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Title: Electrical properties of Sr₂InV₃O₁₁

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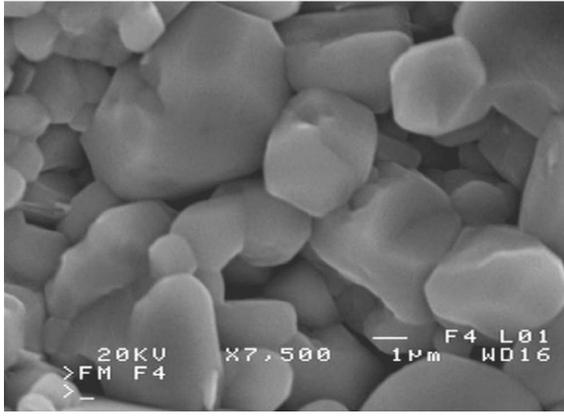


Fig. 2. SEM image of $\text{Sr}_2\text{InV}_3\text{O}_{11}$. Magnification — 7,500.

the temperature range 300–600 K with the aid of a Seebeck Effect Measurement System (MMR Technologies, Inc., USA). Broadband dielectric spectroscopy measurements were carried out using pellet, polished and sputtered with (≈ 80 nm) Ag electrodes in the frequency range of 5×10^2 to 1×10^6 Hz with a Novocontrol Alpha Impedance Analyser and in the temperature range 295–400 K. The sample electrode surface and thickness were 5 mm^2 and 1.0 mm, respectively. For measuring $\varepsilon_r = C/C_0$ [7], where C_0 is the capacity of the empty capacitor and $\tan \delta = \varepsilon''/\varepsilon'$ [7], where ε'' and ε' are imaginary and real part of complex dielectric permittivity, respectively.

3. Results and discussion

In $\text{Sr}_2\text{InV}_3\text{O}_{11}$ the electrical conductivity of less than $3.4 \times 10^{-9} \text{ S/m}$ in the temperature range 300–400 K was observed (Fig. 3). Such small values of electrical conductivity are characteristic of insulators having the value of the energy gap $E_g \approx 3.5 \text{ eV}$ [3]. Thermopower measurements in the range of 300–600 K (Fig. 3) revealed a sign change of thermoelectric power from p -type to n -type at 400 K in a presence of both the vacancy acceptor levels activated at lower temperatures, and the vacancy donor ones activated at higher temperatures. This is the result of ionic bonding of the oxide under study whose the electrical conductivity is nonzero and increases strongly with increasing temperature. At the same time a change of the conductivity type from p to n at $T_{n-p} = 400 \text{ K}$ is observed (Fig. 3). Similar behaviour was found in $\text{AgY}_{1-x}(\text{Gd},\text{Nd})_x(\text{WO}_4)_2$ [4, 5], $\text{MRE}_2\text{W}_2\text{O}_{10}$ ($\text{M} = \text{Cd}, \text{Co}, \text{Mn}$; $\text{RE} = \text{Y}, \text{Nd}, \text{Sm-Er}$) [4, 5] and $\text{RE}_2\text{W}_2\text{O}_9$ ($\text{RE} = \text{Pr}, \text{Sm-Gd}$) [6] tungstates as well as $\text{Cd}_{1-3x}\text{Gd}_{2x}\square_x\text{MoO}_4$ molybdates [4, 5].

Measurements of current–voltage, I – V , characteristics, both at 300 and 400 K revealed linearity and symmetry depending on the electric current as a function of voltage (Fig. 4) by almost two orders of magnitude difference. Such strong emission of charge carriers may be caused by reduced the potential barrier under the influence of

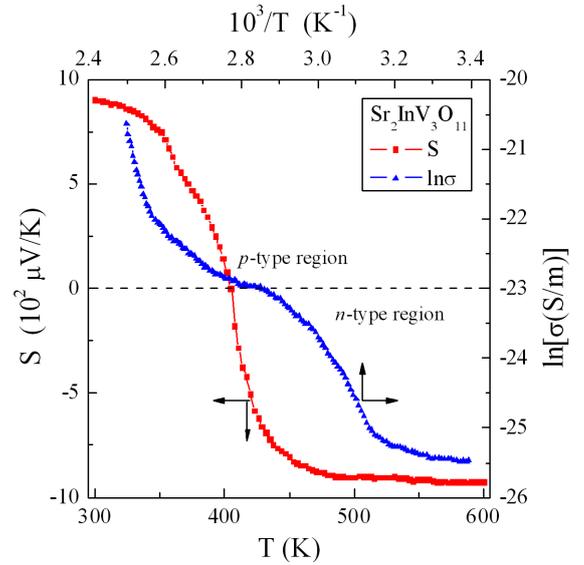


Fig. 3. Electrical conductivity ($\ln \sigma$) vs. reciprocal temperature ($10^3/T$) and thermoelectric power S vs. temperature T .

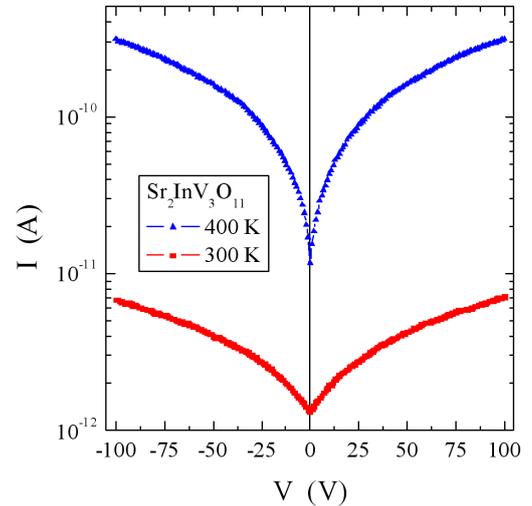


Fig. 4. The I – V characteristics at 300 and 400 K.

an applied electric field because our compound is the insulator with the energy gap of 3.5 eV [3]. Therefore it is unlikely that the thermal energy kT is able to activate the electrons to the conduction band.

Dielectric study revealed a strong dependence on the temperature and frequency of both the relative dielectric constant ε_r (Fig. 5) and the loss tangent $\tan \delta$ (Fig. 6) of the broad maximum of 320 K. Such behaviour could be considered as a relaxation process like in the Maxwell–Wagner [8] or Jonscher [9] model, which is strongly obscured by dc conductivity with the variable activation energy. Usually also the high values ε_r and $\tan \delta$ slightly at lower temperature may be due to the heat loss caused by the flow of electric current, described by the Joule–Lenz law [10, 11]. However, in this case, the effect is not so strong.

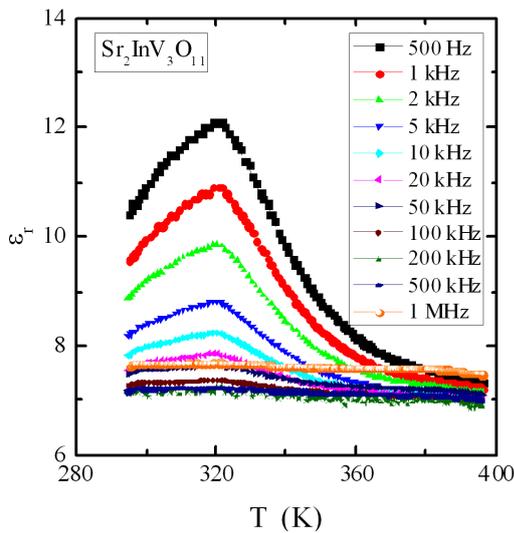


Fig. 5. Dielectric constant ϵ_r vs. temperature T in the frequency range 500 Hz–1 MHz.

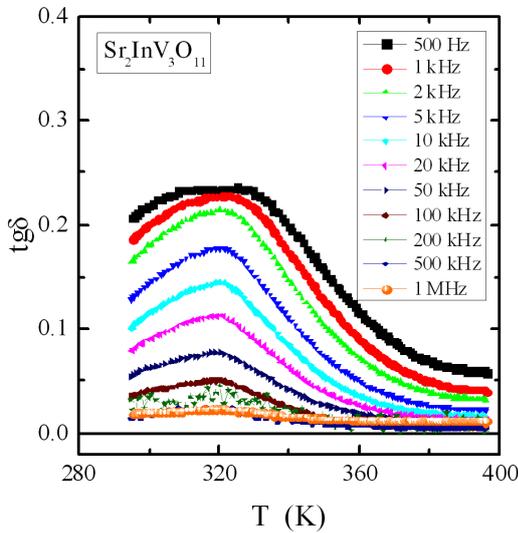


Fig. 6. Loss tangent $\tan \delta$ vs. temperature T in the frequency range 500 Hz–1 MHz.

4. Conclusions

The results of $Sr_2InV_3O_{11}$ ceramic characterization by dielectric spectroscopy, electrical conductivity, thermoelectric power, the I – V characteristics measurements have shown the insulating properties of this material with the band energy gap of 3.5 eV [3]. Moreover, the maximum values of dielectric permittivity and loss tangent slightly above room temperatures are characteristic

of the relaxation process like in the Maxwell–Wagner [8] or Jonscher [9] model. A strong emission of charge carriers forced by the temperature and voltage supports the above results. Almost constant and low values at higher frequencies of relative permittivity and loss tangent of the ceramic material under study can be useful for electronic applications.

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