Impedance spectroscopy of nanocomposite opal-$NaBi(MoO_4)_2:Gd^{3+}$

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Introduction

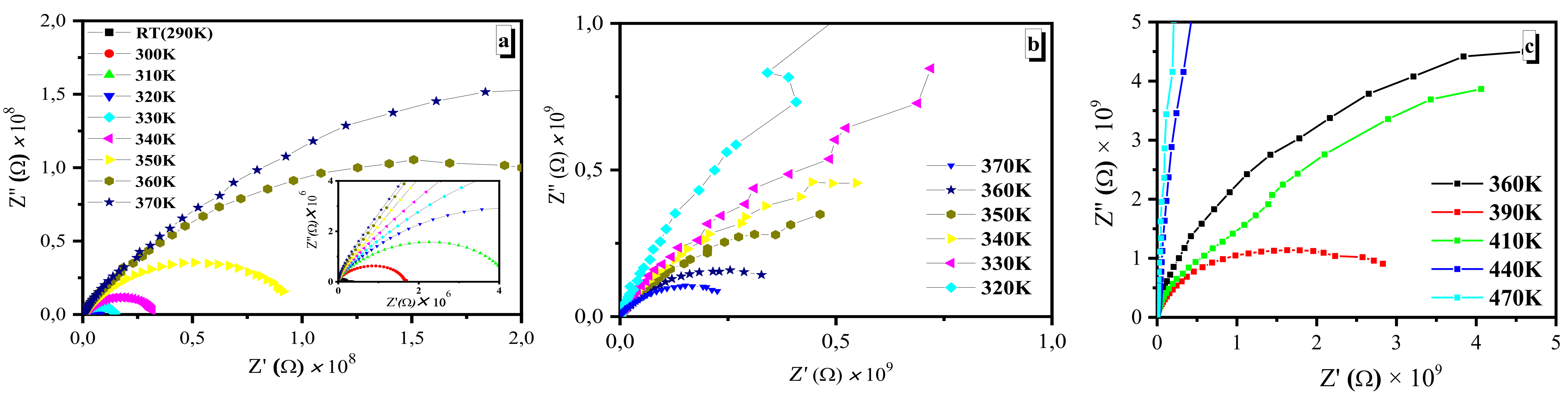
Single crystals of $NaBi(MoO_4)_2$ doped with rare-earth metal ion are promising materials for solid lasers and require comprehensive study. The crystals are disordered in the distribution of Na^+ and Bi^{3+} ions in two nonequivalent type positions, while gadolinium ions Gd^{3+} occupy the position of bismuth [1]. In this work, we studied the conductive properties of opal-$NaBi(MoO_4)_2:Gd^{3+}$ nanocomposite by impedance spectroscopy.

Samples preparation

Samples were prepared by compressing the powder of nanocomposite into circular pellets (10 mm diameter and 1mm thickness) under 10 tons (1MPa) using a hydraulic press at room temperature. Both faces of the pellets were silvered to reduce possible surface current and achieve a good conductivity. Finally, pellets were sandwiched between two parallel electrodes to carry out measurements.

Experimental Results and Discussions

The real and imaginary components of the complex impedance as well as the phase shift were measured in the frequency range from 1Hz to 1MHz and temperature range from 290K to 470K using Solartron-1260 Impedance/Gain Phase Analyzer. The applied voltage signal had an amplitude of 0.2 V with an accuracy of 0.1%. Samples were heated then cooled in one cycle.



The measured impedance spectra of (a) sample under increased temperature and (b) sample when the temperature decreased. Factor *n* is decreasing from 0.99 to 0.77 for temperature range from 290K to 370K. Factor *n* is decreasing from 0.77 to 0.10 for temperature range from 360K to 470K.

Impedance hodographs (Nyquist plots) for nanocomposite were undeformed semicircles. The semicircle centers were below the abscissa, which indicates a deviation from the ideal Debye behavior, and is characteristic of ionic conductors. It was found that the bulk conductivity can be described by the Arrhenius equation with activation energy E_a = 0.213 eV. The type of conductivity mechanism in the nanocomposite was determined from the frequency dependence of the conductivity described as $\sigma(\omega) = \sigma(0) + A\,\omega^n$, where *n* is decreasing from 0.99 to 0.77 as the temperature increases for temperature range from 290K to 370K; for temperature range from 360K to 470K factor *n* is decreasing from 0.77 to 0.10. This confirms the hopping mechanism of conductivity in the nanocomposite. It is assumed that surface ionic conductivity (over the surface of nanocrystalline grains) occurs in nanocomposite samples, which is caused by sodium and oxygen ions.

References

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