# Fabrication of $SnO_2$-based varistor ceramics for industrial applications.

M.A Ramírez[1], J. F. Fernández[2], J. de Frutos[3], M.A. de la Rubia[3], P.R. Bueno[1], E. Longo[1] and J.A. Varela[1]

1. Universidade Estadual Paulista, UNESP, Instituto de Química, Araraquara, Brazil.
2. Instituto de Cerámica y Vidrio, Departamento de Electrocerámica, Madrid, España.
3. Universidad Politécnica de Madrid, Departamento de Física, Madrid, España.

**Abstract** – The viability of the manufacture of varistor ceramics based on $SnO_2$ at laboratory level with suitable geometry to absorb energy from high current pulses were studied in this work. The $SnO_2$-based system is interesting due to minimal volatilization losses of its dopant elements, which provides electrical and microstructural homogeneity.

The use of lightning rods and other protection devices for high-voltage lines has been improved in the last years by the development of metallic oxide varistors [1]. This sectors grows currently with an annual medium rate above of 6,4%, with excellent expectations for the future. Damages of electronic equipment (computers, TV, video, etc) and installations in general due overvoltages have increased during the last years. This due to the use of more and more voltage sensible electronic components. A long period of operation under alternating current (AC) or direct current (DC) and short spikes above nominal voltage can cause the degradation of the varistor properties [2]. This constitutes a great economic problem; recently the European Union has created a work group with the objective to establish and to normalize the procedures to detect imperfections of protection devices in use. To the costs for damages of the devices one has to add the damages of the installations and the costs for the absence of electricity. In 1995 our research group published a study on a $SnO_2$-based system [3] which presented excellent electrical properties (high value of the nonlinear coefficient (41), high electrical breakdown field (3900 V/cm) and low leakage current (below 90 μA), values of great commercial interest.

These materials need low amount of dopant oxides to get good properties, leading to a simple microstructure and resistance to degradation so that it has become interesting for the electronics industry. Consequently, such systems should be studied, basically degradation phenomena. Therefore, in this work we present a study on the influence of varistor geometry on their electrical properties, aiming at manufacturing parts of industrial size with great capacity for energy dissipation. The ceramics were sufficiently homogeneous and their electrical characteristics are indicated in the table below. The first number of the sample description indicates the sintering temperature, the second one the mass of $SnO_2$ used to manufacture the ceramic and the third one (if any), the order of the pellet from the base to the top.

In conclusion, the A/V relation does not affect the electrical and microstructural properties of $SnO_2$-based ceramics the difference of ZnO-based varistors [4], what it facilitates vastly the production process.

| Sample | A/V | $E_{J=1}= E_b$ (V/cm) | $V_b$ (V) | $I_L$ (μA) | α |
|---|---|---|---|---|---|
| 1300(0.5) | 25.7 | 2706.3 | 162.4 | 7.9 | 33.3 |
| 1300(1.0) | 15.4 | 2449.4 | 284.1 | 6.6 | 33.6 |
| 1300(2.0) | 8.9 | 2152.2 | 520.6 | 6.6 | 40 |
| 1300(5.0)2 | 5.2 | 1848.1 | 258.7 | 6.1 | 30.6 |
| 1300(5.0)3 | 5.2 | 1906.8 | 270.8 | 5.9 | 31.4 |
| 1300(5.0)4 | 5.2 | 2007.8 | 273.1 | 4.5 | 31.1 |
| 1300(10.0)2 | 3.9 | 1911.8 | 269.6 | 8.1 | 29.2 |
| 1300(10.0)3 | 3.9 | 1950.3 | 280.8 | 4.7 | 28.6 |
| 1300(10.0)4 | 3.9 | 1950.3 | 279 | 4.0 | 29.3 |
| 1300(10.0)5 | 3.9 | 1998.6 | 291.8 | 3.9 | 28.4 |
| 1300(10.0)6 | 3.9 | 1943.6 | 291.5 | 6.7 | 28.7 |
| 1300(10.0)7 | 3.9 | 2574.2 | 399 | 1.9 | 32 |
| 1300(20.0)1 | 2.8 | 2747.7 | 626.5 | 5.1 | 44.3 |
| 1300(20.0)2 | 2.8 | 2415.8 | 347.9 | 2.3 | 32 |
| 1300(20.0)3 | 2.8 | 2866.8 | 412.8 | 1.6 | 37.5 |
| 1300(20.0)4 | 2.8 | 3023.8 | 635 | 0.8 | 44 |
| 1300(20.0)5 | 2.8 | 2985.4 | 462.7 | 0.9 | 37.8 |
| 1300(20.0)6 | 2.8 | 3961 | 507 | 2.1 | 51.6 |

**Table 1. Electrical properties of $SnO_2$ varistores with different area/volume ratio, sintered at 1300°C for 1 hour.**

## References

[1] M.S Matsuoka, Jap. J. Appl. Phys. 736-746, 10 (1971).

[2] M.A. Ramirez, P.R. Bueno, W.C. Ribeiro, D.A Bonett, J.M. Villa, M.A Márquez, J.A. Varela, C.R. Rojo, J. Mat. Sci.. 5591-5596, 40 [21] (2005).

[3] S.A. Pianaro, P.R. Bueno, E. Longo, J.A. Varela, J. Mat. Sci. Lett. 692-694, 14 (1995).

[4] M.A. de la Rubia, M. Peiteado, J.F. Fernández, A.C. Caballero, J. Europ. Ceram. Soc. 1209-1212, 24 (2004).