11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

The analysis of Nb_2O_5-doped ZrO_2-TiO_2 ceramic as soil water content sensor element in controlled environments

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Abstract - In this work, the behavior of ZrO_2-TiO_2 porous ceramics doped with controlled percentages of Nb_2O_5 for application as sensor elements of soil water content is presented. The goal of this research was to correlate the capacitance and impedance variation of the sensing elements, when immersed in soils previously selected, with the ceramic microstructure. The results obtained evidenced that the ZrO_2-TiO_2 porous ceramics presented potential to be applied as sensor elements for soil moisture.

The Research Group on Solid Surface and Micro and Nanostructured Ceramics (SUCERA), of the Aerospace Research National Institute (INPE), has been working for 15 years on porous ceramics for application as relative humidity sensors. The research project for the fabrication of ceramic sensors to monitor the soil water content started on 2001. In this work, the experimental investigation on the sensing capability of ZrO_2-TiO_2 porous ceramics doped with 1, 5, 10, 15 and 20 % (mols) is proposed. Typical aspects of the corresponding porosities are presented in Figures 1a, 1b, 1c and 1d. The ceramic sensor elements were manufactured from powders mixture. The commercial powders ZrO_2,TiO_2 and Nb_2O_5 were mechanically mixed, pressed with a pressure of 100 MPa and sintered at 1100 ºC, in order to obtain a suitable porous microstructure for the intended application. The ceramic elements were characterized through X-ray diffraction and scanning electron microscopy. The sensing capability of the ceramic sensor elements was evaluated by the capacitance and impedance variation, in two types of soil, with distinct characteristics, in temperature and relative humidity controlled environments. Up to now, the results are very promising. The sensing elements, manufactured from ZrO_2, TiO_2 and Nb_2O_5 present very attractive characteristics as soil moisture sensors, such as: good sensitivity when in contact with the water, good reproducibility and low hysteresis.

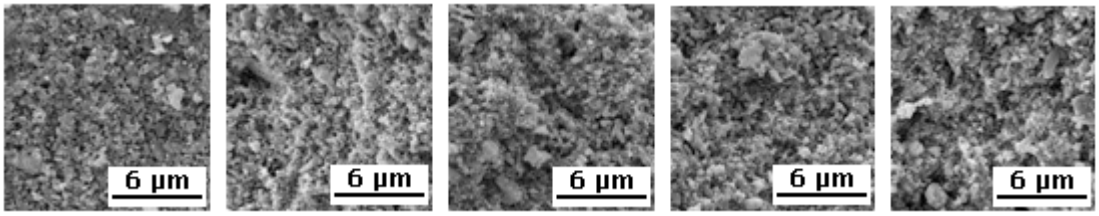

Figure 1. Fracture surface of ZrO_2-TiO_2 porous ceramic doped with a) 1, b) 5, c) 10, d) 15 and e) 20 % of Nb_2O_5. Magnification: 5.000 X.