Investigation of the percolation threshold of electrical properties in hydrated YSZ –nanopowder systems

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Introduction:

The features of hydrated nanopowder system transition from non-conducting state to state with final conductivity [1] are interesting for power nanoelectronics. The purpose of this work is to study the hydrated nanopowder systems of YSZ composition in strong electric field.

Research object:

The powders of ZrO_2 - 3% mol Y_2O_3 (YSZ) composition which was obtained by the method of co-precipitation followed by annealing at temperatures from 400°, 500° and 600°C [2] were used. The laboratory models of nanopowder humidity sensors in the form of polymer films filled with nanosized YSZ crystallites were obtained by applying a powder slurry in 4% PVA solution in water to dielectric substrates with silver electrodes. The distance between the electrodes was 2 mm.

Research method:

In a special chamber where the sensor was placed, using salts, the required value of atmospheric humidity was set in the range from 60 to 75% in 5% steps, then a voltage was applied in the range from 0 to 900V in 50V steps, set by the Stromversorgung SVE 143 device. The VC9808 + measuring device set the corresponding voltage value at the sensor.

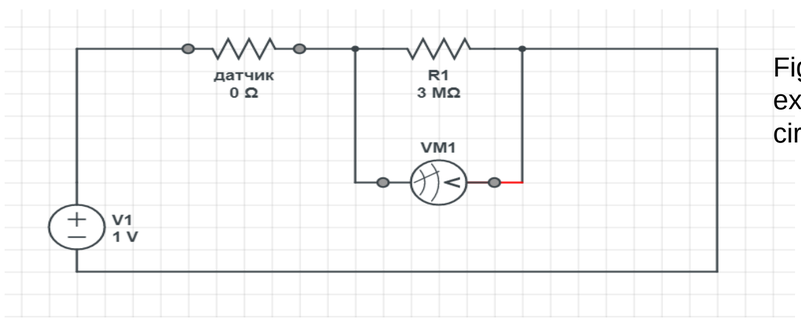

Fig. 1 experimental setup circuit diagram

Results:

According to Ohm's law $I = \frac{U}{R}$, $Usens. = I * R$

$$Rsens. = \frac{Usens.}{I} \qquad I = \frac{U}{R1 + Rsens.}$$

$$Rsens. = \frac{U}{I} - R1 \qquad Rsens. = \frac{Uext. * R1}{U} - R1$$

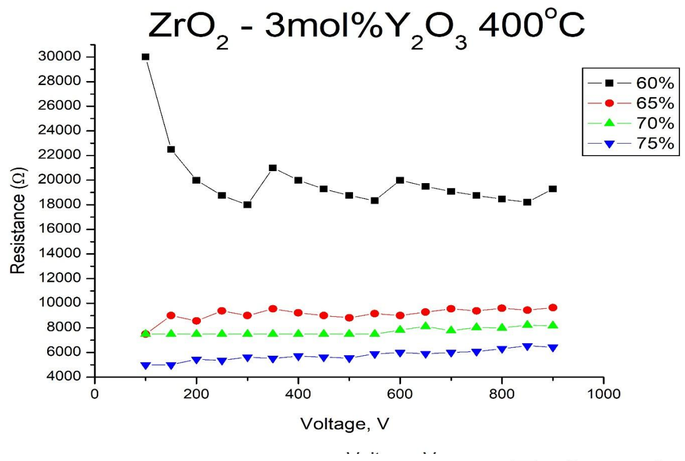

Fig. 3. Graphs of resistance versus applied voltage is expressed, where each curve defines the corresponding moisture value for the sensor based on ZrO_2 – 3mol% Y_2O_3 400ºC

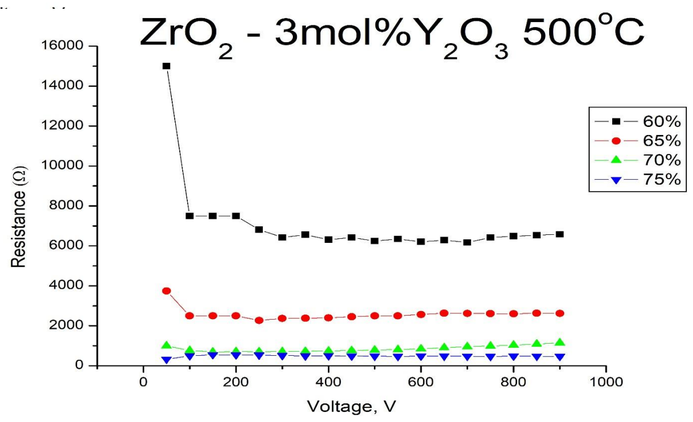

Fig. 4. Graphs of resistance versus applied voltage is expressed for the sensor based on ZrO_2 – 3mol% Y_2O_3 500ºC

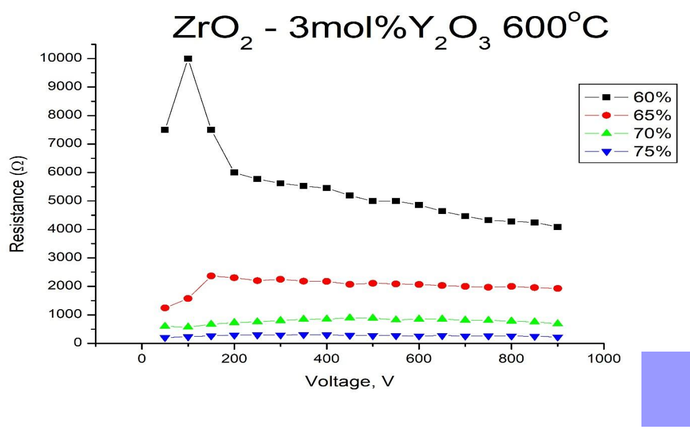

Fig. 5. Graphs of resistance versus applied voltage for the sensor based on ZrO_2 – 3mol% Y_2O_3 600ºC

Research aims:.

The purpose of this work is investigation of current-voltage characteristics at high potentials and also finding the dependences of the resistance on the particle size of nanopowders. That can be relevant for systems with percolation thresholds.

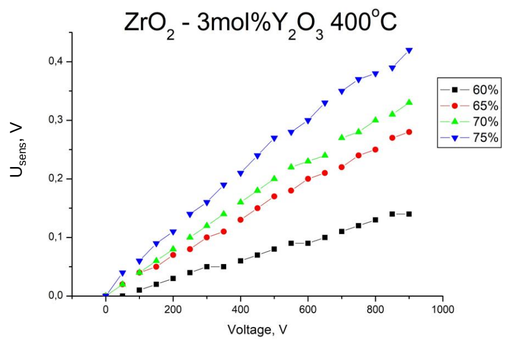

Fig. 2. This graph shows dependency curves, where each curve corresponds to a humidity. The abscissa represents the applied voltage, and the ordinate represents the voltage removed from the sensor (U_{sens}). Such methods are intermediate for calculating resistance.

Conclusions:

It has been found that the process of percolation of electrical conductivity in YSZ systems with particle size of 7.5nm (annealing at 400ºC) in the electric field up to 400V/mm has an extreme non-monotonic character. It has been found that the feature is reduced by increasing particle size.

References:

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