



(51) International Patent Classification:

C04B 35/453 (2006.01) **H01C 7/10** (2006.01)
H01C 7/112 (2006.01)

(21) International Application Number:

PCT/MY2010/000051

(22) International Filing Date:

12 April 2010 (12.04.2010)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant (for all designated States except US): **UNIVERSITI SAINS MALAYSIA** [MY/MY]; Pejabat Inovasi, Bangunan 106, 11800 USM Pulau Pinang (MY).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **SHAHROM BIN MAHMUD** [MY/MY]; c/o Universiti Sains Malaysia, Pejabat Inovasi, Bangunan 106, 11800 USM Pulau Pinang (MY).

(74) Agent: **YAP, Kah Hong**; Pyprus SDN BHD, Suite 8.02, 8th Floor, Plaza First Nationwide, 161, Jalan Tun H. S. Lee, 50000 Kuala Lumpur (MY).

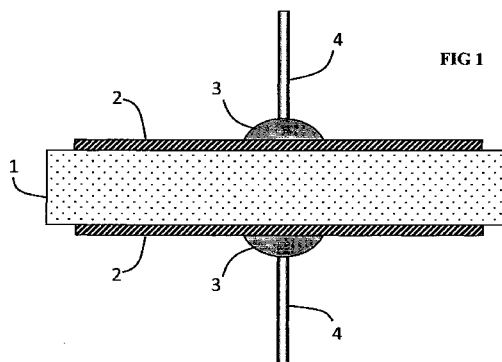
(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: CERAMIC COMPOSITION, LOW VOLTAGE ZINC OXIDE VARISTOR MADE FROM THE CERAMIC COMPOSITION AND PROCESS FOR MANUFACTURING THE LOW VOLTAGE ZINC OXIDE VARISTOR



(57) Abstract: The present invention provides a ceramic composition for manufacturing a low voltage zinc oxide varistors. The present invention further provides a low voltage zinc oxide varistor. The present invention also provides a process for manufacturing the low voltage zinc oxide varistor. Superior energy handling capabilities are demonstrated by the low voltage varistors in that the varistors are capable of handling very high surge peak currents over twice the peak current specified by international standards.



**CERAMIC COMPOSITION, LOW VOLTAGE ZINC OXIDE VARISTOR MADE
FROM THE CERAMIC COMPOSITION AND PROCESS FOR
MANUFACTURING THE LOW VOLTAGE ZINC OXIDE VARISTOR**

5

Field of the Invention

[0001] The present invention generally relates to voltage-dependent varistors, and more particularly to a ceramic composition for low voltage zinc oxide varistor, a low voltage zinc oxide varistor made from the ceramic composition, and further to a process for manufacturing the low voltage zinc oxide varistor.

10

Background of the Invention

[0002] Currently, zinc oxide (ZnO) varistors are the electronic components that are most widely used to protect electronic devices and electrical circuits from hazardous electrical transients and surges. They are normally connected in parallel to the devices that are being protected. Under normal steady state operation, a varistor is dormant; it is a state known as the sleep mode. If an electrical transient/surge is present, the varistor detects it in nanosecond speed and switches into a highly conductive state thereby creating a low impedance path to divert the electrical transient/surge away from the electronic devices but into the varistor. Thus, the varistor absorbs the energy of the electrical transient/surge or diverts the electrical transient/surge to ground if the varistor is grounded.

15

[0003] The switch of a varistor occurs at a threshold voltage that is 15%-20% higher than the maximum continuous operating voltage of the device being protected. Above the threshold voltage, the varistor is highly nonlinear and draws in huge currents with little voltage increase. In this nonlinear region, the current-voltage characteristics is commonly expressed as equation (1):

25

[0004]
$$I = KV^\alpha \quad (1)$$

30

[0005] where K is a constant and α is the nonlinear coefficient. With a large value of α , the varistor offers excellent response to transients by conducting current more quickly. The nonlinear coefficient is defined as equation (2):

[0006]
$$\alpha = \frac{\log(I_2 / I_1)}{\log(V_2 / V_1)} \quad (2)$$

[0007] where I_2 and I_1 are currents at voltages V_2 and V_1 , respectively, with V_2 larger than V_1 .

[0008] In countries where lightning occurrence is high, there is an imperative need
 5 for electrical surge protection against lightning-induced electrical surges because of their very high energy and peak currents. The lightning-induced surges can cause serious damage to many electrical equipments especially low voltage equipments (below 30 Vrms), and these extreme surges are probable causes of building fires.

10

Summary of the Invention

[0009] It is the objective of the present invention to offer a ceramic composition that can produce varistors with high energy handling capable of handling lightning-induced surges without compromising other varistor characteristics. The ceramic compositions are
 15 optimized to produce low voltage zinc oxide varistors with excellent electrical properties for the full range of the ohmic and nonlinear current-voltage spectra.

[0010] One embodiment of the present invention provides a ceramic composition comprises zinc oxide and metal oxide additives of Bi, Co, Ni, Ti, Mn, Si, and B, wherein the ceramic composition comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to
 20 6 mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si, 0.01 to 0.1 mole % of B, and 90 to 99 mole % of ZnO; wherein the ceramic composition is used to manufacture a sintered body for making a low voltage zinc oxide varistor.

[0011] In another embodiment of the ceramic composition, the ceramic composition comprises 0.2 to 3 mole % of Bi_2O_3 , 0.2 to 2 mole % of Co_2O_3 , 0.2 to 2 mole % of NiO, 0.2
 25 to 2 mole % of TiO_2 , 0.2 to 2 mole % of Mn_2O_3 , 0.01 to 1 mole % of SiO_2 , 0.01 to 1 mole % of B_2O_3 , and 95 to 99 mole % ZnO.

[0012] In yet another embodiment of the ceramic composition, the ceramic composition comprises 0.5 to 1 mole % of Bi_2O_3 , 0.3 to 0.7 mole % of Co_2O_3 , 0.3 to 0.7 mole % of NiO, 0.3 to 1 mole % of TiO_2 , 0.3 to 0.7 mole % of Mn_2O_3 , 0.02 to 0.05 mole %
 30 of SiO_2 , 0.05 to 0.08 mole % of B_2O_3 , and 95 to 99% ZnO.

[0013] Another embodiment of the present invention provides a low voltage zinc oxide varistor comprising a sintered body, a pair of electrode layers sandwiching the sintered body in ohmic contact, a pair of solder contacts conductively coupling with the electrode layers, and a pair of wire leads conductively coupled with the electrode layers via the solder contact; wherein the sintered body is made of a ceramic composition, and wherein the ceramic composition comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to 6 mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si, 0.01 to 0.1 mole % of B, and 90 to 99 mole % of ZnO.

[0014] In another embodiment of the low voltage zinc oxide varistor, the sintered body is any suitable form selected from the group consisting of circular disc, square plate or rectangular plate.

[0015] In another embodiment of the low voltage zinc oxide varistor, the ceramic composition comprises 0.2 to 3 mole % of Bi_2O_3 , 0.2 to 2 mole % of Co_2O_3 , 0.2 to 2 mole % of NiO , 0.2 to 2 mole % of TiO_2 , 0.2 to 2 mole % of Mn_2O_3 , 0.01 to 1 mole % of SiO_2 , 0.01 to 1 mole % of B_2O_3 , and 95 to 99 mole % ZnO.

[0016] In another embodiment of the low voltage zinc oxide varistor, the ceramic composition comprises 0.5 to 1 mole % of Bi_2O_3 , 0.3 to 0.7 mole % of Co_2O_3 , 0.3 to 0.7 mole % of NiO , 0.3 to 1 mole % of TiO_2 , 0.3 to 0.7 mole % of Mn_2O_3 , 0.02 to 0.05 mole % of SiO_2 , 0.05 to 0.08 mole % of B_2O_3 , and 95 to 99% ZnO.

[0017] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0018] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0019] FIG 1 is a partial cross-section view of a varistor in accordance with one embodiment of the present invention.

[0020] FIG 2 is a graph showing voltage-current characteristics of exemplary varistors in accordance with embodiments of the present invention.

Detailed Description of the Invention

[0021] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0022] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0023] The present invention provides a low-voltage zinc oxide varistor that has improved capability in handling very high energy overvoltage surges without compromising other varistor characteristics. FIG 1 shows a partial cross-section view of a low voltage zinc oxide varistor in accordance with one embodiment of the present invention. As shown in FIG 1, the varistor comprises a sintered body **1**, a pair of electrode layers **2** sandwiching the sintered body in ohmic contact, a pair of solder contacts **3** conductively coupling with the electrode layers, and a pair of wire leads **4** conductively coupled with the electrode layers via the solder contact. The sintered body **1** can be any suitable form; for example, circular disc, square plate or rectangular plate.

[0024] The sintered body **1** is made from a ceramic composition that is comprised of zinc oxide and various metal oxides. In one embodiment, the ceramic composition comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to 6 mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si, 0.01 to 0.1 mole % of B, and 90 to 99 mole % of ZnO. In another embodiment, the ceramic composition preferably comprises 0.2 to 3 mole % of Bi₂O₃, 0.2 to 2 mole % of Co₂O₃, 0.2 to 2 mole % of NiO, 0.2 to 2 mole % of TiO₂, 0.2 to 2 mole % of Mn₂O₃, 0.01 to 1 mole % of SiO₂, 0.01 to 1 mole % of B₂O₃, and 95 to 99 mole % ZnO. In yet another embodiment, the ceramic composition preferably comprises 0.5 to 1 mole % of Bi₂O₃, 0.3 to 0.7 mole % of Co₂O₃, 0.3 to 0.7 mole % of NiO, 0.3 to 1 mole % of TiO₂, 0.3 to 0.7 mole % of Mn₂O₃, 0.02 to 0.05 mole % of SiO₂, 0.05 to 0.08 mole % of B₂O₃, and 95 to 99% ZnO.

[0025] In one embodiment, the sintered body **1** comprises about 90 to about 99 mole % of ZnO and about 1 to about 10 mole % of metal oxide additives. The composition of the metal oxide additives comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to 6

mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si and 0.01 to 0.1 mole % of B. In another embodiment, the composition of the metal oxide additives comprises 0.2 to 3 mole % of Bi_2O_3 , 0.2 to 2 mole % of Co_2O_3 , 0.2 to 2 mole % of NiO, 0.2 to 2 mole % of TiO_2 , 0.2 to 2 mole % of Mn_2O_3 , 0.01 to 1 mole % of SiO_2 , and 0.01 to 1 mole % of B_2O_3 . In yet another embodiment, the composition of the metal oxide additives preferably comprises 0.5 to 1 mole % of Bi_2O_3 , 0.3 to 0.7 mole % of Co_2O_3 , 0.3 to 0.7 mole % of NiO, 0.3 to 1 mole % of TiO_2 , 0.3 to 0.7 mole % of Mn_2O_3 , 0.02 to 0.05 mole % of SiO_2 , and 0.05 to 0.08 mole % of B_2O_3 .

[0026] In one specific example of the present invention, the ceramic composition for making the sintered body of the low voltage zinc oxide varistor is listed in Table I. Three batches of ZnO (A, B, C) with white seal grade were obtained from three different ZnO manufacturers. The specific surface area of the three ZnO powder types varied from about 4.3 to about 5.7 m^2/g . Three batches of ceramic compositions of which each containing one batch of ZnO (A, B or C) were homogenously mixed with distilled water and organic binder in a ball mill containing zirconia grinding media. A deflocculant was added to obtain correct slurry viscosity. The ratio of solid content to liquid content was about 65:35. After ball milling for about 24 h, the slurry was dried without segregation, sieved to less than 200 μm size and pressed into discs at about 15 kpsi. The green varistor discs were sintered at a temperature in the range of about 1100°C to about 1300°C for a time in the range of about 1 h to about 3 h in air. Electrode layers and wire leads were applied to the sintered body via conventional methods. One exemplary varistor was 13-mm diameter low voltage varistor model for testing hereinbelow.

[0027]

TABLE I

MATERIAL	MOL %
ZnO	97.00
Bi_2O_3	0.800
Co_2O_3	0.500
NiO	0.500
TiO_2	0.600
Mn_2O_3	0.500
SiO_2	0.030
B_2O_3	0.070

[0028] The varistors were tested in accordance with European Standard specifications CECC 42201 that are summarized in Table II whereby the specifications are for 13-mm diameter models. FIG 2 shows typical voltage-current characteristics of the tested varistors made in accordance with the present invention. The destructive surge test were done up to 1000 A peak current under a 8x20μs waveshape and the varistors exhibited extraordinary energy handling capability at 1000 A peak current that are not previously known. These high performance varistors are excellent surge suppressing components for lightning-prone regions with high frequencies of lightning-induced electrical surges.

[0029]

TABLE II

Low Voltage Varistor Models	11 V _{rms}	14 V _{rms}	17 V _{rms}
Voltage at 1mA, V _{1mA} (V)	17 - 19	21 - 23	26 - 28
Clamping Surge Peak Current (A)	5	5	5
Maximum Clamping Voltage (V)	33	43	53
Voltage for Leakage Current Test (V _{dc})	14	18	22
Maximum Leakage Current (μA)	100	100	90
Destructive Test Peak Current (A) (8x20μs waveshape current surge)	500	500	500

[0030] The physical properties of the varistors for the three batches A, B and C are listed in Table III whereby the values are suitable for mass production. The electrical characteristics of the varistors for the three batches A, B and C are listed in Table IV whereby all of the values satisfy the international standard specifications listed in Table I. The varistors' exceptional characteristic of electrical energy handling are shown in Table V whereby the varistors were subjected to current surges with peak currents 1000 A and 2000 A under a 8x20μs waveshape. All varistor samples survived the very destructive tests without any obvious physical damage. Currently specifications for 1000 A and 2000 A current surge tests do not exist for 13-mm diameter low voltage varistor models. The fact that the varistors survived surge current four times that of the international standard is an amazing one indeed.

TABLE III

PROPERTIES	PHYSICAL PROPERTIES OF VARISTOR SAMPLES		
	A	B	C
Sintered Weight (g)	0.4633	0.4611	0.4598
Sintered Thickness (mm)	0.913	0.911	0.907
Green Thickness (mm)	1.0432	1.0462	1.0462
Thickness Shrinkage (%)	12.481	12.923	12.998
Sintered Diameter (mm)	11.130	11.070	11.062
Diameter Shrinkage (%)	15.038	15.496	15.557
Sintered Area (cm ²)	0.9729	0.9625	0.9611
Sintered Volume (cm ³)	0.08883	0.08768	0.08717
Sintered Density (g/cm ³)	5.216	5.259	5.275
% Theoretical Density	91.2	91.9	92.2

[0031]

TABLE IV

5

Electrical Characteristics	A	C	D
Grain Boundary Resistivity, ρ_{gb} (M Ω .cm)	2.759	2.250	2.325
Grain Boundary Barrier, V_{gb} (V)	1.26	1.66	1.76
Leakage Current, I_r (μ A)	15.87	5.48	18.31
Dielectric Constant, κ at 1kHz	14 161	15 564	8 156
Capacitance at 1 kHz (nF)	6.9	7.6	4.0
Onset Switch Voltage, V_{on} (V)	21.07	18.34	25.56
Nonlinear Coefficient, α	17.28	18.19	36.68
Voltage at 1mA, V_{1mA} (V)	21.78	18.44	26.96
Capacitance Critical Voltage, V_{cr} (V)	22	19	27
Capacitance Resonant Frequency, f_r (MHz)	10	10	12.5
Onset Upturn Voltage, V_{upon} (V)	34.41	32.08	35.64
Clamping Ratio	2.11	2.14	1.51
ZnO Grain Resistivity, ρ_{gr} (Ω .cm)	0.589	0.524	0.831
Degradation (%)	0.58	2.68	2.18

[0032]

TABLE V

Sample Label	RMS Rating (at 1mA)	DC rating (at 1mA)	Voltage across Varistor before 1000A surge test, 8/20 μ s (V)	Voltage Across Varistor after 1000A surge test, 8/20 μ s (V)	Voltage across Varistor after 2000A surge test, 8/20 μ s (V)
A11	14	22	21	18	15
A17	17	28	27	24	17
A24	14	22	20	16	13
C20	14	22	20	18	12
C23	11	19	19	15	9
C30	11	19	14	8	6
D17	17	28	26	18	5
D9	14	22	22	14	9
D14	11	19	18	11	7

[0033] While the present invention has been described with reference to particular
embodiments, it will be understood that the embodiments are illustrative and that the
invention scope is not so limited. Alternative embodiments of the present invention will
become apparent to those having ordinary skill in the art to which the present invention
pertains. Such alternate embodiments are considered to be encompassed within the scope
of the present invention. Accordingly, the scope of the present invention is defined by the
appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

- 5 1. A ceramic composition comprises zinc oxide and metal oxide additives of Bi, Co, Ni, Ti, Mn, Si, and B, wherein the ceramic composition comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to 6 mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si, 0.01 to 0.1 mole % of B, and 90 to 99 mole % of ZnO; wherein the ceramic composition is used to manufacture a sintered body for making a low
10 voltage zinc oxide varistor.
2. The ceramic composition of claim 1, wherein the ceramic composition comprises 0.2 to 3 mole % of Bi_2O_3 , 0.2 to 2 mole % of Co_2O_3 , 0.2 to 2 mole % of NiO, 0.2 to 2 mole % of TiO_2 , 0.2 to 2 mole % of Mn_2O_3 , 0.01 to 1 mole % of SiO_2 , 0.01 to 1 mole % of B_2O_3 ,
15 and 95 to 99 mole % ZnO.
3. The ceramic composition of claim 1, wherein the ceramic composition comprises 0.5 to 1 mole % of Bi_2O_3 , 0.3 to 0.7 mole % of Co_2O_3 , 0.3 to 0.7 mole % of NiO, 0.3 to 1 mole % of TiO_2 , 0.3 to 0.7 mole % of Mn_2O_3 , 0.02 to 0.05 mole % of SiO_2 , 0.05 to 0.08
20 mole % of B_2O_3 , and 95 to 99% ZnO.
4. A low voltage zinc oxide varistor comprising a sintered body, a pair of electrode layers sandwiching the sintered body in ohmic contact, a pair of solder contacts conductively coupling with the electrode layers, and a pair of wire leads conductively
25 coupled with the electrode layers via the solder contact; wherein the sintered body is made of a ceramic composition, and wherein the ceramic composition comprises 0.05 to 7 mole % of Bi, 0.05 to 5 mole % of Co, 0.05 to 6 mole % of Ni, 0.05 to 5 mole % of Ti, 0.05 to 5 mole % of Mn, 0.01 to 0.1 mole % of Si, 0.01 to 0.1 mole % of B, and 90 to 99 mole % of ZnO.

5. The low voltage zinc oxide varistor of claim 4, wherein the sintered body is any suitable form selected from the group consisting of circular disc, square plate or rectangular plate.

5 6. The low voltage zinc oxide varistor of claim 4, wherein the ceramic composition comprises 0.2 to 3 mole % of Bi_2O_3 , 0.2 to 2 mole % of Co_2O_3 , 0.2 to 2 mole % of NiO , 0.2 to 2 mole % of TiO_2 , 0.2 to 2 mole % of Mn_2O_3 , 0.01 to 1 mole % of SiO_2 , 0.01 to 1 mole % of B_2O_3 , and 95 to 99 mole % ZnO .

10 7. The low voltage zinc oxide varistor of claim 4, wherein the ceramic composition comprises 0.5 to 1 mole % of Bi_2O_3 , 0.3 to 0.7 mole % of Co_2O_3 , 0.3 to 0.7 mole % of NiO , 0.3 to 1 mole % of TiO_2 , 0.3 to 0.7 mole % of Mn_2O_3 , 0.02 to 0.05 mole % of SiO_2 , 0.05 to 0.08 mole % of B_2O_3 , and 95 to 99% ZnO .

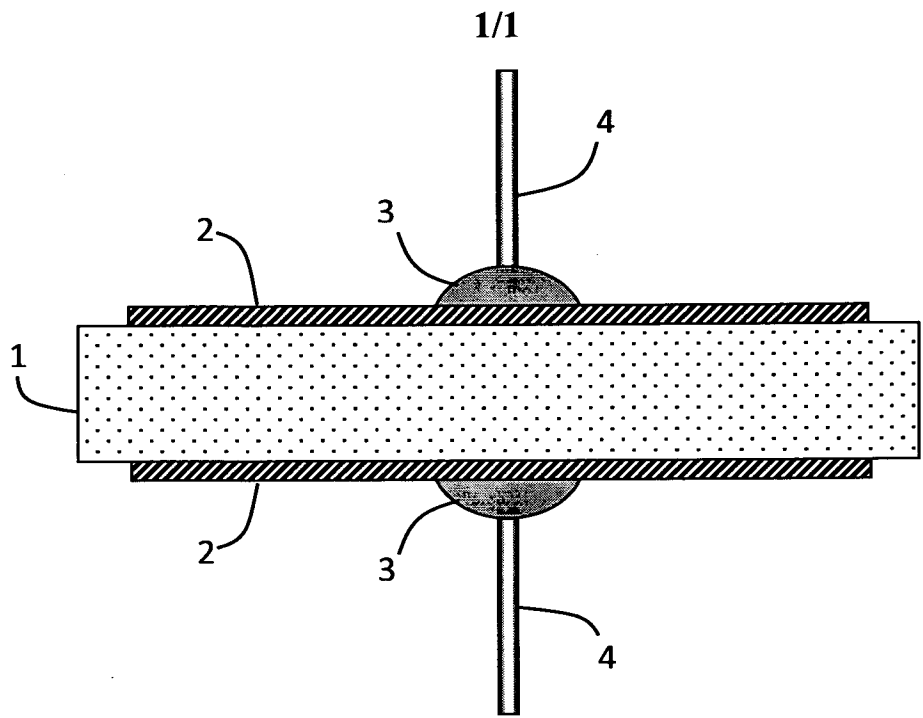


FIG 1

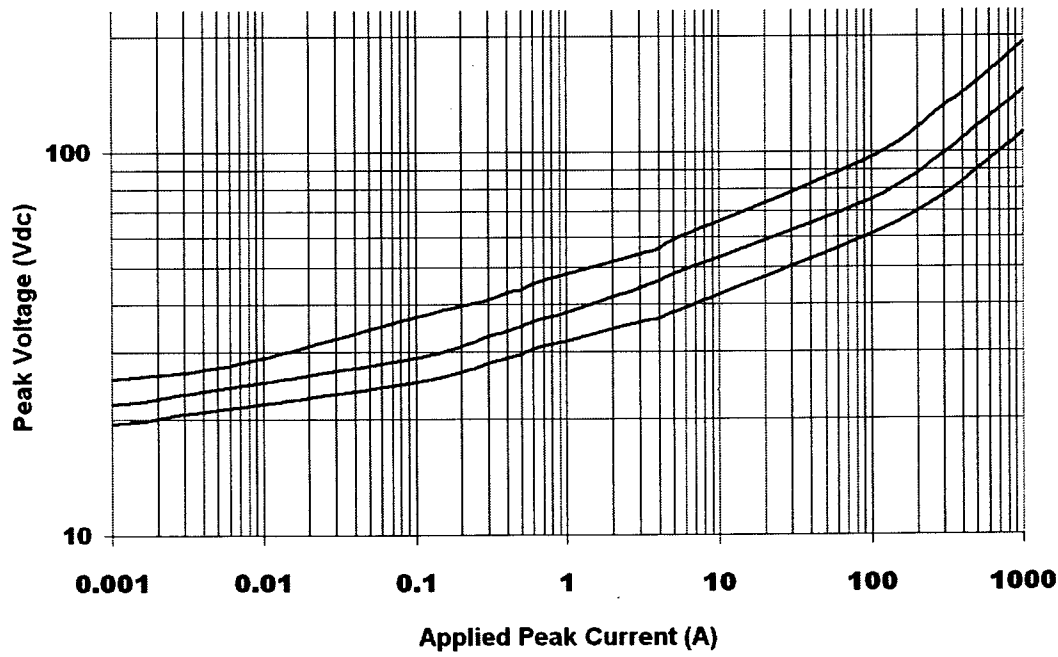


FIG 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/MY2010/000051

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C04B 35/453 (2006.01) H01C 7/112 (2006.01) H01C 7/10 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
epoque, wpi: varistor?, variable resistor?, ZnO, zinc w oxide, cobalt, titanium, manganese, nickel, bismuth etc

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2242065 A (ECCO LIMITED) 18 September 1991 See page 2, 5, Table 2	1-7
X	US 3962144 A (MATSUURA et al.) 8 June 1976 See col 3 line 10-20, col 4 line 8-22, Table 5	1-7
X	GB 1244745 A (MATSUSHITA ELECTRIC INDUSTRIAL COMPANY LIMITED) 2 September 1971 See col 1 line 14-45, col 3 line 3-19, Table 2, 11, example 9	1-7

☒ Further documents are listed in the continuation of Box C☒ See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
30 June 2010

Date of mailing of the international search report

- 6 JUL 2010

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustalia.gov.au
Facsimile No. +61 2 6283 7999

Authorized officer

KATHY WONG
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No : +61 2 6283 2737

INTERNATIONAL SEARCH REPORT

International application No.

PCT/MY2010/000051

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5973589 A (WU et al.) 26 October 1999 See whole document	
A	US 6146552 A (IGA et al.) 14 November 2000 See whole document	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2010/000051

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
GB	2242065	DE	4108674	FR	2659785	IE	910870
		JP	5251211	US	5973588	US	6334964
		US	2002024040	US	6743381		
US	3962144	CA	1019463	DE	2450108	FR	2248592
		GB	1487388	JP	50067484	NL	7413720
GB	1244745	NONE					
US	5973589	NONE					
US	6146552	AU	52033/96	CA	2175539	CN	1139652
		CN	1393426	EP	0731065	EP	0741347
		JP	9001442	JP	8241803	JP	9025161
		SG	35510	SG	35511	US	5575099
		US	5770113				
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							