EIS study of humidity sensor based on mesostructured porous silica thin film material

Esposito, Vincenzo; de Florio, Daniel Z.; Bertolo, J. Mio ; Bearzotti, A. ; Falcaro, P.; Innocenzi, P. ; Traversa, Enrico

Published in:
Proceedings of the 204th Meeting of The Electrochemical Society

Publication date:
2003

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Esposito, V., de Florio, D. Z., Bertolo, J. M., Bearzotti, A., Falcaro, P., Innocenzi, P., & Traversa, E. (2003). EIS study of humidity sensor based on mesostructured porous silica thin film material. In *Proceedings of the 204th Meeting of The Electrochemical Society* Article 1481 The Electrochemical Society.

EIS study of humidity sensor based on meso-structured porous silica thin film material.

V. Esposito[1], D. Z. de Florio[2], J. Mio Bertolo[3], A. Bearzotti[3], P.Falcaro[4], P. Innocenzi[5] and E. Traversa[1].

[1] Universiy of Roma "Tor Vergata", Dipartimento di Scienze e Tecnologie Chimiche, Via della Ricerca Scientifica, 00133, Roma, Italy
[2] Instituto de Pesquisas Energéticas e Nucleares, Centro Multidisciplinar para o Desenvolvimento de Materiais Cerâmicos, C.P.: 11049, Pinheiros, 05422-970, São Paulo, SP, Brazil
[3]IMN-CNR, Area di Ricerca Roma, Tor Vergata, via Fosso del Cavaliere 100, 00133 Rome, Italy
[4]University of Padova, Dipartimento di Ingegneria Meccanica, Settore Materiali, , via Marzolo 9, 35131 Padova, Italy
[5]University of Sassari sede Gemmata di Alghero, Dipartimento di Architettura e Pianificazione, Piazza Duomo, Palazzo Pous Salit, 07041 Sassari, Italy

Electrochemical impedance spectroscopy (EIS) is a standard technique used to characterize the electrical properties of materials especially considering ionic conductivity. Application of EIS in sensor characterization gives important information on the nature of the electrical conductivity in correlation to the environmental changes. The presence of water affects the electrical conductivity of mesoporous silica (MPS) films. High porosity and surface modification are key factors to achieve high proton conductivity in MPS materials. According to several authors proton migration on the oxide surface is dominated by the Grotthus mechanism [1]. In this mechanism the proton forms H_3O^+ and other ion complexes, in which H^+ jumps to the neighboring lone pair through ice-like ordered water clusters. In the MPS thin film deposited on interdigitated gold electrodes all the conditions for such a water physisorption and proton conduction are realized.

In this work an electrochemical impedance spectroscopy study on MPS based humidity sensors is presented. The dc electrical performances of the sensor were already tested in different environmental conditions [2, 3]. Further EIS measurements allowed to understand the conduction mechanisms and the correlation between electrical response and MPS fabrication process.

Figure 1 shows a comparison between the impedance diagrams of the MPS films calcined at 250 °C and 350 °C, measured at about 50% relative humidity (RH) and room temperature (RT) stable values. The MPS thermal treatment changed the sensor electrical response.

Figure 2 shows the electrical resistance variation with the RH values. A very large electrical resistance variation of six orders of magnitude, from 10^5 Ω to 10^{11} Ω, was observed, indicating the good material response to the amount of present water. EIS measurements were performed at constant value of RH, increasing and decreasing RH, only a very slight hysteresis was observed for MPS films.

Our findings demonstrated that EIS analysis is a very important tool for the characterization of the sensing mechanism of the humidity-sensitive materials. MPS films showed chemical and physical stability and they are very promising candidates for integrated humidity microsensors.

Figure 1: Impedance diagrams of mesoporous silica films calcined at 250° C and 350 °C measured in the wetting at constant room temperature and 50% of relative humidity.

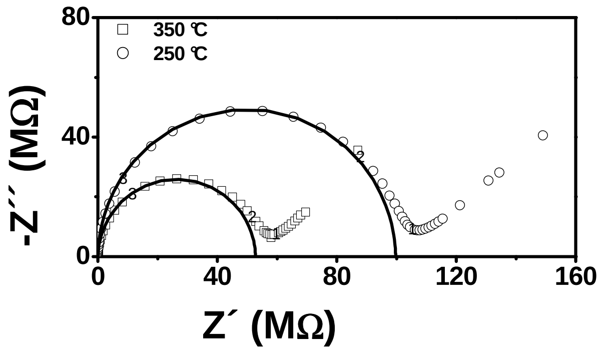
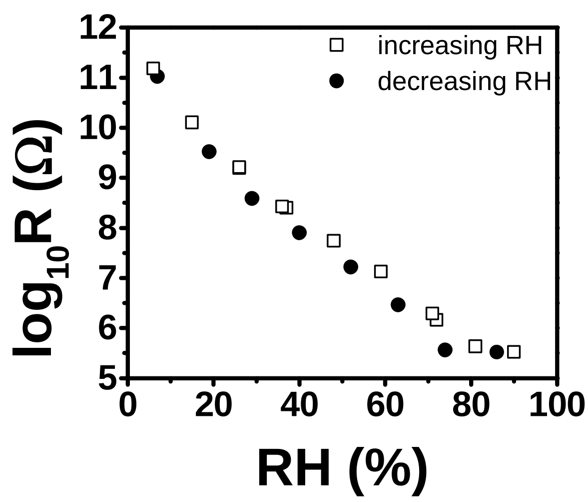


Figure 2: Dependence of resistance values on relative humidity in the constant regime for the mesoporous silica film calcined at 350 °C in wetting (□) and drying (○) conditions.



References:

(1) M. T. Colomer, M. A. Anderson, J. Non-Cryst. Solids 93, **290**, (2001).
(2) P. Innocenzi, A. Martucci, M. Guglielmi, A. Bearzotti, E Traversa, Sens. and Actuators B **76**, 299, (2001).
(3) P. Innocenzi, A. Martucci , M. Guglielmi ,A. Bearzotti , E. Traversa, J. C. Pivin, J. Eur. Ceram. Soc. **21**, 1985, (2001)
(4) S. Mikhailenko, D. Desplantier-Giscard, C. Danumah, S. Kaliaguine, Micropor. Mesopor. Mater. **52**, 29, (2002).