Electrical conductivity of Ag_6PS_5I-based superionic ceramic prepared from nanopowder

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Recently, an active search for new materials is underway and ways to create on the basis of already known materials effective materials for solid-state batteries are being developed. Superionic ceramic materials are those materials that can replace single crystals due to their efficiency, manufacturability and economy. Synthesis of Ag_6PS_5I was carried out in vacuumed to 0.13 Pa quartz ampoules using simple substances: silver (99.995%), phosphorus (99.999%), sulfur (99.999%), and pre-synthesized binary silver (I) iodide, additionally purified by directional crystallization method, taken in stoichiometric ratios.

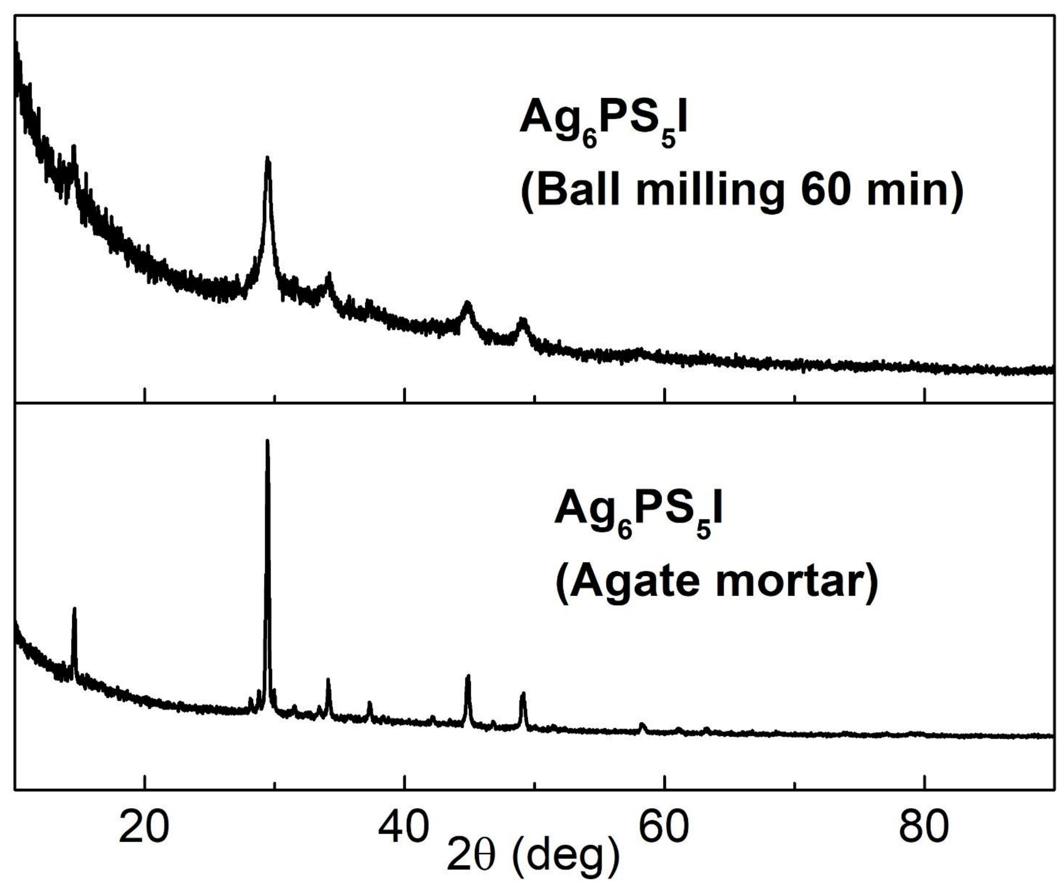

Fig.1. Powder diffraction patterns of Ag_6PS_5I obtained by grinding in agate mortar and planetary ball mill for 60 min.

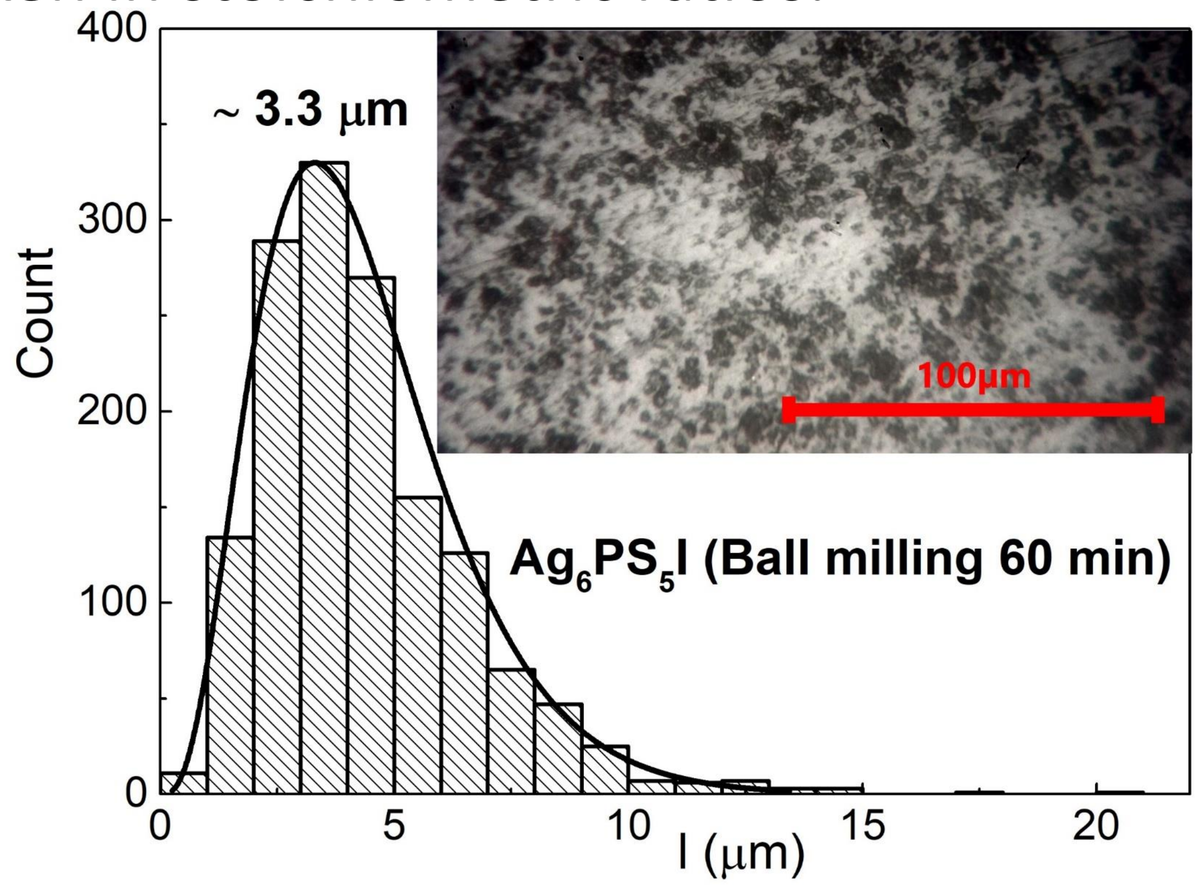

Fig.2. Histogram of distribution of sizes of crystallites of ceramics prepared on the basis of Ag_6PS_5I compound. The insert shows the microstructure of the ceramic material.

Nanocrystalline powder for preparing ceramic sample obtained by grinding in a planetary ball mill PQ-N04 for 60 min with a speed of 200 rpm.

The powder obtained as a result of grinding were investigated using XRD (fig.1.) and SEM techniques.

Pressing of sample was carried out at a pressure of ~ 400 MPa, annealing - at 973 K during 36 hours. As a result of recrystallization, the average size of crystallites for ceramic is ~ 3.3 µm (fig.2.).

Investigation of the electrical conductivity of ceramic sample based on Ag_6PS_5I superionic conductor was carried out by impedance spectroscopy method. It should be noted that for ceramic sample the obtained dependence of the total electrical conductivity on the frequency are of a typical behavior; an increase in conductivity with a frequency is observed, being characteristic of materials with ionic conductivity in solids (fig3). For the detailed studies of frequency behavior of electrical conductivity and its separation into ion and electron components, a standard approach using EEC and their analysis on Nyquist plots was used (fig4).

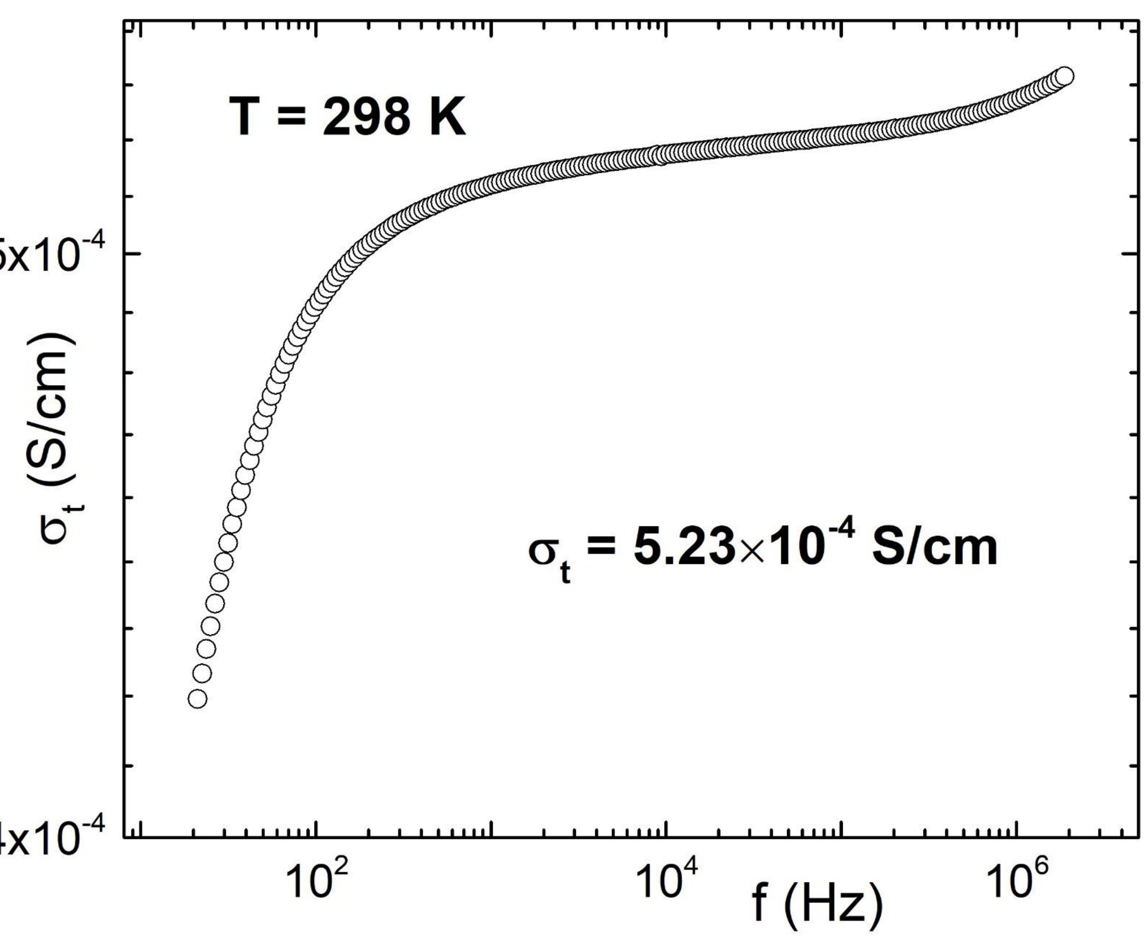

Fig.3. Frequency dependence of total electrical conductivity for ceramic samples based on Ag_6PS_5I

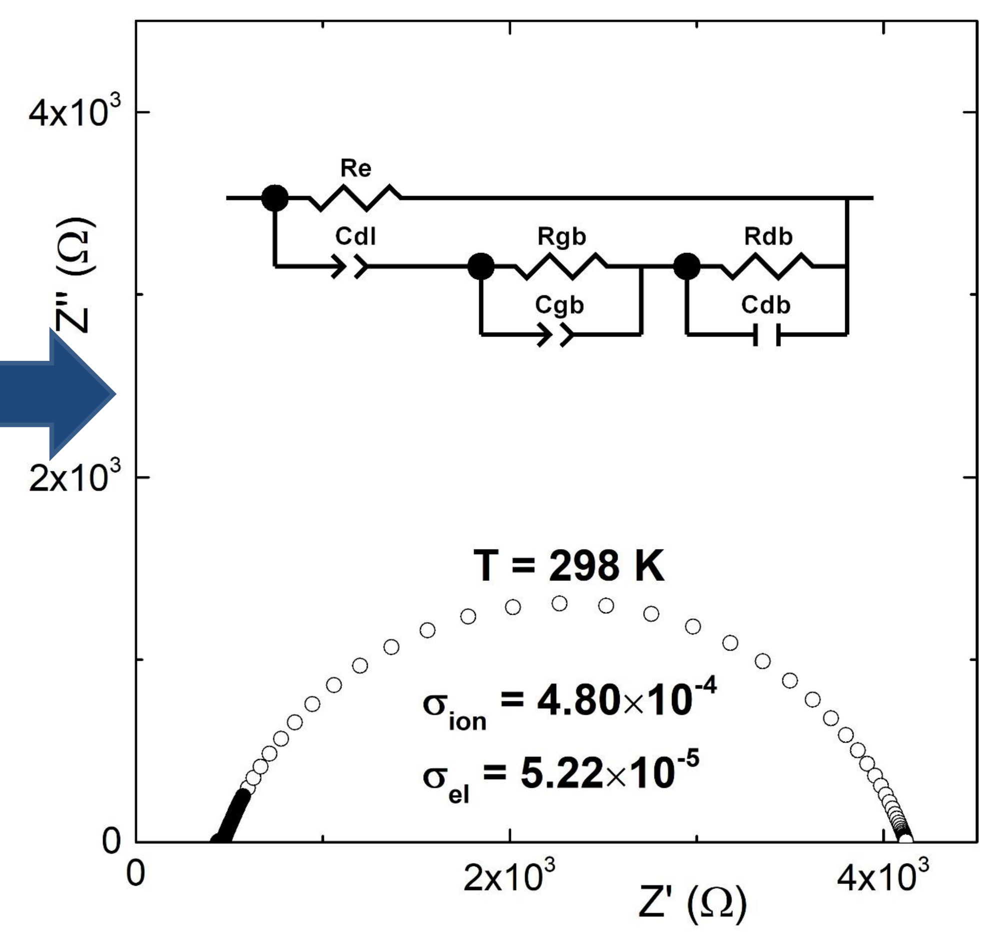

Fig.4. EEC and Nyquist plot for ceramic samples prepared on the basis of Ag_6PS_5I. Experimental data correspond to the solid dots, calculated data correspond to the open dots.

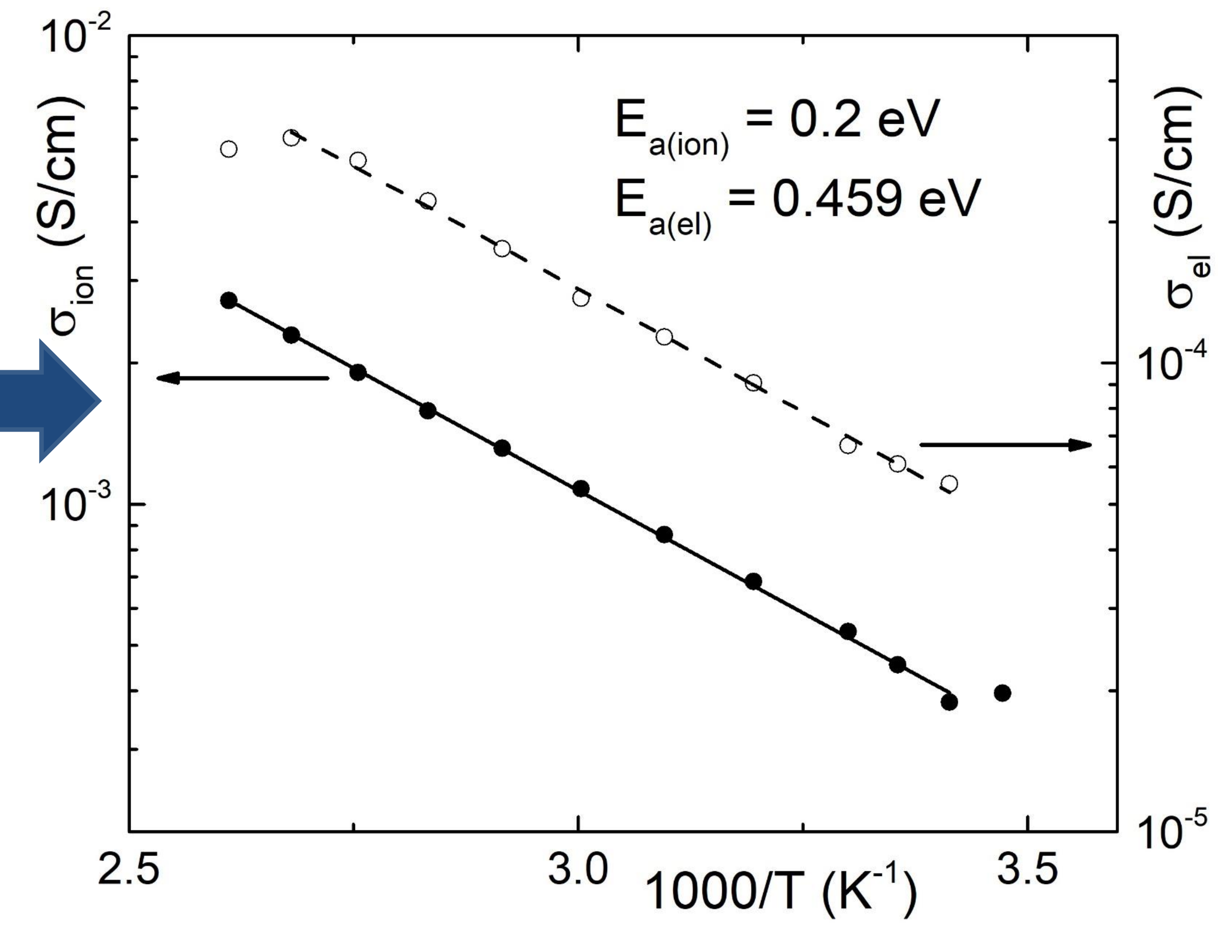

Fig.5. Temperature dependence of ionic and electronic components of electrical conductivity for ceramic sample based on Ag_6PS_5I.

It is shown that the temperature dependencies of ionic and electronic components of total electrical conductivity (fig.5.) of ceramic sample based on Ag_6PS_5I are described by Arrhenius law, which confirms the thermoactivation nature of electrical conductivity. As a result, their activation energies were determined.

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