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Bezeichnung der Erfindung: Zirconia ceramics and a method of producing the same

Title of invention:

Titre de l'invention :

Klassifikation / Classification / Classement : C04B 35/48

ENTSCHEIDUNG / DECISION

vom / of / du 14 July 1989

Anmelder / Applicant / Demandeur :

Patentinhaber / Proprietor of the patent /
Titulaire du brevet :

NGK INSULATORS, LTD

Einsprechender / Opponent / Opposant :

01 Kyocera Corporation
02 Feldmühle AG
03 Pechiney SA

Stichwort / Headword / Référence : Zirconia ceramics

EPU / EPC / CBE Articles 56, 83, 84, 102, 113(2); Rules 58(2), 67

Schlagwort / Keyword / Mot clé : "Inventive step (yes)", "Relevant state of the art - Formulation of the technical problem", "Reinstatement of claims", "Decision on auxiliary request", "Procedural violation (no)", "Amendment of patent by proprietor in opposition (appeal) procedure", "Amendment of a request by the Board of Appeal"

Leitsatz / Headnote / Sommaire

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Chambres de recours



Case Number : T 155/88 - 3.3.1

D E C I S I O N
of the Technical Board of Appeal
of 14 July 1989

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Decision under appeal : Decision of the Opposition Division of the European Patent Office of 24 November posted on 3 February 1988 revoking European patent No. 0 036 786 pursuant to Article 102(1) EPC

Composition of the Board :

Chairman : K.J.A. Jahn
Members : P.K.H. Krasa
G.D. Paterson

Summary of Facts and Submissions

- I. European patent 36 786 containing five claims was granted in response to European patent application 81 301 292.9 filed on 25 March 1981 claiming priority of two earlier applications in Japan of 26 March 1980 and 17 February 1981. The mention of grant was published on 24 October 1984.

The patent is concerned with providing zirconia ceramics having improved strength properties. Claim 1 as granted is as follows:

Zirconia ceramics, characterized by comprising ZrO_2 and Y_2O_3 in a molar ratio of Y_2O_3/ZrO_2 of 2/98-7/93, whereby up to about 30 mol% of the Y_2O_3 may be replaced by oxides of rare earth elements or by CaO or MgO and consisting of crystal grains having a mixed phase comprising a tetragonal phase and a cubic phase or having a phase comprising a tetragonal phase, the average size of the said crystal grains being not larger than 2 μm .

- II. Three notices of opposition were filed on 18 July 1985, 19 July 1985 and 24 July 1985 respectively, all requesting that the patent be revoked in its entirety. The grounds for opposition were lack of novelty and inventive step (Article 100(a) EPC). They were supported by six documents. During the opposition proceedings thirteen further documents were cited. Twelve of these documents were relied upon in the appeal proceedings, the following three of which were eventually dealt with during the hearing before the Board of Appeal.

- (2) U.S. Department of Commerce, National Technical Information Service Technical Report AD-A-057 240, July 1978;
- (4) Journal of Material Science, Vol. 14, (1979), pages 59 to 65;
- (6) DE-A-2 810 134.

Of particular importance are also:

- (1) Journal of Material Science, Vol. 12 (1977), pages 2421 to 2426, essentially corresponding to:
 - (1a) Science of Sintering, Vol. 10, No. 3, pages 205 to 216 (1978); and
- (7) JP-A-4 913/79 (English translation of part of this document).

III. On 23 May 1986 the Appellant filed an Experimental Report showing various properties - especially flexural strength prior to and after durability tests at 200°C to 300°C - of zirconia ceramics according to the patent in suit and of other zirconia ceramics. He filed a new set of claims comprising product claims on 31 October 1987 as his main request, and in addition four separate sets of claims as auxiliary requests I to IV later on. During the Oral Proceedings before the Opposition Division the Patentee withdrew his main request - in view of the results of the Opposition Division's deliberations - and requested maintenance of the patent on the basis of an amended Auxiliary Request IV which then comprised two claims (process claims only).

- IV. By a decision delivered orally on 24 November 1987, with written reasons posted on 3 February 1988, the Opposition Division revoked the patent. The reasons of the decision can be summarized as follows:

The subject-matter of Claim 1 as amended was directed to a method of producing zirconia ceramics, and was novel but did not involve an inventive step. The Opposition Division considered that the claimed method differed from that of the closest prior art, as represented by document (2), inter alia in the use of sintering aids.

According to the Opposition Division, the use of sintering aids solved the problem of improving the thermal stability of zirconia ceramics for use at temperatures between 200 and 300°C. However, in its opinion a skilled person wishing to use the ceramics disclosed in document (2) as a solid electrolyte in an oxygen sensor for the exhaust systems of an automobile engine would, as part of his common knowledge as evidenced by the teaching of the prior art, use alumina or silica as a sintering promoter. Therefore, the high durability of the ceramics obtained by the claimed process was to be regarded as a bonus effect.

- V. On 12 April 1988 an appeal was lodged against the above decision and the appropriate fee paid.

In the Statement of Grounds filed on 10 June 1988 the Appellant filed amended sets of claims by way of a main request and first and second auxiliary requests, and contended that the Opposition Division committed a substantial procedural violation during the oral proceedings when requiring the Appellant to choose between revocation on the basis of the main request or withdrawal of the main request and selection of an auxiliary request.

The Appellant, therefore, requested reimbursement of the appeal fee.

With respect to inventive step the Appellant basically argued that document (2) is not immediately combinable with the use of a sintering aid and that the use of a sintering aid gives an unexpected and highly useful result. Thus, the material described in citation (2) is not suitable for use as an oxygen sensor since it is porous and there is no teaching in this document as to how to make the material denser, except perhaps by using higher sintering temperatures. In view of the theoretical approach of this document the Appellant does not consider it to be relevant for the assessment of inventive step.

The Appellant filed further amended sets of claims on 10 May 1989, in response to objections raised under Article 123(2) EPC in a communication dated 3 February 1989. The Appellant requested that the decision under appeal be set aside and the patent be maintained on the basis of the main request or the two auxiliary requests.

The main request comprises seven claims. The independent claims read:

1. A zirconia ceramics including sintering aid and consisting of

ZrO_2 and Y_2O_3 in a molar ratio of Y_2O_3/ZrO_2 in the range of 2/98 - 7/93, in which up to about 30 mol% of the Y_2O_3 may be replaced by oxides or rare earth elements or by CaO or MgO and the crystal grains of which have a mixed crystal phase comprising a tetragonal phase and cubic phase or have a phase comprising a tetragonal phase, the average grain size

of said crystal grains being not larger than $2\mu\text{m}$, an amount which is not more than 30% by weight, based on the total weight of the ceramics of a sintering aid selected from Al_2O_3 , SiO_2 and clay.

3. A method of producing zirconia ceramics, comprising the steps of providing zirconium oxide having a crystallite size not larger than 100 nm or amorphous zirconium oxide, mixing said zirconium oxide with an yttrium compound in a molar mixing ratio, calculated as oxide, of $\text{Y}_2\text{O}_3/\text{ZrO}_2$ of 2/98 - 7/93, wherein up to about 30 mol% of the Y_2O_3 may be replaced by oxides of rare earth elements or by CaO or MgO, and further including a sintering aid selected from Al_2O_3 , SiO_2 or clay in an amount of not more than 30% by weight based on the total amount of the ceramics, moulding the mixture into a moulded article, and firing the moulded article at a temperature within the range of 1,000 - 1,550°C, thereby to obtain a zirconia ceramics in which the crystal grains have a mixed crystal phase comprising a tetragonal phase and a cubic phase or have a phase comprising a tetragonal phase, the average size of said grains being not larger than 2 μm .

The Appellant stated that he did not intend to attend oral proceedings, and declared his willingness to accept any amendment which the Board of Appeal might consider necessary at the scheduled oral proceedings.

- VI. The counter-arguments of the Respondents are basically as follows:

The product claims withdrawn during the oral proceedings before the Opposition Division cannot be reinstated during the appeal proceedings. Moreover, Claim 1 of the main request is unclear.

The skilled person on the basis of general knowledge, common in the field, would readily consider adding a sintering aid to the zirconia ceramics known from document (2) or from documents (1) or (1a), especially in view of e.g. documents (4) or (6).

The examples of the impugned patent and the Experimental Report filed on 23 May 1986 do not support the Appellant's assertion that a surprising effect is obtained by the use of sintering aids. Even if there were an unexpected result obtained this would not necessarily mean that an inventive step is present. The claimed zirconia ceramics differ from those disclosed in reference (2) merely by the presence of a sintering aid whose minimum amount is not even specified.

- VII. Oral Proceedings took place on 14 July 1989 to which the Appellant was duly summoned, but in which he did not participate.

The Respondents requested that the appeal be dismissed.

The decision was announced at the conclusion of the oral proceedings that the decision of the Opposition Division was set aside and the case was to be remitted to the first instance with the order to maintain the patent on the basis of Claims 1 to 4 and 7 filed as the main request on 10 May 1989.

Reasons for the decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is, therefore, admissible.

2. Procedural matters

- 2.1 As set out in paragraph V above, the Appellant has alleged that a substantial procedural violation occurred during the oral proceedings before the Opposition Division on 24 November 1987: on page 2 of the Statement of Grounds it is stated that the Opposition Division "required the patentee (immediately) to choose between (a) revocation on the basis of the main request, and (b) withdrawal of the main request and selection of an auxiliary request". The Statement of Grounds then goes on to state that in view of the opinions already expressed by the Opposition Division as to the non-allowability of the main request, the patentee took course (b) and selected auxiliary request IV.

The minutes of the oral proceedings do not fully reflect what is stated in the Statement of Grounds. The minutes show that the Opposition Division stated its "conclusions" as regards the Main Request, namely that it was not allowable, and then state as follows: "Thereafter the Chairman asked the Proprietor to decide whether or not he maintained his Main Request. After a short intermission the Proprietor agreed to withdraw the Main Request" (see page 6 of the minutes). The minutes were sent to the parties on 22 January 1988, and thereafter the Appellant did not suggest that such minutes were inaccurate until (by implication) the filing of the Statement of Grounds on 10 June 1988.

In this circumstance the Board is clearly not in a position to decide exactly what took place at the oral proceedings, and is certainly unable to decide that the Appellant's version of what took place is correct.

However, the Appellant agrees with what is stated in the minutes, that he did in fact withdraw his Main Request, and all of the auxiliary requests except Auxiliary Request IV.

In the Board's view it would clearly be very wrong if an Opposition Division did attempt to "require" a patentee to withdraw a main request or any auxiliary request, as alleged by the Appellant. However, in reality, a patentee cannot be required to withdraw any request. If he files one or more auxiliary requests in addition to a main request and does not withdraw any of them, an Opposition Division is obliged in its decision to give reasons why each successive request is either not admissible (in the exercise of its discretion under Rules 57(1) and 58(2) EPC, as to which, see Decision T 406/84, OJ EPO 1989, 302), or not allowable on substantive grounds - Decision T 234/86, OJ EPO 1989, 79. If an Opposition Division allowed an auxiliary request without giving reasons in its decision as to why the main request or preceding auxiliary requests were not allowable, such decision would be set aside as void and of no legal effect, and the appeal fee refunded on the basis of a substantial procedural violation, as took place in Decision T 234/86 and Decision T 484/88 dated 1 February 1989.

Regardless of whether or not the Opposition Division attempted to require withdrawal of the main request, in the present case the Appellant on his own admission voluntarily at the oral hearing withdrew each of his requests except the fourth Auxiliary Request. In this circumstance, in the Board's judgement, no substantial procedural violation took place before the Opposition Division, and the Appellant's request for refund of the appeal fee is refused.

2.2 As set out in paragraph VI above, the Respondents submitted that the Appellant having voluntarily withdrawn all his requests except the fourth Auxiliary Request during the procedure before the Opposition Division, the subject-matter of such earlier requests must be taken to have been abandoned, and the Appellant should not therefore be allowed to reinstate such subject-matter in his requests filed during the appeal proceedings.

If a patentee in a particular case proposes amendments to his claims which arise out of the opposition and which are intended to meet the grounds of objection raised in the opposition by limiting the scope of protection sought, this should not normally be interpreted as an abandonment of the subject-matter protected by the claims of the patent as granted. Such proposals to amend during the course of opposition proceedings do not normally prevent the patentee from subsequently proposing amendments which effectively reinstate the subject-matter of the claims as granted (see in this connection Decision T 123/85, OJ EPO 1989, 336). In the Board's view, such a proposal to amend by way of limitation should only be interpreted as an irrevocable abandonment of the broader subject-matter of the previous claims if the circumstances make it absolutely clear that such was the real and unambiguous intention of the patentee. It is in the interest of an efficient opposition procedure before the EPO that patentees should feel free to propose limiting amendments which are genuinely intended to meet the objections raised therein (and which may be acceptable to the Opponents) without thereby putting at risk their freedom to reinstate their earlier broader claims in order that a decision should be issued on the allowability of such broader claims. This is, of course, subject to the discretionary control of the Opposition Division or the Board of Appeal to admit amendments only if they are appropriate and

necessary in the sense of Rules 57(1) and 58(2) EPC (as to which, see Decision T 295/87 dated 6 December 1988, Reasons paragraph 3, to be published in OJ).

In the present case, the Appellant's proposal to amend so as to limit his claims to those set out in his fourth Auxiliary Request during the oral hearing before the Opposition Division was very clearly made in circumstances such that there was no intention by the Appellant to abandon the possibility of reverting to the subject-matter of the claims of the earlier Requests proposed before the Opposition Division.

3. **Admissibility of the amended claims**

Claim 1 according to the main request differs essentially from Claim 1 as granted by the additional feature of the presence of "an amount which is not more than 30% by weight, based on the total weight of the ceramics of a sintering aid selected from Al_2O_3 , SiO_2 and clay." Zirconia ceramics with this additional feature were disclosed in the application as originally filed (see page 9, lines 10-14) and the specification as granted (see page 4, lines 18-23).

Claims 2, 3, 4 and 7 of the main request correspond to Claims 2, 3, 4 and 5 both as granted and as originally filed; they all contain the same limiting feature - i.e. the sintering aid - as does Claim 1, either expressis verbis (Claim 3) or due to their dependency from Claim 1 or Claim 3 respectively. Thus, no formal objections can be raised against the wording of Claims 1, 2, 3, 4 and 7 according to the main request under Article 123(2) and (3) EPC.

- 3.2 In contrast to the above-mentioned claims, the subject-matter of Claims 5 and 6 of the main request has no counterpart in the claims of the patent as granted.

In accordance with Decisions T 406/86 and T 295/87 identified above, in the Board's judgement the introduction of such subject-matter into the claims is neither appropriate nor necessary within the meaning of Rule 58(2) EPC, because such amendments do not arise out of the grounds of opposition raised by the Opponents.

- 3.3 The Respondents have asserted that Claim 1 of the main request is unclear for the following reasons:

- (i) it is not clear whether the sintering aids are indeed confined to Al_2O_3 , SiO_2 and clay;
 - (ii) no lower limit is given for the amount of the sintering aid.
- 3.3.1 (i) In the Board's judgement, the wording of Claim 1, "... zirconia ceramics including sintering aid and consisting of ZrO_2 and Y_2O_3 ... [and] an amount ... of a sintering aid selected from Al_2O_3 , SiO_2 and clay", clearly requires that the zirconia ceramics claimed must comprise a sintering aid which without doubt can only be selected from the said three substances. Therefore, Claim 1 is clear in this respect.
- (ii) The second objection, that there is no lower limit regarding the amount of sintering aid, is in its essence an objection against the broadness of the claim. However, the Respondents -who have the burden of proof -did not demonstrate that there exists a critical lower limit in this respect and that,

therefore, the present wording of Claim 1 is not justified. On the contrary, the Appellant has shown that the beneficial effect of a reduced deterioration can be seen with as low an amount as 0.1% of weight (cf. the Experimental Report mentioned supra, especially Table 1(3), lines 1 and 4 in combination with Table 1(1), lines 1 and 4); with the sintering aid selected being clay this low amount yields the best results regarding maintenance of flexural strength. Under these circumstances it would be unfair to restrict the scope of protection sought in Claim 1. This would deprive the Appellant of the adequate protection for his invention without any objective reasons for doing so.

Thus, in the Board's judgement, Claim 1 of the main request satisfies Article 84 EPC.

3.3.2 The objection was raised by one Respondent that because of the absence of a lower limit for the sintering aid there is no sufficient teaching which would enable the skilled person to carry out the invention. This objection under Article 83 was not further substantiated. It was already decided by this Board (T 14/83 - OJ EPO 1984, 105) that the question of sufficient disclosure has not to be judged merely on the basis of the claims. There cannot be any doubt that the examples of the impugned patent show how ceramics of the invention as defined in Claim 1 can be obtained. Thus the requirements of Article 83 EPC are also met.

4. Novelty and inventive step

4.1 The impugned patent is concerned with partially stabilised zirconia ceramics having a high strength and a high resistance against deterioration in strength due to use

for a long period of time in a limited temperature range (Claims 1 and 2 of the main request) and a method for producing such zirconia ceramics (Claims 3, 4 and 7 of the main request). These zirconia ceramics can be used as oxygen sensors in exhaust gases (see page 2, lines 6-20 and lines 37-42 in combination with page 4, lines 26-31). Zirconia ceramics partially stabilised with Y_2O_3 (= PSZ) were already known for the same application, but - according to the statements in the description - show a noticeable deterioration in strength with lapse of time when used in the temperature range of 200°-300°C. While there was no reference cited which shows this unfavourable conduct of the PSZ of the state of the art, this fact was not contested by the Respondents.

- 4.1.1 The Opposition Division considered document (2) as the closest state of the art in respect to the then pending Claim 1 which was a process claim. In the Board's judgement that document is not the proper starting point for defining the technical problem underlying the disputed patent since in this purely scientific paper no utility is given and, moreover, these PSZ were not apt for use as a solid electrolyte for oxygen sensors, due to their low density of 88-92% of the theoretical value (see (2), page 7, lines 4 and 5 and Appellant's uncontested statement in the Grounds of Appeal, page 8, paragraph 2).

This was contested by the Respondents on the basis that present Claim 1 according to the main request was not limited to zirconia ceramics for use as oxygen sensors only. However, the patent law under the EPC aims at the protection of inventions which are technically applicable. The claimed invention is not confined to the mere provision of a ceramics product. A claimed invention which is directed to a chemical product is allowable only if in addition to the disclosure of its composition there is

also a teaching of its technical use. However, if this condition is satisfied, the claims need not be limited to such use.

These considerations make it appropriate, when evaluating the patentability of an invention, to start with a disclosure within the state of the art which not only materially comes close to the claimed product, but which can also be practically applied for the solution of the same or a similar technical problem in the same technical field.

- 4.1.2 In the Board's judgement, document (7) represents the closest state of the art in relation to the subject-matter of Claim 1. This reference discloses a zirconia ceramic comprising 4 mol% Y_2O_3 (and 96 mol% ZrO_2) and 2% (by weight, based on the total weight of the ceramic) of Al_2O_3 as sintering promoter (table 1, fourth example). This ceramic was said to have sufficient temperature shock resistance in respect to a temperature difference between 1100°C and room temperature (see note 2 to table 1).

There is no disclosure in reference (7) regarding the grain size and crystal phase of the respective PSZ. However, as far as only the chemical composition is concerned, this PSZ is clearly within the scope of those parameters of Claim 1 relating to the chemical composition of the ceramics. It should be mentioned already now, for the sake of completeness, that document (7) does not anticipate the subject-matter of Claim 1: As already indicated, this document is silent on grain size and crystal phase of the PSZ, while Claim 1 gives particular values for the grain size and also specifies the crystal phase. Thus, the subject-matter of Claim 1 is a selection from the PSZ of document (7) in respect to these distinguishing physical parameters, even if it shows the

same chemical composition as the PSZ known from reference (7).

- 4.2 According to the undisputed representation in the specification of the patent (cf. page 2, lines 6-20) the drawbacks of PSZ of the state of the art is a very noticeable deterioration in strength with lapse of time within a limited temperature range of from 200°C to 300°C resulting eventually in breakage of the ceramics.

The technical problem - as defined in the description of the impugned patent and refined in view of reference (7) - may thus be seen in providing PSZ showing a reduced deterioration of strength when exposed to temperature fluctuation between 200° and 300°C for a prolonged period of time (3000 hours).

According to the patent in suit this problem is essentially solved by providing zirconia ceramics which consist of ZrO_2 and Y_2O_3 in a molar ratio of Y_2O_3/ZrO_2 in the range of 2/98 - 7/93 (in which up to about 30 mol% of Y_2O_3 may be replaced by other particular metal oxides) and a sintering aid in an amount of not more than 30% by weight of the total weight of the ceramics, the crystal grains being not larger than 2 μm and comprising a tetragonal phase.

The test report filed by Appellant on 23 May 1986 demonstrates that such PSZ according to Claim 1 retain more than 90% of their original flexural strength after exposure to temperature fluctuations between 200°-300°C for 3000 hours (cf. Table 1(3), Examples 1-6); Example 6 shows a retention of flexural strength of 99% and Examples 1 and 3 show an increase in flexural strength

after such treatment. In the light of these results the Board is satisfied that the above defined problem is plausibly solved.

- 4.3 After examination of the cited prior art, the Board has reached the conclusion that the zirconia ceramics of Claim 1 of the main request are not disclosed therein and the claimed subject-matter is, therefore, novel. Since novelty was not disputed in the appeal procedure it is not necessary to consider this matter in detail (see also No. 4.1.2 supra).
- 4.4 For purposes of inventive step the question to be examined is whether the claimed solution would, in view of the other citations, have been obvious to a person skilled in the art faced with the problem defined above.

In the oral proceedings before the Board the Respondents referred to references (4) and (6) as being highly relevant.

- 4.4.1 Reference (4) is concerned with the influence of sintering temperature, sintering time and nature of sintering aid on the density of, inter alia, cubic zirconia ceramics stabilised with 12% by weight Y_2O_3 . This corresponds to about 6.9 mol% Y_2O_3 in relation to ZrO_2 and, thus, the ceramics in question are also PSZ.

The purpose of the investigation described in (4) was to find sintering aids which allow the preparation of sufficiently dense ceramics for use as oxygen probes in liquid steel at sintering temperatures below 1500°C (see (4), page 59, introduction). As far as the Y_2O_3 stabilised PSZ are concerned, no information is available on their average grain size (for CaO-stabilised PSZ doped with

2 mol% Al_2O_3 an average grain size of 12 μm is given; (4), page 63, left column).

In view of the different problem citation (4) was concerned with, and its silence on temperature shock resistance of the respective ceramics, the skilled person would not have considered (4) in the context of the problem underlying the present invention either alone or in combination with reference (7).

4.4.2 Document (6) teaches zirconia ceramics which, according to Claim 12, can be used for determining the oxygen content of exhaust gases especially of combustion engines. The problem to be solved according to (6) was to improve the mechanical properties of the rather coarse grained cubic zirconia ceramics comprising low amounts of sintering aid (less than 5 mol.%). This was achieved by the addition of higher amounts of Al_2O_3 as sintering aid (8-85 vol.%; see (6) Claim 1). It is said (cf. (6), end of page 11) that with more than 15 vol.% Al_2O_3 these completely stabilised zirconia ceramics (=CSZ) showed a temperature shock resistance matching that of PSZ and that their structural stability is far superior to that of PSZ. The thermal shock resistance was determined by one-sided chilling of specimen applying a cold air stream using an acoustic emission analysis, however, no details are given about the temperature interval.

Document (6) also mentions that Al_2O_3 -addition is not only advantageous for CSZ but also in case of ceramics comprising low amounts of non-stabilised zirconia, i.e. with low amounts of monoclinic or tetragonal ZrO_2 (cf. (6), page 6, paragraph 2).

Example 8 of document (6) shows a zirconia ceramic with 6 mol% Y_2O_3 and 94 mol% of ZrO_2 and Al_2O_3 in an amount of

32% by weight based on the total weight of the ceramic; thus, this is a PSZ. No information is given either on grain size or crystal structure of this product nor on its durability at 200°C-300°C.

Thus, the skilled person cannot find any indication in reference (6) which would have lead him to the claimed solution.

- 4.4.3 Document (2) deals in detail with Y_2O_3 -stabilised PSZ, which otherwise show the same chemical and structural parameters as the claimed ones (molar relation ZrO_2/Y_2O_3 , grain size, contents of tetragonal phase), but which do not contain a sintering aid. Dependency of tetragonal-phase-retention (when cooling the ceramics) on grain size and Y_2O_3 -contents was investigated as was the dependency of fracture toughness from the contents of tetragonal phase. The fracture toughness was determined at room temperature (see (2), page 4, lines 5-7). There is no teaching in (2) which relates fractural strength of zirconia ceramics at room temperature with durability at 200°C - 300°C. Moreover, the zirconia ceramics according to reference (2) were not apt for use in oxygen concentration cells due to their porosity (= low density; cf. No. 4.1, supra). Neither was it set forth nor was it recognisable for the Board, how a hint to the claimed solution could have been derived therefrom.
- 4.4.4 References (1) and (1a) disclose Y_2O_3 -stabilised PSZ which resemble structurally and chemically those of present Claim 1, but also lack a sintering aid. In (1) and (1a) the dependency is investigated of tetragonal-phase retention (on cooling) of the PSZ from the sintering temperature. It is demonstrated that specimen with high amounts of tetragonal phase exhibit high flexural strength (roughly three times as high as cubic-structured

zirconia) and show no microcracks. While it is not stated expressis verbis, it is to be assumed that the flexural strength was measured at room temperature. This follows from the general purpose of these citations to demonstrate the existence at room temperature of zirconia ceramics with a tetragonal phase (see (1), page 2426, conclusions) and that no particular temperature is given for the flexural strength test (see (1a), page 206, experimental procedure) making it plausible that room temperature was prevailing. No potential use as an oxygen sensor is mentioned or foreshadowed in citations (1) or (1a) for the respective ceramics let alone their behaviour in respect of durability at 200° to 300°C; thus, there is no information available from these documents which could have led the skilled person to combine their teachings with that of document (7) to solve the technical problem as defined.

- 4.5 Hence, it follows from the preceding discussion that the cited references, neither on their own nor in combination with each other or with document (7), are such as to render the subject-matter of Claim 1 obvious. It, therefore, involves an inventive step.
- 4.6 Nothing else would result if the evaluation of inventive step of the claimed subject-matter would consider reference (2) as a starting point which, however, is not actually done by the Board for the reasons given under Nos. 7.1 and 7.2. However, if one would follow the Opposition Division's approach, then in view of (2) and considering the results obtained with the claimed solution, the problem to be solved would be a two-fold one and could be defined as follows:

Providing a zirconia ceramic with

- an increased density sufficient to allow its use in an oxygen sensor and simultaneously with
- an increased durability in long term use (3000 hours) at temperatures between 200 and 300°C.

There is, as already discussed, no hint in the other documents cited how the second part of the problem could be solved. In the Board's judgement it is not permitted to take for a "bonus effect" - which is said not to contribute to inventive step - the solution of an important, if not the most important, aspect of a complex problem.

The Board considers, however, that (2) is not the correct starting point for evaluation of inventive step as this would result from a rather arbitrary pre-selection of a document from the overall state of the art which was possible only because having knowledge of the invention and by not giving due importance to other references which were concerned with zirconia ceramics for the same use as the claimed zirconia ceramics.

- 4.7 The subject-matter of Claim 2 derives its patentability from that of Claim 1.

Claim 3 as well as Claims 4 and 7 are concerned with a method of manufacture of zirconia ceramics according to Claim 1. The subject-matter of these claims is also derived from the same inventive concept to provide the beneficial zirconia ceramics mentioned hereinbefore via a process adapted for this; thus no further representations are necessary in this respect.

Order

For these reasons, it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order that the European patent be maintained on the basis of Claims 1 to 4 and 7 filed as main request on 10 May 1989.

