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High Performance Bi - Nb - Ox Thin - Film Capacitors Fabricated by Chemical Solution Deposition Process.

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Various metal-oxide paraelectric insulators have been studied for long time, and those have been used not only in passive components such as voltage-tunable devices, high density storage condensers for telecommunication system but also in active components such as gate insulators for thin-film transistors and metal-oxide-semiconductor field effect transistors. The required performances for those insulators are dependent on device applications. In particular, we focused on paraelectric thin-film capacitors which have a high relative permittivity (>100) and a low dielectric loss. Among them, (Ba, Sr)TiO3 (BST) paraelectric thin films have been widely investigated because of their high relative permittivity (~400). However, they have inherent problem of large dielectric loss. Meanwhile, bismuth based paraelectric insulators such as Bi-Nb-Ox (BNO) and Bi-Zn-Nb-Ox (BZN) have been considered as an alternative to BST due to their low dielectric loss as well as high relative permittivity. But there have been not many reports about BNO (Bi/Nb=1/1) thin-films and the obtained relative permittivity was only around 50 by using mixed oxide method [1]. In this study, we report a new type of the BNO (Bi/Nb=1/1) film having very high relative permittivity via chemical solution deposition (CSD) process.
We fabricated a BiNbOx (BNO) thin film (~170nm) on Pt substrate (Pt/TiOx/SiO2/Si) by using CSD process. The precursor solution of the BNO film was prepared by dissolving metal organic based bismuth and niobium in alcohol solvent. The BNO precursor solution was spin-coated on a Pt substrate, dried at 250 °C and then annealed at 550 °C in O2 for 20min. Then, top electrodes of Pt (~150nm) were deposited on the BNO film by sputtering to make a capacitor. As a reference, a sputtered BNO capacitor was also fabricated on a Pt substrate. The obtained relative permittivity and dielectric loss at room temperature of the solution processed BNO capacitor were about 170 and 1.6×10-3 at 1kHz applied frequency, respectively, while those of the sputtered BNO capacitor were about 65 and 4.8×10-3, respectively. These high properties of the solution processed BNO films were repeatedly confirmed, resulting in the values between 150 and 200. We observed cross sectional TEM images and found that there existed a unique phase structure, which could be considered as a cause of the high relative permittivity. It is concluded that during the decomposition process from solution to a solid film through a gel condition BNO precursor is put in a proper condition to decompose to such a special phase as would cause a high properties. It is clearly said the solution process created a new type of material. Details will be reported on the conference. [1] D. Zhou et al., Appl. Phys. Lett. 90, 172910 (2007)

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