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DECISION
of 5 June 1997

Case Number: T 0636/94 - 3.4.1

Application Number: 89105911.5

Publication Number: 0390944

IPC: H01L 23/538

Language of the proceedings: EN

Title of invention:
Multilayer ceramic substrate and its manufacturing method

Applicant:
Murata Manufacturing Co., Ltd.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step: main and auxiliary requests 1 to 3 (no), auxiliary request 4 (yes)"

Decisions cited:
-

Catchword:
-

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Chambres de recours

Case Number: T 0636/94 - 3.4.1

DECISION
of the Technical Board of Appeal 3.4.1
of 5 June 1997

Appellant:

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Decision under appeal:

Decision of the Examining Division of the European Patent Office posted 5 April 1994 refusing European patent application No. 89 105 911.5 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: G. D. Paterson
Members: H. J. Reich
R. K. Shukla

Summary of Facts and Submissions

1. European patent application No. 89 105 911.5 (publication No. 0 390 944) was refused by a decision of the Examining Division on the basis of Claim 1 filed on 4 November 1993 reading:

"1. A method for manufacturing a multilayer ceramic substrate which contains a circuit element such as capacitors or resistors having thickness in the order of 50 to 60 μm or more the method comprising:

making a first ceramic green sheet having first and second main surfaces, from a material which is selected to form an insulator substrate upon firing;

forming a circuit element paste layer from a material which is selected to form a circuit element upon firing on a portion of the first main surface of said ceramic green sheet;

forming an insulator material layer from a material which is selected to form an insulator spacer upon firing, at least on another portion of said first main surface of said ceramic green sheet, so as to form a generally smooth surface in cooperation with said circuit element paste layer;

making a separate second ceramic green sheet from a material which is selected to form a separate second insulator substrate upon firing;

forming a laminate by laminating said separate ceramic green sheet on said smooth surface; and

pressing and firing said laminate."

II. The reason given for the refusal was that the subject-matter of above Claim 1 was not novel in view of document:

D1: EP-A-0 292 125

and therefore did not satisfy the requirements of Articles 52(1) and 54 EPC. The Examining Division took the view that the term "circuit element" in Claim 1 must be understood as to comprise also the superconducting interconnection conductors disclosed in document D1. Even if the subject-matter of Claim 1 was restricted to include only special circuit elements like capacitors and resistors, there would be no inventive step involved therein (Articles 52(1) and 56 EPC), because the person skilled in the art would see no obstacle in applying the method of D1 accordingly, the resistance against delamination remaining unchanged in such application. Moreover, thickness of a circuit element as claimed is not specified in the application as originally filed, in particular the thickness of 50 to 60 μm as indicated in Claim 1. Since the application documents do not appear to contain subject-matter patentable under Article 52(1), any allowable amendment of Claim 1 would not lead to another result.

III. The Appellant lodged an appeal against this decision and filed with the grounds of appeal on 28 July 1994 a new **main request** based on the set of claims as originally filed.

Independent Claims 1 and 4 of the **main request** read as follows:

"1. A multilayer ceramic substrate comprising, an insulator substrate;

a circuit element formed on a portion of one main surface of said insulator substrate;

an insulator spacer formed, at least, on the other portion of one main surface of said insulator substrate and forming a generally smooth surface in cooperation with said circuit element; and a separate insulator substrate formed on said smooth surface.

4. A method for manufacturing a multilayer ceramic substrate set forth in claim 1 comprising,

a process for preparing a ceramic green sheet which is formed into said insulator substrate by firing;

a process for forming a circuit element paste layer which is formed into said circuit element by firing on a portion of one main surface of said ceramic green sheet;

a process for forming an insulator material layer which is formed into said insulator spacer by firing, at least, on the other portion of one main surface of said ceramic green sheet, so as to form a generally smooth surface in cooperation with said circuit element paste layer;

a process for preparing a separate ceramic green sheet which is formed into said separate insulator substrate by firing;

a process for forming a laminate by laminating said separate ceramic green sheet on said smooth surface; and

a process for pressing and firing said laminate."

Claims 2 and 3 of the main request are dependent on Claim 1 and Claims 5 to 10 are dependent on Claim 4.

With the grounds of appeal the appellant additionally filed an **auxiliary request 1** based on a Claim 1 which has the wording of Claim 1 underlying the appealed decision (see paragraph I above) with the wording, "such as capacitors or resistors having thickness in the order of 50 to 60 μm or more" having been cancelled. Claims 2 to 9 of the first auxiliary request are dependent on Claim 1.

IV. In an annex to a summons to oral proceedings, the Board informed the appellant of its following provisional views:

The subject-matter of Claims 1 and 4 of the main request and of Claim 1 of auxiliary request 1 appears to be obvious. The subject-matter of these claims differs from the closest prior art disclosed in document D1 in that it comprises a "circuit element" in the sense of a passive or active circuit component such as a capacitor or resistor in a ceramic substrate. Since document

D3: "Wescon Technical Papers", vol. 14, 1970, pages 1 to 6,

in particular page 3, right-hand column, lines 20 to 24 and page 4, steps 1 to 4 of the process flow diagram, stresses the necessity of forming a flat surface of uniform height when screening a circuit element (resistor) and a dielectric filler of inverse pattern for its integration into a multilayer ceramic substrate, document D3 appears to hint a skilled person to include a circuit element also into the multilayer ceramic substrate and method disclosed in document D1.

New amended claims restricted to a "spacer" in the form of an extra green sheet (original claim 7) would be obvious in view of the use of green sheet 36 in Figure 4 of document

D2: EP-A-0 212 124,

as can be seen in detail from document D2, the summary and column 4, lines 39 to 49.

V. Prior to the oral proceedings, the appellant filed on 28 April 1997 an auxiliary request 2 and an auxiliary request 3.

Claim 1 of **auxiliary request 2** adds to the wording of Claim 1 of auxiliary request 1 the following features:

"said forming of said insulator material layer including forming an insulator paste layer having a thickness which is generally the same as that of said circuit element paste layer, and

said forming said laminate including laminating said separate ceramic green sheet on said circuit element paste layer and said insulator paste layer."

claim 1 of **auxiliary request 3** contains in addition to Claim 1 of auxiliary request 2 the wording:

"said forming of said insulator material layer further including making an insulator ceramic green sheet having a thickness generally the same as that of said circuit element paste layer and having a through hole at a position opposed to said circuit element paste layer, and

a step of laminating said insulator ceramic green sheet on the other portion of the first main surface of said ceramic green sheet, and furthermore

said forming of said laminate further including a step of laminating said separate ceramic green sheet on said circuit element paste layer and said insulator ceramic green sheet."

Auxiliary request 2 comprised a further independent Claim 4 and auxiliary request 3 a further independent Claim 3. (The subject-matter of these independent claims was additionally pursued in auxiliary request 4 filed during oral proceedings; see paragraph VI below.) All further claims of auxiliary requests 2 and 3 are dependent on a respective independent claim.

VI. During the oral proceedings held on 5 June 1997, the appellant filed an auxiliary request 4.

Claim 1 of **auxiliary request 4** reads as follows:

"1. A method for manufacturing a multilayer ceramic substrate which contains a circuit element, the method comprising:

making a first ceramic green sheet having first and second main surfaces, from a material which is selected to form an insulator substrate upon firing;

forming a circuit element paste layer from a material which is selected to form a circuit element upon firing on a portion of the first main surface of said ceramic green sheet;

forming an insulator material layer from a material which is selected to form an insulator spacer upon firing, at least on another portion of said first maim surface of said ceramic green sheet, so as to form a generally smooth surface in cooperation with said circuit element paste layer;

making a separate second ceramic green sheet from a material which is selected to form a separate second insulator substrate upon firing;

forming a laminate by laminating said separate ceramic green sheet on said smooth surface; and

pressing and firing said laminate;

said forming of said insulator material layer including forming an insulator layer on the other portion of the first main surface of said ceramic green sheet <u>and on said circuit element paste layer</u> so as to make a surface of said insulator layer generally smooth,

and

said forming of said laminate including laminating said separate ceramic green sheet on said insulator paste layer."

Claims 2 to 5 of auxiliary request 4 are dependent Claim 1.

The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of one of the following requests:

Main request - text as originally filed.

Auxiliary request 1 - as filed on 28 July 1994.

Auxiliary requests 2 and 3 - as filed on 28 April 1997.

Auxiliary request 4 - as filed during oral proceedings dated 5 June 1997.

VII. In support of his requests the appellant argued essentially as follows:

(a) The invention consists in providing smooth surfaces for integrating relatively thick circuit elements into a multilayer ceramic substrate. The invention avoids that the substrate delaminates during firing. Since the superconducting layers disclosed in document D1, are much thinner and have a very low working temperature of only 70°K, document D1 concerns a technical field which is different from that of the invention. A skilled person would not consider the field of superconductors for improving usual conductor devices.

(b) The correct technical starting point for the invention is disclosed in the introductory part of the description at page 2, lines 10 to 20 of the present application with reference to Japanese Patent Application Laid Open No. 56204/1987. In this conventional multilayer ceramic substrate gaps between the paste printed on each ceramic green sheet are liable to form and cause the paste-printed surface to delaminate easily during firing. The skilled person would have no technical reason to combine the teaching of this Japanese document with that of document D1. The volume of spacer 16 in Figure 5 of document D1 is much too small with regard to the spacers volume needed in the invention.

(c) Also document D3 contains no technical teaching that would help a skilled person to reach the invention.

(d) Green sheet 36 in Figure 4 of document D2 has the shape of a frame which surrounds the area needed for vias and conduction metallurgy patterns. Such shape does not hint a skilled person to use a ceramic green sheet as a filler and to provide it before lamination with the required through-holes or recesses. The appellant had to undertake a considerable number of tests in order to arrive at the invention as claimed. The use of spacers in the form of a ceramic green sheet avoids the formation of holes in the spacer volume. Such holes appear during the firing of a printed spacer paste.

VII. At the conclusion of the oral proceedings, the decision was announced that the decision of the Examining Division is set aside and that the case is remitted to the first instance with an order to grant a patent on the basis of auxiliary request 4.

Reasons for the Decision

1. *Inventive step: Main request - Claims 1 and 4 and Auxiliary requests 1 and 2 - Claim 1*

1.1 In the appeal proceedings, the Board followed the appellant's submission that in the context of the present application the term "circuit element" should be interpreted to exclude from its subject-matter any interconnecting circuitry such as the superconducting layers 12, 13 in Figure 5 of document D1.

Taking into account the technical field of the invention derivable from the original application documents, the term "circuit element" is regarded to embody an active or passive device or circuit component

.../...

such as a resistor or capacitor. Hence, the issue in the present appeal proceedings is not of novelty but of inventive step.

1.2 It is the established jurisprudence and practice of the Boards of Appeal of the EPO to regard as the closest prior art a document which discloses the most promising technical starting point to arrive at the claimed subject-matter. Since all essential technical features of the present invention are disclosed in document D1, contrary to the appellant's view in paragraph VII-(b) above, the Board considers that the multilayer ceramic substrate and the method for its manufacture as disclosed in document D1 constitutes the prior art coming closest to the present invention. Hence, the question to be examined is whether it would be obvious to incorporate a circuit element instead of a conductive element into this known structure.

1.3.1 Document D1 discloses the following technical features of **Claim 1 of the main request**:

"A multilayer substrate comprising an insulator substrate (see Dl, 11 in Figure 5) a "conductive" element (12, 13 in Figure 5) formed on a portion of one main surface of said insulator substrate; an insulator spacer (16) formed, at least, on the other portion of one main surface of said insulator substrate and forming a generally **smooth surface** in cooperation with said "conductive" element (D1, page 7, lines 20 to 22 and 25, 26); and a separate insulator substrate (11' in Figure 5) formed on said smooth surface).

1.3.2 In the wording of independent **Claim 4 of the main request** document D1 discloses:

"A method for manufacturing a multilayer ceramic substrate set forth in claim 1 comprising, a process for preparing a ceramic green sheet (11 in Figure 5) which is formed into said insulator substrate by firing (D1, page 7, lines 2 to 4 in combination with page 5, lines 54 to 57); a process for forming a "conductive" element paste layer which is formed into said "conductive" element by firing (page 7, lines 4 to 19 and 49 to 51); a process for forming an insulator material layer (page 7, lines 20 to 22) which is formed into said insulator spacer (16) by firing, at least, on the other portion of one main surface of said ceramic green sheet, so as to form a generally smooth surface in cooperation with said circuit element paste layer (page 7, lines 25, 26); a process for preparing a separate ceramic green sheet (page 7, lines 27 to 31) which is formed into said separate insulator substrate (11') by firing; a process for forming a laminate by laminating said separate ceramic green sheet on said smooth surface; and a process for pressing and firing said laminate (page 7, lines 41 and 49)."

1.3.3 Furthermore, from document D1, example 2 relating to Figures 4 to 6, there is known in the wording of **claim 1 of auxiliary request 1**:

"A method for manufacturing a multilayer ceramic substrate which contains a "conductive" element (see D1, 22, 23, 25, 26, 27 in Figure 6), the method comprising:

(a) making a first ceramic green sheet (11 in Figure 5) having first and second main surfaces, from a material which is selected to form an insulator substrate upon firing (page 7, lines 2 to 4);

(b) forming a "conductive" element paste layer (12, 13 in Figure 5) from a material which is selected to form a "conductive" element upon firing on a portion of the first main surface of said ceramic green sheet (page 7, lines 4 to 19);

(c) forming an insulator material layer (16 in Figure 5) from a material which is selected to form an insulator spacer upon firing, at least on another portion of said first main surface of said ceramic green sheet (page 7, lines 20 to 22, 25 and 26), so as to form a generally **smooth surface** in cooperation with said "conductive" element paste layer (page 7, line 26);

(d) making a separate second ceramic green sheet (11' in Figure 5) from a material which is selected to form a separate second insulator substrate upon firing (page 7, lines 27 to 31);

(e) forming a laminate by laminating said separate ceramic green sheet on said smooth surface; and

pressing and firing said laminate (page 7, lines 41 and 49)."

A skilled person derives the crucial feature of the subject-matter of the above claims, i.e. the **smooth surface** or even surface formed by the insulator layer in cooperation with the "conductive" element layer, from the wording in document D1, page 7, lines 25 and 26 stating that the insulating material paste layer is applied in order to "level off the top surface of the printed (i.e. the element layer structure supporting) green sheet." Moreover, document D1, page 7, lines 36 and 37 teaches that in order to level off the surface of a green sheet "a complementary pattern" of insulating material paste is printed.

1.3.4 Claim 1 of auxiliary request 2 differs from that of auxiliary request 1 in that the smooth surface in the former is formed by an insulator paste layer having a **thickness** which is generally **the same** as that of said conductive element paste layer; see also paragraph V above. This feature is however known from the embodiment as shown in Figure 5. The insulating layer 16 as shown in the figure has generally the same thickness as the combined thickness of the layers 12 and 13 forming the wiring layer. The further features added in Claim 1 of auxiliary request 2, i.e. "said forming said laminate including laminating said separate ceramic green sheet on said circuit element paste layer and said insulator paste layer" only repeat the same technical measures as already claimed in step (e) of Claim 1 of auxiliary request 1.

1.3.5 Hence, the subject-matter of all above claims differs from the closest prior art disclosed in document D1 in that the element layer is a **circuit** element layer in the sense defined in paragraph 1.1. above.

1.4 The objective problem underlying the invention as claimed in the above claims is to avoid delamination of a multilayer ceramic substrate having circuit elements during firing and provide the multilayer ceramic substrate with a generally smooth surface. Delamination and insufficient evenness or smoothness of the surface of a ceramic substrate are observable in practice. For this reason, the formulation of the objective problem does not contribute to an inventive step in the subject-matter of the above claims.

1.5 Document D1 and the present invention relate to the identical technical field of ceramic substrates. The solution of the objective problem as claimed in the above claims concerns exclusively an improvement of the properties of the overall ceramic structure and has no effect on the properties of the embedded interconnecting conductors of circuit elements. Therefore, in the Board's view, the skilled person competent for the present invention is an expert in the field of multilayer ceramic substrate. This expert can be expected to know that a prerequisite for sufficient adherence between the layers to be laminated by firing is that the layers are in intimate contact with each other along the entire interface. He easily recognises in the disclosure of document D1 that the technical means for achieving the desired adherence is the "smooth surface of the contacting boundaries, allowing for a homogeneous material distribution without gaps in the region of the boundaries. The competent skilled person is able to realise that the decisive element of the solution - i.e. the evenness or smoothness of the surface of the printed green sheet - is independent from the kind and thickness of a material printed on top of the individual ceramic green sheets before their lamination. The original application documents of the present invention are silent about any specific numerical value of the thickness of the circuit element paste layers for the embodied resistors and capacitors. There is no evidence on file that smooth surfaces cannot at all or only with technical difficulties be realised in layers thicker than the superconducting layers of document D1 (20 to 40 μm, see D1, page 6, line 27). If the superconducting layer 12, 13 of document D1 was indeed smaller, as suggested by the applicant, such a fact would suggest to a skilled person the necessity of providing a smooth surface by filling the gaps between thicker circuit elements.

The schematic drawing of Figure 5 of document D1 does not allow one to derive therefrom any dimensions of the overall area covered by insulator material layer 16. The particular structure shown in the sectional plane of Figure 5 of document D1 does not enable one to extrapolate the extension of layer 16 in other planes. For the above reasons, the appellant's arguments according to paragraphs VI-(a) and (b) provide no relevant technical reason that would prevent a skilled person from making an analogous use of the teaching of document D1 in a multilayer ceramic structure having circuit elements. Hence, the gist of the present invention is clearly disclosed in document D1 and the skilled person would consider its application in solving the technical problem mentioned above.

1.6 It follows from the disclosure in document D3 that a multilayer ceramic substrate having a circuit element (resistor) embedded therein is comprised in the prior art; see D3, the process flow diagram on page 4. On page 6, left column, lines 9 to 12, it is stated, "Thick film multilevel hybrid packaging technology is capable of high resolution, is flexible and available, and the packages are **stable** and have good **thermal** characteristics." The essential teaching of document D3 is disclosed on page 3, right column, lines 19 to 24, reading: "... each layer was made of uniform height. This was done by screening a fill layer; that is, using the inverse of the conductor pattern and screening dielectric material on the same level as the conductor." Document D3 thus discloses relevant prior art since in the multilevel ceramic substrate of document D3 the gaps between the printed element layers are already filled with an insulator spacer as claimed in the above claims. For this reason, the advantages of flat surfaces of ceramic component embedding resistors as disclosed in document D3, provide a clear technical incentive to make use of the ceramic green sheet technology disclosed in document D1 in manufacturing multilevel ceramic substrates having circuit elements embedded therein. Therefore, a skilled person **would** replace superconducting layer 12, 13, in Figure 5 of document D1 by a circuit element paste layer and thereby arrive at the subject-matter of the above claims in an obvious way.

1.7 For the reasons indicated in detail in paragraphs 1.1 to 1.6 above, Claims 1 and 4 of the main request, Claim 1 of auxiliary request 1 and Claim 1 of auxiliary request 2 are considered to lack an inventive step and not to be allowable with regard to Articles 52(1) and 56 EPC. The dependent claims of the main request and auxiliary request 1 fall because of their dependence on the respective independent claim.

2. *Inventive step - auxiliary request 3 - Claim 1*

2.1 As can be seen from paragraph V above, Claim 1 of auxiliary request 3 narrows the subject-matter of Claim 1 of auxiliary request 2 to comprising an insulator material layer (spacer) in the form of an "insulator ceramic **green sheet** ... having a **through hole** at a position opposed to said circuit element paste layer."

2.2 A multilayer ceramic substrate having a spacer in the form of an insulator ceramic green sheet with a through hole is disclosed in document D2; see additional green sheet 36 in Figure 4 and the corresponding description. Document D2, column 4, lines 42 to 47 read: "In order to **compensate** for the volume of conductive metal paste in the central area of (ceramic green) sheets 32, a sheet 36 is disposed in the stack of sheets. Sheet 36 is preferably formed of the same ceramic material as sheet 32, but has a large central opening 38." Contrary to the appellant's submission in paragraph VII-(d) above, the Board regards reshaping the frame-like structure of the green sheet spacer document D2 into comprising a through hole opposed to the element paste layer to be compensated, as representing a normal routine adaption in the obvious additional use of the teaching of document D2 in the non-inventive application of the green sheet technology of document D1.

The original application documents disclose no unexpected properties of a green sheet spacer with regard to a printed one.

2.3 For the reasons set out in paragraphs 1.1 to 1.6, 2.1 and 2.2, in the Board's judgment, the subject-matter of Claim 1 of auxiliary request 3 does not involve an inventive step in the sense of Article 56 EPC and, therefore, Claim 1 is not allowable under Article 52(1) EPC. Hence, auxiliary request 2 cannot be granted because of its unallowable Claim 1.

3. *Auxiliary request 4*

3.1 The subject-matter of Claim 1 of auxiliary request 4 is disclosed in the embodiments according to Figures 6A to 6C and 7A to 7D with their corresponding description. There is, therefore, no objection to such amended claim under Article 123(2) EPC.

3.2 None of the documents cited in the European Search Report discloses a method for manufacturing a multilayer ceramic substrate which contains a circuit element, wherein the method comprises the step of "forming an insulator material layer on the other portion of the first main surface of said ceramic green sheet **and on said said circuit element paste layer** so as to make a surface of said insulator layer generally smooth". In all multilayer ceramic substrates of the cited prior art the smooth surface is composed of an insulator material layer **and** a circuit element paste layer which are both of an inverse pattern. The insulator material layer levels off the free surface of the circuit element paste layer without forming a coating.

Thus, the subject-matter of Claim 1 is considered new in the sense of Article 54 EPC.

3.3 There is no hint in the cited prior art to solve the objective problem as defined in paragraph 1.4 above by applying an insulator material layer not only as a levelling filler of the gaps between the volume occupied by the circuit element paste layer but additionally as a coating or cover on top of the free surface of the circuit element paste layer. In the Board's view, it is not obvious that such a cover for the circuit element paste layer would contribute to the smoothness of the entire multilevel ceramic substrate by compensating for any thickness variations of an individual circuit element paste layer within the laminate; see also the original description page 15, lines 1 to 6.

For this reason Claim 1 of auxiliary request 4 is regarded to involve an inventive step in the sense of Article 56 EPC.

3.4 Thus, Claim 1 of auxiliary request 4 is allowable under Article 52(1) EPC. Dependent Claims 2 to 5 concern particular embodiments of the method claimed in Claim 1 and are, therefore, likewise allowable.

3.5 The case is remitted to the Examining Division in order that the description should be adapted to the above set of claims.

Order

For these reasons it is decided that:

1. The decision of the Examining Division is set aside.

2. The case is remitted to the first instance to grant a patent on the basis of auxiliary request 4.

The Registrar: The Chairman:

M. Beer G. D. Paterson