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Original Article

Study the Dielectric Properties of BZN Thin Films

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Abstract

The paper presents the effects of electron (8mev) irradiation on the properties of BZN thin films The BZN pyrochlore thin films (0.3 µm thickness) were grown by Pulsed Laser Ablation technique. The required targets were synthesized by solid state reaction method. The dielectric measurements of BZN thin films were done in the frequency range from 100 Hz to 100 khz and in the temperature range from 300 K to 573 K. There is an appreciable decrease in the dielectric constant at room temperature due to electron irradiation. The dielectric constant decreased to a value ~ 50 for a delivered dose 80 kgy. Surprisingly, it increased to ~ 225 for a delivered dose 100 kgy. Again it decreased further to below 50 values for 120 kgy delivered dose. The room temperature dielectric constant value of unirradiated BZN thin film at 100 khz is 240.84 while it is 28.89, 197.95 and 15.39, respectively, for delivered doses 80, 100 and 120 kgy.

Keywords: *Bismuth Zinc Niobate, Dielectric constant, irradiation.*

Introduction

Pyrochlore oxides are named after the mineral pyrochlore, (naca)(nbta)O_6F/(OH), with which they share a similar structure. $A_2B_2O_7$ pyrochlores are ternary metallic oxides whose crystal chemistry is complex enough to make them favorable for a wide range of applications. Recently, bismuth-based pyrochlore compounds have demonstrated excellent properties for use in capacitor and high-frequency filter applications: low loss, high permittivity, and good temperature stability. Golovschikova *et al* [1] and Jeanne *et al* **[2]** first investigated bismuth-based pyrochlore materials for dielectric applications in the early 1970s. Since cubic pyrochlores have many interesting applications in memory devices, microwave communications and micro-electro-mechanical devices etc., the study of radiation effects on their physical, structural, electrical and dielectric properties is important for their utility in radiation environment. Irradiation is one of the best methods to study and to change the parameters of the substance. It has been observed that the point defects, extended defects, microstructural and micro compositional changes produced by irradiation can lead to profound changes in properties.

Irradiation effects

High energy electron initially excites electron-hole pairs in materials via the Compton effect **[3-5].** Electron being a negatively charged particle, most of its energy will be dissipated by ionization effects through columbic interactions. The energy deposition of the electron increases more slowly with penetration depth due to the fact that its direction is changed so much more drastically. As these hot electrons travel through the material they ionize other atoms, losing the energy of ionization while forming an electron cascade. When the electron no longer has sufficient energy to ionize additional atoms, they can be trapped at the sites of defects (such as non-bridging oxygen's, oxygen vacancies, etc.), which were either pre-existing or created by the high energy electrons themselves. Another effect of ionizing radiation is the creation of bound electron-hole pairs (excitons), whose non-radiative de-excitation can result in the displacement of atoms by the radiolytic process [3]. If the incident electron has sufficient energy, it can then create knock-on displacement of atom. In the knock-on process, the momentum and energy of the incident particle are directly transferred to an atom in the crystal lattice.

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If the energy is sufficient to break the bond, the struck atom is displaced into an interstitial position. The minimum energy required to accomplish such a knock-on event is of the order of the strength of the bond which must be broken, usually about 4-25 ev. The minimum energy required for the electron to remove a silicon atom from its position in the glass matrix is 0.26 mev, while that for an oxygen atom is 0.16 mev **[6].**

Tunable materials caused more and more interest due to the rapid developing demand of wireless communication for applications such as phase shifters and tunable oscillators. Recently, a paraelectric Bi_2O_3-zno-Nb_2O_5 (BZN) pyrochlore system has been suggested as a potential candidate. These BZN based pyochlores were first explored in 1970 by Chinese engineer for low firing temperature multilayer capacitors. These cubic pyrochlore BZN attracted much attention as a dielectric material for microwave tunable applications mainly due to its very low dielectric constant. Depending on the composition, BZN have been found to have two different structures; a cubic pyrochlore and a monoclinic zirconate. Recent studies reveled that the cubic pyrochlore BZN thin films exhibit very low loss of 10^{-4} and large dielectric tunability upto 55 % at 1 MH. In this Paper, the dielectric properties of cubic pyrochlore bismuth zinc niobate thin films, both before and after electron irradiation, will be discussed. The films were irradiated with electrons (8 mev energy; delivered dose 80, 100 and 120 kgy). The films were well characterized, both before and after electron irradiation. The measurements were carried out on BZN thin films in Metal –Insulator- Metal configuration. Here, the silver acts as bottom electrode with gold dots as top electrode.

Synthesis

The BZN pyrochlore thin films (0.3 µm thickness) were grown by Pulsed Laser Ablation (PLD) technique. The required targets were synthesized by solid state reaction method.

Results and Discussion

The dielectric measurements of BZN thin films were done in the frequency range from 100 Hz to 100 khz and in the temperature range from 300 K to 573 K. The variation of room temperature dielectric constant with frequency for unirradiated and electron irradiated (with delivered dose of 80,100 and 120 kgy) BZN thin films are as shown in Figure 1. There is an appreciable decrease in the dielectric constant at room temperature due to electron irradiation at all measured frequencies. The dielectric constant decreased to a value ~ 50 for a delivered dose 80 kgy. Surprisingly, it increased to ~ 225 for a delivered dose 100 kgy. Again, it decreased further to below 50 value for 120 kgy delivered dose. The room temperature dielectric constant value of unirradiated BZN thin film at 100 khz is 240.84 while it is 28.89, 197.95 and 15.39, respectively, for delivered doses 80, 100 and 120 kgy. The dielectric constant variation becomes nearly independent of the measured frequencies for the case of irradiated films. It may be noted that the dielectric constant decreases with increase in frequency for pristine BZN films.

The variation of room temperature dielectric loss, for both unirradiated and electron irradiated BZN films, are shown in Figure 2. The dielectric loss is high for unirradiated films at low frequencies. The dielectric loss, at lower frequencies, is reduced significantly due to electron irradiation. The dielectric loss decreases further with increase in delivered dose upto a dose of 100 kgy. With further increase in delivered dose, the loss increases. So, a delivered dose of 100 kgy, at room temperature and at lower frequencies may be considered as the threshold value to keep a low value of dielectric loss in BZN films. At high frequencies, all the loss curves merge. The values are tabulated in Table 1. From Figures 1 and 2, it is clear that both ε' and $\tan\delta$ values decrease with increase in frequency, much so in pristine films. This may be due to the reason that, the jumping frequency of electric charge carriers cannot follow the variation of applied electric field beyond a certain critical frequency [7]. This nature was also reported by Khaw *et al* [**8**].

The temperature response of the dielectric constant and loss of unirradiated and electron irradiated BZN films are shown in Figure 3(a-d). The plots show the common nature of decrease in dielectric constant with increasing frequencies, true at all measured temperatures. The dielectric loss was found to be more for 80 and 120 kgy delivered doses compared to unirradiated and 100 kgy delivered dose.

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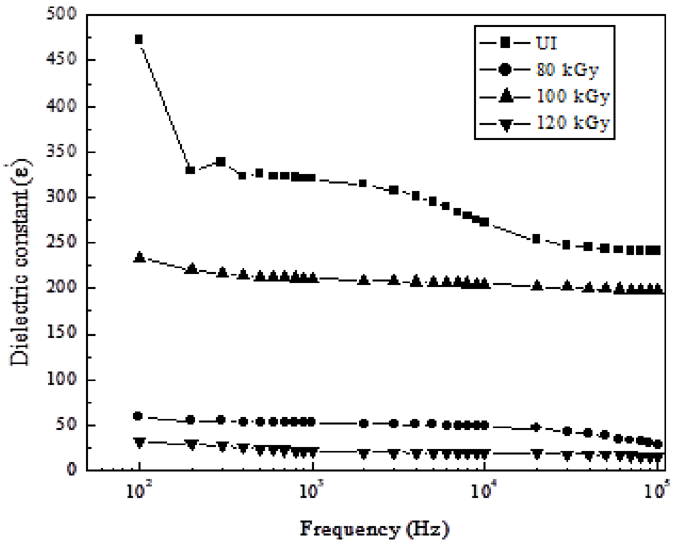

Figure 1 : *R.T. ε′ vs. f UI, EI BZN thin films*

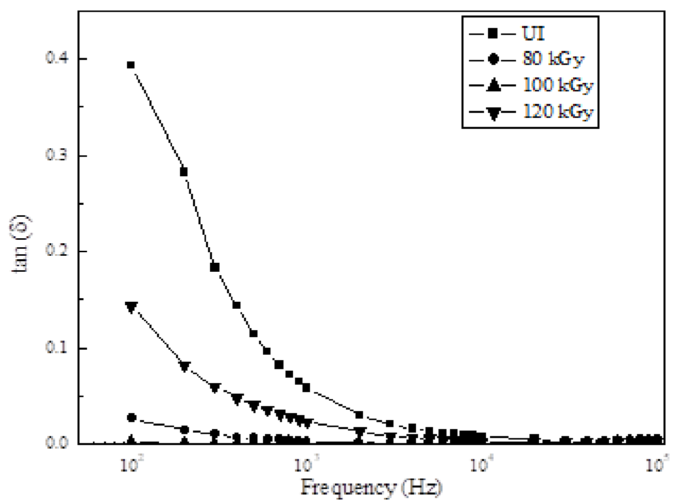

Figure 2 : tanδ *vs. f UI, EI BZN thin film*

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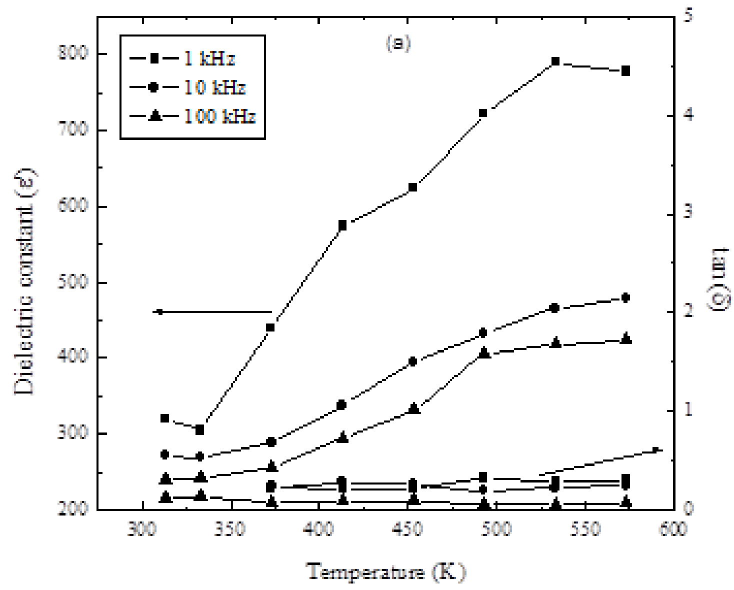

Figure 3 (a) : *ε′ and* tanδ *Vs T: UI BZN thin films*

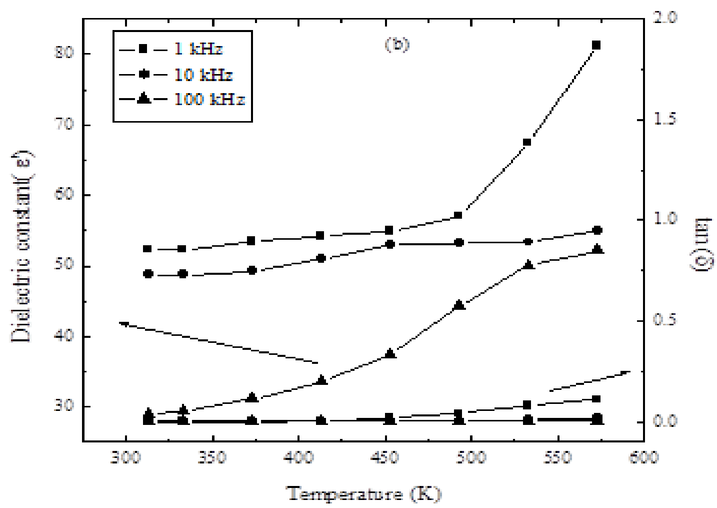

Figure 3 (b): *d* tanδ *Vs T :80 kGy: BZN thin films*

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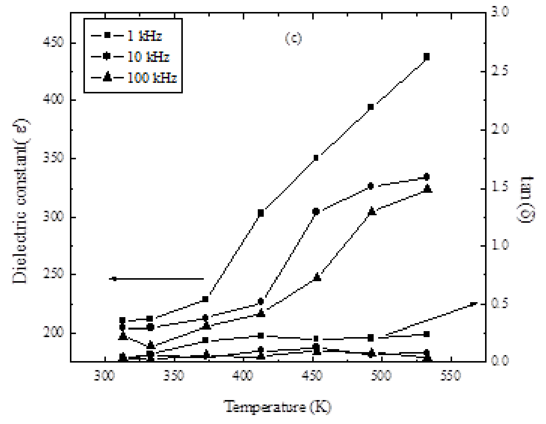

Figure 3(c): *d* tanδ *Vs T :100 kGy : BZN thin films*

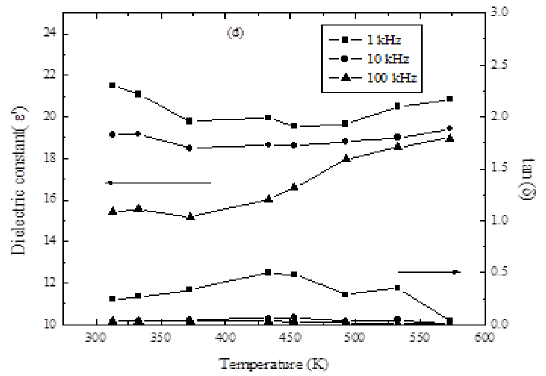

Figure 3 (d): *d* tanδ *Vs T: 120 kGy :BZN thin films*

Summary and Conclusion

The BZN pyrochlore thin films (0.3 µm thickness) were grown by Pulsed Laser Ablation technique. The required targets were synthesized by solid state reaction method. The dielectric measurements of BZN thin films were done in the frequency range from 100 Hz to 100 khz and in the temperature range from 300 K to 573 K. There is an appreciable decrease in the dielectric constant at room temperature due to electron irradiation. The dielectric constant decreased to a value ~ 50 for a delivered dose 80 kgy. Surprisingly, it increased to ~ 225 for a delivered dose 100 kgy. Again it decreased further to below 50 value for 120 kgy delivered dose. The room temperature dielectric constant value of unirradiated BZN thin film at 100 khz is 240.84 while it is 28.89, 197.95 and 15.39, respectively, for delivered doses 80, 100 and 120 kgy.

Reference

1. G. I. Golovschikova, V. A. Isupov, A. G. Tutov, I. E Mylnikova, P.A. Nikatnia and Tulinova, () . Sov. Phys. J. Solid State **14** (1973) p.2539.
2. G. Jeanne, G. Desgardni and B. Raveau. Mater. Res. Bull. **9** (1974) p.1321.
3. D. L. Griscom. SPIE, **541** (1985) p.38.
4. W. Primak, E. Edwards, D. Keiffer, H. Szymanski. Phys. Rev., **133** (1964) p.531.
5. Mohan Rajaram and E. J. Friebele. J. Non-Cryst. Solids. **108** (1989) p.1.
6. H. L. Du, X. Yao, Mater. Sci. Eng. B **00** (2003) p. 1.
7. C. C. Khaw, K. B. Tan, C. K. Lee, Ceram. Inter.**35**,(4) (2009) p. 1473.