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Datasheet for the decision of 26 July 2024

Case Number: T 3178/19 - 3.4.03

Application Number: 09177853.0

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IPC: H01C7/112, C04B35/453, C04B35/626

Language of the proceedings: EN

Title of invention:
Current-voltage non-linear resistor and method of manufacture thereof

Patent Proprietor:
Kabushiki Kaisha Toshiba

Opponent:
Hitachi Energy AG

Relevant legal provisions:
EPC Art. 83, 84, 101(3)(b), 111(1)

Keyword:
Sufficiency of disclosure - (no)

Decisions cited:
G 0003/14, T 0226/85, T 0175/97, T 0871/08, T 0234/09

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Boards of Appeal

Chambres de recours

Boards of Appeal of the
European Patent Office
Richard-Reitzner-Allee 8
85540 Haar
GERMANY
Tel. +49 (0)89 2399-0
Fax +49 (0)89 2399-4465

Case Number: T 3178/19 - 3.4.03

D E C I S I O N
of Technical Board of Appeal 3.4.03
of 26 July 2024

Appellant: (Opponent)	Hitachi Energy AG Brown-Boveri-Strasse 5 8050 Zürich (CH)
Representative:	Schaad, Balass, Menzl & Partner AG Bellerivestrasse 20 Postfach 8034 Zürich (CH)
Respondent: (Patent Proprietor)	Kabushiki Kaisha Toshiba 1-1, Shibaura 1-chome, Minato-ku Tokyo (JP)
Representative:	Hoffmann Eitle Patent- und Rechtsanwälte PartmbB Arabellastraße 30 81925 München (DE)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 23 September 2019 concerning maintenance of the European Patent No. 2194541 in amended form.**

Composition of the Board:

Chairman	T. Häusser
Members:	M. Ley
	G. Decker

Summary of Facts and Submissions

I. The opponent's appeal is against the interlocutory decision of the opposition division to maintain European patent EP 2 194 541 in amended form (Article 101(3)(a) EPC) on the basis of the then seventh auxiliary request.

II. At the oral proceedings before the board the appellant (opponent) requested that the decision under appeal be set aside and the patent be revoked.

The respondent (patent proprietor) requested as a main request that the appeal be dismissed, i.e. that the patent be maintained in amended form as held allowable by the opposition division, or, alternatively, that the decision under appeal be set aside and the patent be maintained in amended form on the basis of the claims of the first auxiliary request filed with the reply to the statement setting out the grounds of appeal, of the third auxiliary request filed with the letter dated 10 February 2022, or of the second auxiliary request filed with the letter dated 23 July 2021, in this order of preference.

III. Reference is made to the following documents:

D12 "Concise Encyclopedia of Chemical Technology", Kirk-Othmer, Fourth Edition, 1999, John Wiley & Sons, pages 1836 to 1838.

E4 S.C. Pillai et al., *High Performance ZnO Varistors Prepared From Nanocrystalline Precursors for Miniaturised Electronic Devices*, J. Mater. Chem., 2008, 18, pages 3926 to 3932

IV. Claim 1 of the **main request**, i.e. the request as maintained by the opposition division, has the following wording (board's feature labelling):

(a) *A current-voltage non-linear resistor comprising:*
(b) *a sintered body of a mixture whose chief constituent is zinc oxide and* ***(c)*** *including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni;*
(j) *wherein the mixture contains as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, NiO, and containing at least 95 mol% of the zinc oxide main constituent,*
(d) *an average grain size of said mixture is from 0.05 µm to 0.4 µm before the heating step of sintering, as measured by laser diffraction/dispersion; and*
(e) *an average grain size of zinc oxide grains in said sintered body is no more than 7.5 µm, as measured with a scanning Electron Microscope,*
characterized in that
(f) *a standard deviation based on a grain size distribution of zinc oxide grains in said sintered body is no more than 15% of said average grain size of said zinc oxide grains, and*
(g) *an average grain size of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 1 µm and* ***(h)*** *a standard deviation based on a grain size distribution of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 40% of said average grain size of said spinel grains.*

Claim 1 according to the **first auxiliary request** has the following wording:

A method of manufacturing a current-voltage non-linear resistor comprising:

a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni;

an average grain size of said mixture is from 0.05 μm to 0.4 μm before the heating step of sintering, as measured by laser diffraction/dispersion; and

an average grain size of zinc oxide grains in said sintered body is no more than 7.5 μm, as measured with a scanning Electron Microscope, and a standard deviation based on a grain size distribution of zinc oxide grains in said sintered body is no more than 15% of said average grain size of said zinc oxide grains;

an average grain size of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 1 μm and a standard deviation based on a grain size distribution of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 40% of said average grain size of said spinel grains

the current-voltage non-linear resistor having a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni,

characterized in that

said method comprises:

a powder pulverization step of introducing a mixture containing at least 95 mol% of said zinc oxide main constituent and containing as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, and NiO, and an organic solvent, such that the content of said mixture is 30 to 60 weight%, into a wet pulverizing apparatus; and

mixing said mixture while pulverizing so that the average grain size of said mixture is no more than 0.4 μm, as measured by laser diffraction/dispersion, so as to manufacture a slurry;

a pelletizing powder forming step of forming a pelletized powder of grain size 70 to 130 μm by spraying said slurry;

a molding step of forming a molding having a prescribed shape by applying a prescribed pressure load to said pelletized powder;

a first heating step of removing said organic solvent by heating said molding to a first temperature of 350 to 500°C and holding said first temperature for a prescribed time to remove said organic solvent;

a second heating step of sintering by heating said molding from which said organic solvent has been removed to a second temperature of 900 to 1300°C and holding said second temperature for a prescribed time; and

a cooling step of cooling said sintered molding.

Claim 1 according to the **third auxiliary request** has the following wording:

A method of manufacturing a current-voltage non-linear resistor comprising:

a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni;

an average grain size of said mixture is from 0.05 μm to 0.4 μm before the heating step of sintering, as measured by laser diffraction/dispersion; and

an average grain size of zinc oxide grains in said sintered body is no more than 7.5 μm, as measured with a scanning Electron Microscope, and a standard deviation based on a grain size distribution of zinc

oxide grains in said sintered body is no more than 15% of said average grain size of said zinc oxide grains;

an average grain size of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 1 μm and a standard deviation based on a grain size distribution of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 40% of said average grain size of said spinel grains

the current-voltage non-linear resistor having a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni,

wherein the mixture contains as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, and NiO, containing at least 95 mol% of the zinc oxide main constituent,

characterized in that

said method comprises:

a powder pulverization step of introducing a mixture containing at least 95 mol% of said zinc oxide main constituent and containing as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, and NiO, and an organic solvent, such that the content of said mixture is 30 to 60 weight%, into a wet pulverizing apparatus; and mixing said mixture while pulverizing so that the average grain size of said mixture is from 0.05 μm to 0.4 μm, as measured by laser diffraction/dispersion, so as to manufacture a slurry;

a pelletizing powder forming step of forming a pelletized powder of grain size 70 to 130 μm by

spraying said slurry;

a molding step of forming a molding having a prescribed shape by applying a prescribed pressure load to said pelletized powder;

a first heating step of removing said organic solvent by heating said molding to a first temperature of 350 to 500°C and holding said first temperature for a prescribed time to remove said organic solvent;

a second heating step of sintering by heating said molding from which said organic solvent has been removed to a second temperature of 900 to 1300°C and holding said second temperature for a prescribed time; and

a cooling step of cooling said sintered molding.

Claim 1 according to the **second auxiliary request** has the following wording:

A method of manufacturing a current-voltage non-linear resistor comprising:

a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni;

an average grain size of said mixture is from 0.05 μm to 0.4 μm before the heating step of sintering, as measured by laser diffraction/dispersion; and

an average grain size of zinc oxide grains in said sintered body is no more than 7.5 μm, as measured with a scanning Electron Microscope, and a standard deviation based on a grain size distribution of zinc oxide grains in said sintered body is no more than 15% of said average grain size of said zinc oxide grains;

an average grain size of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 1 μm and a standard deviation based on a grain size distribution of spinel grains whose chief

constituent is $Zn_7Sb_2O_{12}$ in said sintered body is no more than 40% of said average grain size of said spinel grains

the current-voltage non-linear resistor having a sintered body of a mixture whose chief constituent is zinc oxide and including as auxiliary constituents at least Bi, Sb, Mn, Co, and Ni,

wherein the mixture contains as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, and NiO, containing at least 95 mol% of the zinc oxide main constituent,

characterized in that

said method comprises:

a powder pulverization step of introducing a mixture containing at least 95 mol% of said zinc oxide main constituent and containing as auxiliary constituents 0.3 to 1 mol% of Bi_2O_3, 0.5 to 2.5 mol% of Sb_2O_3, 0.3 to 1.5 mol% of Co_2O_3, 0.2 to 2 mol% of MnO, and 0.5 to 3 mol% of NiO, respectively calculated as Bi_2O_3, Sb_2O_3, Co_2O_3, MnO, and NiO, and an organic solvent, such that the content of said mixture is 30 to 60 weight%, into a wet pulverizing apparatus; and mixing said mixture while pulverizing so that the average grain size of said mixture is from 0.5 μm to 0.4 μm [sic], as measured by laser diffraction/ dispersion, so as to manufacture a slurry;

a pelletizing powder forming step of forming a pelletized powder of grain size 70 to 130 μm by spraying said slurry;

a molding step of forming a molding having a prescribed shape by applying a prescribed pressure load to said pelletized powder;

a first heating step of removing said organic solvent by heating said molding to a first temperature

of 350 to 500°C and holding said first temperature for a prescribed time to remove said organic solvent;

a second heating step of sintering by heating said molding from which said organic solvent has been removed to a second temperature of 900 to 1300°C and holding said second temperature for a prescribed time; and

a cooling step of cooling said sintered molding.

V. The parties' arguments can be summarised as follows:

(a) The respondent argued that the skilled person found in the description enough information to carry out the invention. In support of feature (d), the respondent submitted document D12 as a reply to the board's communication under Article 15(1) RPBA.

(b) The appellant argued that the European patent did not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art. Late-filed document D12 should not be admitted into the appeal proceedings.

Reasons for the Decision

1. The invention

The claimed invention relates to a current-voltage non-linear resistor and its method of manufacturing, whose chief constituent is zinc oxide (ZnO). It may be employed in an over-voltage protection apparatus such as a surge arrester or surge absorber, see paragraph [0001] of the opposed patent.

Over-voltage protection apparatus such as surge arresters or surge absorbers are commonly employed in

order to protect power systems or the circuitry of electronic equipment from abnormal voltages. They possess a non-linear resistance body exhibiting insulating properties under normal voltages and a low resistance when subjected to abnormal voltages. Such current-voltage non-linear resistors are ceramic bodies whose main constituent is zinc oxide (ZnO); at least one or more metal oxides are added thereto as additives in order to obtain the desired voltage non-linear resistance characteristics, see paragraph [0006] of the opposed patent.

Current-voltage non-linear resistors whose main constituent is ZnO with Bi_2O_3, CO_2O_3, MnO, Sb_2O_3 and NiO as auxiliary constituents are known in the art, see paragraphs [0008] and [0009] of the opposed patent.

In order to achieve a sufficient miniaturization of surge arresters, current-voltage non-linear resistors are being sought to have a reduced diameter. However, when a current-voltage non-linear resistor is increased in resistance or reduced in diameter, the energy generated per unit volume when performing surge energy absorption becomes larger, see paragraph [0012] of the opposed patent.

The present invention attempts to provide a current-voltage non-linear resistor with higher resistance and with excellent non-linear resistance characteristics, energy absorption capability and thermal stability. In particular, according to paragraphs [0040], [0067] and [0072] of the opposed patent, the varistor voltage (V_{1mA}), which is the voltage when a current of 1 mA of a commercial frequency (line frequency in the U.S.A. or mains frequency in the U.K.) is passed, may be 400 V/mm or more. According to paragraph [0072] of the opposed

patent, the coefficient of non-linearity V_{10kA}/V_{1mA} may be smaller than 1.5, the resistive leakage current I_R may be smaller than 15mA, and the energy absorption capability may be more than 500 J/cc. The voltage V_{10kA} is measured when an impulse current of 10 kA is passed for 8 x 20 µs (paragraph [0068] of the opposed patent). The resistive leakage current I_R is measured by applying AC voltage of 90% of the varistor voltage V_{1mA} under atmospheric pressure at 200°C, see paragraph [0069] of the opposed patent. The energy absorption capability is measured according to paragraph [0070] of the opposed patent.

2. Admittance of document D12

The appellant argued that document D12 should have been filed during the opposition proceedings, because the issue of obtaining the claimed average grain size of the mixture was already a point of discussion prior to the appeal proceedings.

The board accepts the respondent's argument that document D12 was submitted in reaction to point 6.4.4 of the board's communication pursuant to Article 15(1) RPBA to show that the reference to "wet pulverizing" in the description of the opposed patent suffices "to establish enablement" for the claimed grain size according to feature (d). D12 merely illustrates common general knowledge.

Document D12 is thus admitted into the appeal proceedings under Article 13(2) RPBA.

3. Sufficiency of disclosure - Article 83 EPC

3.1 The appellant argued that the opposed patent did not disclose the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

3.1.1 To correctly determine which examples of the opposed patent, e.g. of Table 3, had a chemical composition conforming to claim 1, the values in Table 3 had to be rounded to the same degree of precision which the respondent chose to recite in the claims. Reference was made to T 234/09, T 871/08, T 175/97 and the Guidelines [2019], G-VI, 8.1. For example, the claimed Co_2O_3 content of 0.3 mol% covered a range from 0.25 mol% to 0.34 mol%.

3.1.2 The appellant objected that some examples (i.e. examples 37, 40, 43, 49, 52, 55, 56, 62, 65, 66, 68, 81, 83 and 84) in Table 3 of the opposed patent were marked with an asterisk as comparative examples (see paragraph [0088] of the patent specification) but had the composition according to features (b), (c) and (j) without however achieving the objective of the invention, namely a varistor voltage of at least 400 V/mm, a coefficient of non-linearity smaller than 1.5 and a resistive leakage current smaller than 15 mA and an energy absorption capability of more than 500 J/cc.

Table 2 also contained examples (namely examples 25, 27, 31 to 33) fulfilling said objective of the invention and having the claimed average grain size, while being marked with an asterisk.

Moreover, the appellant argued that said objective of the invention was not achieved by all examples in Table 3 having an Sb_2O_3 content of more than 2.5 mol%

and all examples having an NiO content of less than 0.5 mol%. Hence, Table 3 did not provide examples achieving said objective over the whole scope of feature (j). The opposed patent did not contain any information about the grain size distribution of most of the examples of Table 3, either.

The appellant further argued that in Table 5 of the opposed patent only examples 5, 6, 8, 16, 24 and 54 showed features (g) and (h) (related to the spinel grain size), all having an NiO content of 0.5 mol%. It could not be assumed that the examples without an asterisk in Table 3 had features (g) and (h). There were serious doubts whether the skilled person could carry out the invention over the whole range of NiO of 0.5 to 3 mol%.

Examples from Table 5 with the contents appropriately rounded to the same precision as the claimed value had the claimed composition without having features (g) and (h) and achieving said object of the invention. Reference was made to examples 37, 43, 49, 52 and 56. However, they were all produced by the process of paragraphs [0089] to [0096] of the opposed patent. Example 55 was produced using a mixture according to feature (j) and said process, while not achieving feature (f), see Table 4.

Moreover, examples 5, 6, 8, 16 and 24 achieved the effects of the invention and included Al^{3+} (page 18, lines 6 and 7 of the original description), which was not claimed and which was known to improve the characteristics of varistors.

Based on the above, the data shown in the examples raised serious doubts about whether the invention could

be carried out over the whole claimed range. The opposed patent did not disclose a way of obtaining features (d) to (h), when starting of a composition according to (j). One sole example 8 was not enough, see T 226/85.

A person skilled in the art would have to carry out a research program based on trial and error to reproduce the results of the invention and manufacture a resistor having the desired characteristics mentioned above, i.e. features (e) to (h) of claim 1.

3.1.3 With respect to feature (d), the appellant argued that document D12 merely stated that submicrometer-particles could be produced by wet grinding. Neither D12 nor the opposed patent showed how to obtain an average grain size from 0.05 µm to 0.4 µm. Paragraph [0044] of the patent described that zirconia beads of diameter of 0.05 to 0.3 mm were used. In the case of examples 1 to 24 of Table 1, the beads had a diameter of 0.3 mm and the examples were produced according to paragraph [0059]. D12 mentioned beads in the range of 0.5 to 10 mm, which was in a range different from the one mentioned in the opposed patent.

3.1.4 The appellant also argued that the size determination by the methods mentioned in claim 1 (i.e. laser diffraction and scanning electron microscopy) and calculation of the standard deviation yielded different outcomes depending on the image analysis method.

The outcome for the average grain size of the mixture, as measured by laser diffraction, might differ depending on the specific diffraction model chosen (e.g. Fraunhofer or Mie scattering models). The outcome for the average grain size of zinc oxide grains, as

measured by SEM, might differ on how the SEM image was analysed. For example, the outcome might depend on how a microsection under the microscope was executed. Specifically, one might draw lines in defined distances through the SEM image and count the number of grain boundaries crossing in a certain length of the lines to obtain "the average" grain size. Alternatively, one might measure the largest dimension of the grains according to the Feret technique or, again alternatively, one might apply an equivalent diameter technique by determining the grain area and calculating the equivalent diameter of a circle of the same area. Paragraphs [0103] and [0109] of the opposed patent failed to disclose how the SEM images were to be analysed. Moreover, said paragraphs mentioned samples 87 to 102 and 103 to 118, none of them being listed in Tables 1 to 5 of the opposed patent.

Moreover, the outcome for the standard deviation based on a grain size distribution might differ depending on what kind of distribution was assumed. For example, assuming a Gaussian distribution might yield a different outcome compared to assuming a log-normal distribution.

Furthermore, the appellant argued that variations in the statistical analysis of measurement data for obtaining the features as claimed yielded different outcomes. In particular, the size of the set of values of grain sizes had an impact on the determined average grain sizes and the standard deviations. The same applied to the spinel grains. As the conditions of the statistical analysis were, however, not disclosed in the patent, the skilled person was not enabled to carry out the invention.

Finally, the appellant argued that the disclosure of the patent was insufficient as the patent failed to show how the statistics of the samples disclosed in the patent were taken into account when carrying out the purported invention. For the appellant, "Graph 1" on page 9 of its letter of 26 March 2021 showed that "varistors disclosed in the prior art with exemplary values of parameters such as the average ZnO grain size deviating from the range as claimed may in fact follow a distribution overlapping with the distribution of samples according to the purported invention, and therefore effectively anticipate the claimed subject matter" (point 45 on page 10 of the letter).

The appellant also provided statistical analyses based on Figure 5c of document E4 and two techniques of measuring the spinel grain sizes (Feret technique, equivalent diameter technique). Variations in grain size and standard deviation were found.

3.1.5 Testing compliance with the claimed features required destructive testing to study the ZnO and spinel grains. The tests described in paragraph [0072] of the opposed patent did not allow the skilled person to know whether there was compliance with features (g) and (h).

The appellant added that the skilled person had no guidance on what was meant by "chief constituent" in feature (g). The spinel group included a large class of minerals with differing chemical compositions, see e.g. page 11, line 10 to page 12, line 16 of the application as originally filed. No guidance was given in the description on how one skilled in the art could distinguish spinel grains whose chief constituent was $Zn_7Sb_2O_{12}$ from spinel grains whose chief constituent was other than $Zn_7Sb_2O_{12}$. A skilled person would have

to carry out a research program to determine whether "spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$" could be produced over the entire claimed range, and would also have to carry out a research program to determine how to test for such grains. The disclosure did not enable one skilled in the art to carry out the invention over the entire claimed range according to feature (g).

3.1.6 Furthermore, the appellant added that the examples did not support the entire claimed ranges of features (e) and (f). The description contained no disclosure of how to obtain values lower than 5.4 µm for feature (e) or values of feature (f) lower than 7.5%.

3.2 The respondent argued that the patent provided detailed information on the effects of the different features, how to produce the claimed resistor, and how variations would affect the properties of the resistor (see, for example, paragraphs [0021] to [0028], [0030] to [0035] and [0041] to [0050] and the Examples). The patent exemplified the fabrication method of the sintered body in paragraphs [0058] to [0064], thereby providing the person skilled in the art with step by step information for performing the invention. A two-steps heating was used, see e.g. paragraphs [0062] to [0064] or [0081], [0082]. At most the skilled person would have to make adjustments to the amount of the different components being employed and/or carry out routine measurements of the properties of the obtained resistors, both of which represent routine procedures, the need for which could be expected when attempting to reproduce the invention.

For the respondent, the appellant's arguments concerned the question of whether any particular effect was achieved and thus related to the question of

inventiveness rather than the question of sufficiency of disclosure.

The rounding convention outlined in the passage of the Guidelines [2019] G-VI, 8.1 was developed to compare measurements disclosed in different documents and expressed with a different degree of precision for the purpose of assessing novelty, and not to compare measurements of the same document. At page 7 of the statement of grounds of appeal the appellant argued that the skilled person was unable to carry out the claimed invention because the rounding of experimentally determined values would cause doubt as to whether a product satisfied the specifications of the claims or not. This issue could at most be considered a matter of clarity, which was present in the originally granted claims and hence not open for discussion during opposition proceedings (see G 3/14).

With respect to the argument that various known analysis schemes of the measurement results to be applied for verifying the respective claimed features yielded different outcomes, this was also related to clarity and did not constitute a ground for opposition (G 3/14). The appellant had not provided any proof that there was a causal relation between the alleged different outcomes by different analysis schemes and the alleged chances of success of obtaining the claimed grain size and/or standard deviation. In any case, the facts and evidences (e.g. the evidence concerning Figure 5c of E4) relating to the statistical analysis related to an allegation that was raised for the first time after filing the statement of grounds of appeal and which could have been readily raised earlier in the proceedings.

There was no conclusive data presented for the non-inventive examples of Table 3 of the opposed patent. They were outside the scope of claim 1. For example, contrary to feature (f) sample 55 had a standard deviation of 18% of the grain size distribution of the zinc oxide grains (see Table 4). Other examples (e.g. 37, 43, 49 and 52 of Table 5) did not comply with feature (g) (average grain size of the spinel grains). Example 56 lacked feature (h) (standard deviation of the grain size distribution of spinel grains), 42.7%, i.e. higher than the claimed upper limit 40%. The skilled person would understand why the comparative examples (with asterisk) were outside the scope of claim 1. For example, example 1 had an average grain size of the zinc oxide grains (8.4 µm) due to the average grain size of the used mixture being larger than 0.4 µm, see Tables 1 and 4 of the opposed patent. The same observation could be made for examples 2 and 10, see Table 4. Examples 55 and 57 did not have the claimed standard deviation according to feature (f) due to the excess of Sb_2O_3 (example 57, 3 mol%) or the lack of ZnO (example 55, 94.75 mol%), see Tables 3 and 4.

With respect to features (g) and (h) the respondent referred to paragraph [0028] of the opposed patent, which disclosed that spinel grains were generated during sintering. The appellant's arguments relating to the average grain size of the spinel grains related to an allegation that was raised for the first time in the statement of grounds of appeal and which could have been readily raised earlier in the proceedings.

Regarding feature (d), D12, page 1838, left column illustrated that wet grinding achieved a high percentage of submicrometer particles.

According to the data of Tables 1 to 5, example 8 was in accordance with all limitations of claim 1. There was at least one way of putting the invention into practice. Example 8 provided sufficient support for the invention, see e.g. T 226/85 and "Case law of the Boards of Appeal of the EPO", 10th edition 2022 ("Case Law"), section II.C.6.7. Other examples (i.e. examples 5, 54, 6, 24, and 16 in Table 5 and examples 78, 73, 21, 30, 50 and 7 in Table 4) provided flanking information about how other features influenced the parameters of interest, even if the data was not complete.

3.3 The board is not convinced that the opposed patent discloses the invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art.

3.3.1 The board notes that the values according to the "objective of the invention" indicated by the appellant, i.e. a varistor voltage of at least 400 V/mm, a coefficient of non-linearity smaller than 1.5, a resistive leakage current smaller than 15 mA and an energy absorption capability of more than 500 J/cc (see paragraph [0072] of the patent), are not part of the claimed subject-matter. Hence, whether these values are obtained is a matter of inventive step and not a matter of sufficient disclosure, see Case Law, section II.C.6.1, second paragraph. Insofar the board shares the respondent's view.

3.3.2 The board shares the appellant's view that, in order to compare examples from the description of the opposed patent or from the prior art and the claimed subject-matter, the experimental values are to be rounded to the same degree of precision as recited in the claims.

The skilled person knows that numerical values relating to measurements are subject to measurement errors. The general convention is that the last decimal place of a numerical value indicates its degree of accuracy. When interpreting ranges of values in patent specifications, the skilled person proceeds on the same basis, for example, to compare the claimed subject-matter to the prior art. There is no reason to interpret the ranges in claims 1 and 4 in a different way when dealing with the requirement of sufficiency of disclosure. In the present case, for example, the skilled person understands that a claimed content of at least 95 mol% of ZnO encompasses a content of 94.5 mol% and more or that a claimed Co_2O_3 content of 0.3 mol% and more includes a content of 0.25 mol% and more.

Hence, some so-called comparative examples (with asterisks) from the description of the opposed patent (e.g. in Tables 2 and 3) appear to have the claimed composition. However, this does not necessarily mean that there is an issue with Article 83 EPC. Any possible inconsistencies between the claimed subject-matter and the content of the description might be related to the requirements of Article 84 EPC, in particular, to the requirement that the claims have to be supported by the description. As these possible inconsistencies already existed between the description and the granted claims, this issue is not to be examined in view of the decision of the Enlarged Board of Appeal G 3/14.

3.3.3 The opposed patent also provides measuring methods explicitly recited in features (d) and (e) of claim 1. In the board's opinion the skilled person is aware of how these methods have to be used to determine an average grain size of the mixture, an average grain

size of ZnO grains in the sintered body and an average grain size of spinel grains whose main constituent (or "chief constituent") is $Zn_7Sb_2O_{12}$ (see paragraph [0109] of the opposed patent's specification).

The skilled person is also aware of the fact that a sufficiently high number of measurements has to be done in order to obtain reliable values of the respective standard deviations. Insofar, the argument that the measurement methods and the subsequent analyses of the results might yield different outcomes might be relevant when comparing the claimed subject-matter to the prior art (i.e. for the requirements of Articles 52(1) and 54 EPC), but not necessarily for the issue of sufficiency of the disclosure. For example, the skilled person wishing to carry out the invention might select one way of measuring the grain size (e.g. the equivalent diameter technique) and would have no problems to then determine the average grain sizes and the respective standard deviations. In order to calculate standard deviations from a series of experimental measures, it is not necessary to select a particular model (e.g. a Gaussian distribution), contrary to the appellant's view. The standard deviation is calculated directly from the experimental results of the grain sizes.

3.3.4 The skilled person is further aware of spinel grains whose chief constituent is $Zn_7Sb_2O_{12}$. These are grains composed of $Zn_7Sb_2O_{12}$ having a spinel crystalline structure. They can be identified by scanning electron microscopy, as described in paragraphs [0024] and [0109] of the opposed patent and as also confirmed by the appellant's measurements in relation to Figure 5c of document E4.

3.3.5 However, in the board's judgement, the skilled person does not find sufficient information in the specification of the opposed patent to provide a current-voltage non-linear resistor with a sintered body of a mixture according to features (a) to (c), (j), (d), see Tables 1 to 3. According to paragraphs [0056] to [0065] of the patent specification and Table 1, it is possible to obtain different average grain sizes (see Table 1). As stated before, whether this resistor has the unclaimed characteristics mentioned above (see point 3.3.1 above) might be a matter of inventive step.

The opposed patent, however, does not disclose which steps have to be performed in order to obtain the average grain size in accordance with feature (d). Paragraph [0044] of the opposed patent merely provides details about the wet pulverizing apparatus, without disclosing how to obtain e.g. the average grain size values of Table 1. Paragraph [0059] discloses that the same conditions were used for examples 1 to 24 and only states that "[p]ulverization was conducted in the wet pulverizing apparatus so that the average grain size of the mixture had the values of sample No. 1 to sample No. 24 shown in Table 1". The board is not convinced that document D12 can provide any missing information as it merely shows that average grain sizes smaller than a micrometer ("submicrometer particles") were achievable in 1999. Insofar, the board shares the appellant's view that the opposed patent does not disclose how to obtain the values of the range according to feature (d).

3.3.6 Table 4 discloses some examples, wherein the sintered body has an average grain size of zinc oxide grains of no more than 7.5 µm (feature (e)) and a standard

deviation based on a grain size distribution of zinc oxide grains in said sintered body according to feature (f), namely examples 78, 73, 21, 30, 50, 7 and 8. The composition of the mixture for examples 50, 73 and 78 is provided in Table 3, the composition for examples 30, 7, 8 and 21 is provided in paragraphs [0058] and [0077].

The board notes that in all these examples 0.5 mol% of MnO and NiO were used. In most of these examples 0.5 mol% of Bi_2O_3, 2 mol% of Sb_2O_3 and 1 mol% of Co_2O_3 were used. Hence, the opposed patent does not contain sufficient information to produce features (e) and (f) over the whole scope of feature (j).

Moreover, the opposed patent does not disclose which steps have to be performed for a given mixture in order to obtain the average grain size and standard deviation of the zinc oxide grains in accordance with features (e) and (f). For example, examples 1 to 24 are all made starting with the same mixture (see paragraph [0058]) and the same process (see paragraphs [0059] to [0064]) including a same two-steps sintering process. However, example 8 has the average grain size and standard deviation of zinc oxide grains according to features (e) and (f), while, for instance, comparative examples 1, 2 and 4 do not (see Table 4).

Furthermore, as pointed out by the appellant, examples 37 to 86 were all prepared following the procedure of paragraphs [0089] to [0096] using an average grain size of the mixture of 0.3 µm (see paragraph [0090]) and using a same two-steps sintering process. The opposed patent does not provide any information why e.g. examples 78, 73, 50 have the average grain size and standard deviation of the zinc

oxide grains according to features (e) and (f), while comparative examples 82 and 55 do not (see Table 4). All these examples use a mixture according to features (b), (c), (j) and (d), using the appellant's rounding convention.

3.3.7 Moreover, using again the appellant's rounding convention, which is considered to be appropriate as indicated above, for comparative examples 37, 43, 49, 52 and 56 and for examples 5, 54, 6, 24, 8 and 16 in Table 5, the starting mixture prior to sintering has a composition according to features (b), (c), (j) (see Table 3 and paragraph [0058]) and an average grain size of the mixture according to feature (d) (see Table 1 and paragraph [0090]). The opposed patent remains silent about the sintering parameters to be selected to produce the spinel grain size in accordance with features (g) and (h). Hence, the skilled person lacks the necessary information why e.g. example 54 has spinel grains according to features (g) and (h), while example 52 does not (see Table 5). The board is not convinced that an alleged lack of ZnO (94.75 mol% in example 52 compared to 95 mol% in example 54, see Table 3) would explain a larger spinel grain size. If anything, the skilled person would probably expect the contrary, namely that less ZnO in the mixture prior to sintering would produce smaller $Zn_7Sb_2O_{12}$ grains.

3.3.8 Furthermore, regarding features (g) and (h), the board notes that Table 5 states that only examples 5, 6, 8, 16, 24, 54 exhibit features (g) and (h), while it is unknown whether examples 5, 6, 16, 24 and 54 also have the average ZnO grain size and standard deviation according to features (e) and (f) (see Table 4). On the other hand, the properties of spinel grains (i.e. features (g) and (h)) cannot be derived for examples

78, 73, 21, 30, 50 and 7, which are indicated in Table 4 to exhibit features (e) and (f). It therefore follows that the patent only provides one single example (i.e. example 8) exhibiting all the claimed features, as also mentioned by the appellant in the statement setting out the grounds of appeal.

This is not contested by the respondent. The respondent cited T 226/85 and Case Law, section II.C.6.7, to argue that one single example was sufficient.

This is not convincing. In the present case, in view of the observations made above, the specification or the common general knowledge do not provide adequate instructions which would lead the skilled person necessarily and directly towards success over the broad scope of the claim through the evaluation of initial failures or through an acceptable statistical expectation rate in case of random experiments.

3.3.9 In other words, the opposed patent provides a number of examples of making a resistor with a sintered body from a mixture according to features (b), (c) and (j), but is silent about the specific manufacturing steps to take in order to obtain a sintered body with features (e), (f), (g) and (h) from a mixture with feature (d). The passages indicated by the respondent (i.e. paragraphs [0021] to [0028], [0030] to [0035] and [0041] to [0050]) do not provide the missing information.

In particular, the skilled person is not put into a position to produce a sintered body having the claimed average grain sizes and standard deviations. Spinel grain generation is only mentioned briefly in the opposed patent. However, for example paragraph [0028]

(cited by the respondent) does not provide any details whatsoever.

Therefore, the opposed patent lacks sufficient information for the skilled person to carry out the application over the whole scope of device claim 1 and method claim 4. As pointed out by the appellant, the skilled person would need to carry out an extensive trial-and-error program for finding a product according features (d) to (h) of claim 1 and, in the process, would have to take into account a large number of parameters when preparing the claimed mixture and the sintered body as required by claim 4. This amounts to an undue burden.

Consequently, the patent as amended does not disclose the claimed invention according to the main request in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC).

4. Respondent's auxiliary requests

4.1 The respondent argued that claim 1 according to auxiliary requests 1 to 3 was directed to a method of manufacturing the current-voltage non-linear resistor, wherein it was specified that pelletized powder had a grain size 70 to 130 µm and wherein the heating temperature ranges (350 to 500°C and 900 to 1300°C) were defined. Hence, the skilled person could carry out the invention.

4.2 In the board's opinion the mere specification of the grain size of the pelletized powder or the temperatures used during sintering does not allow to overcome the objection under Article 83 EPC raised against the main

request. In fact, in all comparative examples and examples according to the invention, these parameters are used, see paragraphs [0045] to [0048], [0061] to [0063], [0080] to [0082], [0092] to [0094] of the opposed patent.

Therefore, the patent as amended does not disclose the claimed invention according to the first, third and second auxiliary requests in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC).

5. Conclusion

As no allowable request is on file, the patent must be revoked (Articles 101(3)(b) and 111(1) EPC).

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

S. Sánchez Chiquero T. Häusser

Decision electronically authenticated