A novel device for the study of swelling and shrinkage of hydrides

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We present a novel device for the characterization of volumetric changes of hydride systems as hydrogen concentration is varied, based on electrical measurements (capacitance and resistance).

INTRODUCTION

In the development of new hydrogen storage materials it is necessary to characterize the gas absorption, but also other parameters relevant for the development of hydrogen storage tanks. During the charging / discharging cycles, the materials are subjected to thermodynamic and chemical changes. Metallic alloys can undergo a volumetric change of 10-30% in its crystal structure[1,2], but the macroscopic volumetric changes of the material depend also on other factors including porosity[2]. For the evaluation of these parameters, we propose a novel device to be used together with a Sieverts system.

EXPERIMENTAL/THEORETICAL STUDY

The dilation chamber was designed as a capacitive system with coaxial geometry to evaluate the change in macroscopic volume of the samples by measuring the variations of its capacitance and electrical resistance. This chamber is coupled to a Sieverts apparatus, which monitors in parallel the pressure and temperature to build hydrogen absorption / desorption curves.

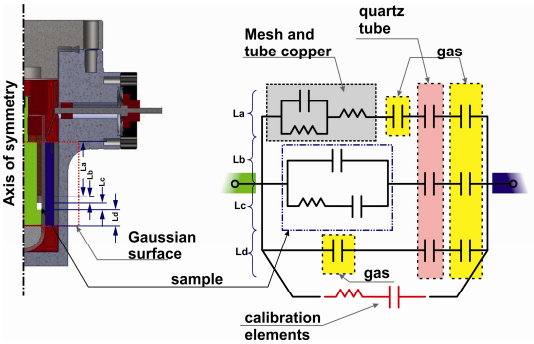

Fig. 1 – A view of the axial symmetry of the dilation chamber with a capacitive geometry, and its equivalent electric circuit. The green and blue components are the conductive elements.

The elements of the chamber were manufactured at the LIP high precision mechanical workshop in Coimbra. It consists first of a central electrode (green in Fig.1), and a filter element for volume control. This assembly is mounted inside a quartz tube where there is a space intended to accommodate the sample to be studied. The quartz tube is then inserted into the chamber where the second electrode is installed (in blue in Fig.1).

The data analysis is performed using algorithms developed from the equivalent circuit and after thorough calibrations of the chamber signals, resulting in the measurement of the volume variations of the hydride bed and its equivalent resistivity.

RESULTS AND DISCUSSION

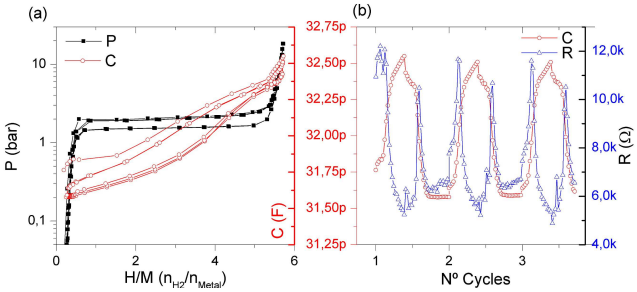

Fig. 2 - Validation of the equipment with the LaNi5-H system: (a) Three room temperature isotherms (black) with their respective signals of electric capacity; (b) Change of electric capacity (red) and resistance (blue) throughout the three cycles.

CONCLUSION

The equipment was successfully implemented and tested, with the observation of a volume change of about 33% for the LaNi5-H system. With this special chamber for measuring volume changes, one can evaluate the expansion of the sample during the hydriding cycles, and this information can quantify the "dead volume" inside a storage tank necessary to support expansion thus reducing mechanical stress on the tank wall.

REFERENCES

1. Charlas, B., et al. *J. Alloys Compd.* 580, 149-152 (2013).
2. Matsushita, M., et al. *Int. J. Hydrogen Energy.* 38, 17, 7056 (2013).

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