect characteristics of BST film. BZN thin film can be the alternative candidate having low loss and high permittivity, which is less affected by stoichiometry and film thickness. The electric-field dependent capacitance is also its attractive feature for applications such as voltage-controlled oscillator and can be estimated with the percentage tunability defined as $(C_{max}–C_{min})/C_{max}$.

MIM type of capacitors was fabricated on platinized vycor glass substrate. BZN film is prepared by RF magnetron sputtering system after a bottom electrode (Ti/Pt, 250/2000(4000Å)) is deposited by electron beam evaporation technique. Ex-situ annealing, then, is done at 750˚C with air ambient for 5 minutes for crystallization. With this temperature and film thickness, the relative permittivity of BZN thin film approximately gives 190. Lift-off process of top electrode (Au, 5000 Å) is accompanied. The rapid thermal annealing (RTA) at 700˚C for 30 seconds is followed, and the evaporation of thick metal for probe measurement contact (Au, 1µm) completes the process.

The total device quality factor and capacitance were analyzed in microwave frequency range (up to 20 GHz) by measuring reflection coefficients with a vector network analyzer. Deembedding procedure eliminated effect of measurement pads. The quality factor including dielectric and electrode loss was more than 200 up to several GHz for 64-um^2 device. The series resistance of the electrodes dominated the device quality factor at higher frequencies. There was no indication of onset of dielectric relaxation for the measurement frequency ranges. In combination with large electric field tunability of the permittivity (45%), these low losses make BZN films attractive candidates for voltage controlled microwave devices.

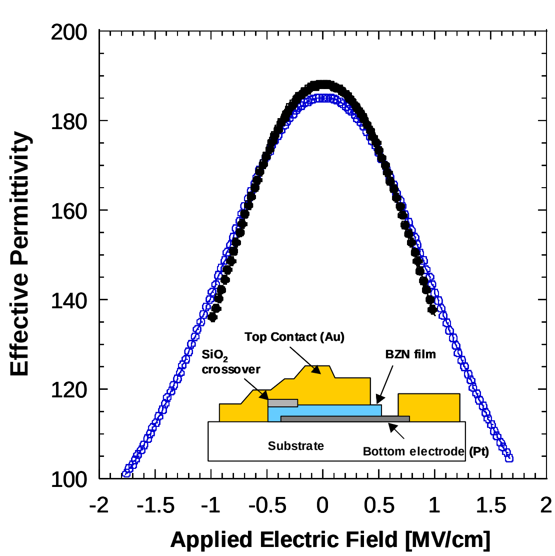

Figure 1

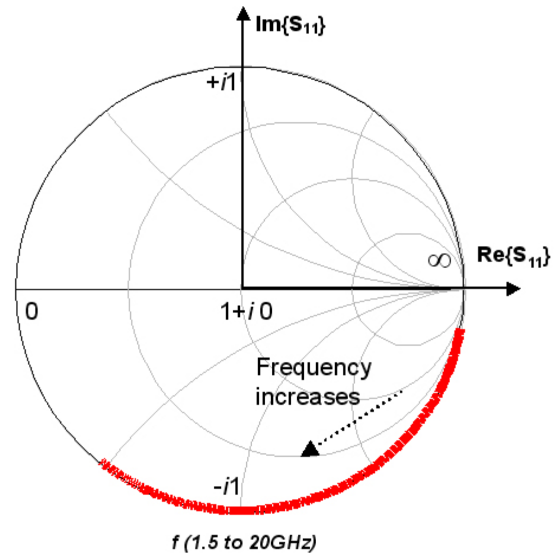

Figure 2

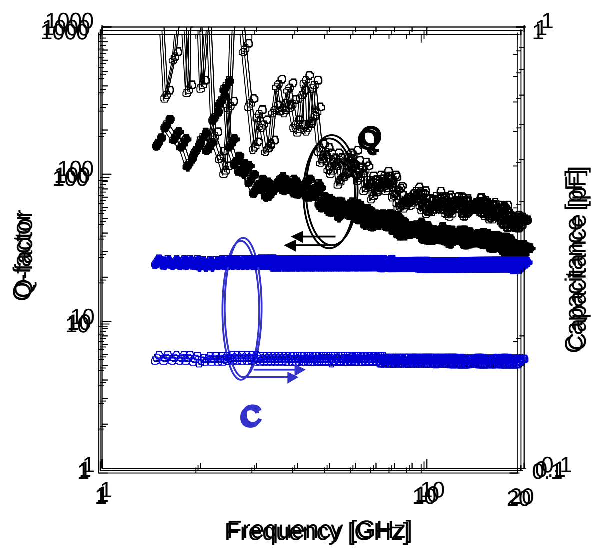

Figure 3

Figure 1 Measured Effective Permittivity for Applied Electric Field (open circle: 1500 μm^2, solid circle: 360 μm^2) and Schematics of Device Cross-section

Figure 2 Measured Reflection Coefficients on Smith Chart (64 μm^2)

Figure 3 Q factor and Capacitance for 64 (open circle) and 100 (solid circle) μm^2 Devices