BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

A		B		C	X

File Number: T 245/90 - 3.3.2

Application No.: 83 104 856.6

Publication No.: 0 095 131

Title of invention: Coated silicon nitride cutting tools

Classification: C04B 41/87

D E C I S I O N
of 13 November 1992

Applicant: GTE Laboratories Incorporated

Opponent: Stora Feldmühle AG
Sandvik Aktiebolag

Headword: Cutting tool/GTE III

EPC Article 56

Keyword: "Inventive step (no) - obvious alternative"

Case Number : T 245/90 - 3.3.2

DECISION
of the Technical Board of Appeal 3.3.2
of 13 November 1992

Appellant : (Proprietor of the patent)	GTE Laboratories Incorporated 100 W. 10th Street Wilmington Delaware (US)
Representative :	Patentanwälte Grünecker, Kinkeldey, Stockmair & Partner Maximilianstrasse 58 W-8000 München 22 (DE)
Respondents : (Opponent 01)	Stora Feldmühle AG Patentabteilung Gladbacher Str. 189 Postfach 100463 W-4060 Viersen (DE)
(Opponent 02)	Sandvik Aktiebolag S-811 81 Sandviken (SE)
Representative :	Östlund, Alf Olof Anders Sandvik AB Patent Department S-811 81 Sandviken (SE)
Decision under appeal :	**Decision of the Opposition Division of the European Patent Office dated** 11 December 1989, posted on 17 January 1990 **revoking European patent No.** 0 095 131 **pursuant to Article** 102(1) **EPC.**

Composition of the Board :

Chairman : P.A.M. Lançon
Members : I.A. Holliday
E.M.C. Holtz

Summary of Facts and Submissions

I. European patent No. 0 095 131 concerning coated silicon nitride cutting tools and based on application No. 83 104 856.6 was granted on the basis of three claims.

II. The two Respondents filed notices of opposition against the European patent. Nine prior art documents were cited of which the following remain relevant in the present appeal:

(1) DE-A-3 039 827
(2) DE-A-2 505 009
(3) EP-A-0 035 777

III. The Opposition Division revoked the patent on the grounds that the subject-matter of the claims as granted as well as that of the amended claims presented during the oral proceedings held on 11 December 1989, lacked an inventive step.

The Opposition Division took the view that the closest prior art was document (1) since it describes a ceramic cutting tool which, apart from the coating, fulfils all the requirements as set out in the disputed claims. It was in particular to be noted that according to (1) a glassy refractory phase comprising yttrium oxide and silicon dioxide was also formed and that the products obtained by pressureless sintering had a density of 99% to 100% of theoretical. It was furthermore the Opposition Division's view that even if there were a better adherence of the coating to the silicon nitride substrate body of the patent in suit compared with other coated substrate bodies known for example from document (2), in the light of the known prior art clearly indicating that the wear and corrosion resistance of sintered silicon nitride cutting tools can be improved by a titanium carbide or titanium carbonitride coating, this would amount to nothing more than a bonus effect.

As regards the subject-matter of the claims further limited to a substrate body comprising only yttrium oxide and hafnium oxide, it was pointed out that document (3) disclosed such a substrate body containing additionally 1 to 60% by volume of a hard refractory material. Even if Claim 1 were construed to exclude small amounts of such hard refractory material, it would be clear to a person skilled in the art that without the hard refractory material substantially complete densification of the silicon nitride matrix could also be obtained. Taking into account the cited prior art, for example according to (2), in the opinion of the Opposition Division, the person skilled in the art would have had the incentive to apply a coating of a refractory material to the resulting matrix and thus would have arrived at the cutting tool according to said further limitation without an inventive step.

IV. The Appellant lodged an appeal against this decision and, on 28 May 1992, filed new Claims 1 and 2 which read as follows:

"1. A coated ceramic cutting tool comprising a densified silicon nitride substrate body showing a density equal to or greater than 98% of theoretical density, at least one refractory coating layer and further comprising a densification aid selected from the group consisting of silicon dioxide, magnesium oxide, yttrium oxide, hafnium oxide, zirconium oxide, the lanthanide rare earth oxides, and mixtures thereof, characterized in that said silicon nitride substrate body has been pressureless sintered and

has a first phase of silicon nitride and a second refractory intergranular phase comprising silicon nitride and an effective amount of said densification aid,
and in that said refractory material coating is selected from the group consisting of the nitrides, carbides, carbon nitrides of titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, tungsten and mixtures thereof, wherein
silicon dioxide is present in the final densified body in an amount which comprises less than about 5 weight percent of the substrate body.

2. A method for the manufacture of a coated ceramic cutting tool comprising a silicon nitride substrate body densified to equal or greater than 98% of theoretical density and having at least one refractory coating layer and further comprising a densification aid selected from the group consisting of silicon dioxide,
magnesium oxide, yttrium oxide, hafnium oxide, zirconium oxide, the lanthanide rate earth oxides, and mixtures thereof, characterized in that said silicon nitride substrate body is pressureless sintered
such that it comprises a first phase of silicon nitride and a second refractory intergranular phase comprising silicon nitride and an effective amount of said densification aid and in that said refractory material coating is selected from the group consisting of the nitrides, carbides, carbon nitrides of titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum, tungsten and mixtures thereof, wherein SiO_2 is present in the final densified body in an amount which comprises less than about 5 weight percent of the substrate body."

Oral proceedings took place on 13 November 1992. Although it was accepted that there was no difference between the composition of the substrate bodies disclosed in (1) and

(3), the Appellant took the view that document (1) should be regarded as the closest prior art since (3) did not describe a substrate body which had been pressureless sintered. The Appellant denied furthermore that the skilled person would arrive at the claimed subject-matter by simply combining documents (1) and (2). In particular, the overall composition of the substrate body profoundly affected the properties of the densified composite. Thus, not only according to (1) but also according to (3) the required degree of densification could only be achieved by a substrate comprising eg Al_2O_3, WC, WSi_2, W and TiC whereas the patent in suit did not require such hard refractory material in the substrate body. Moreover, the presence of this hard refractory material as third phase in the substrate bodies of the prior art clearly would teach away from the present invention. In view of the complexity of silicon nitride technology as could be seen e.g. from document

(10) K.H. Jack in "Science of Ceramics", Vol. 11 (1981), pages 125 to 142,

referred to by Respondent I, there was no reason for those skilled in the art to form a coating layer as generally described in (2) for a large group of very different substrate bodies on the particular new material now claimed.

In particular, the Appellant argued that none of the cited documents disclosed the concept of influencing the refractory intergranular second phase such that the desired high temperature properties of the densified composite would be obtained. Although it could be accepted that coating a substrate body to form a cutting tool was generally known from the prior art, it would not have been obvious that a specific chemical interaction between the coating layer and the dual phase silicon nitride substrate of the patent in suit would result in such a good adherence of the coating.

Since the formation of a coating layer on the new substrate would cost less than the addition of fine powders of hard refractory material to the compositions according to (1) or (3), the technical problem in relation to this prior art was in accordance with col. 2, lines 9 to 11 of the patent in suit to achieve a first quality product at reduced cost.

V. The Respondents argued that, since new Claim 1 used the term "comprising" and column 3, lines 3 to 9 of the specification indicated that the intergranular phase may contain further additional materials in amounts less than 5 weight percent of the host matrix, there was in effect no limitation with respect to the substrate bodies known from the prior art according to (1) or (3). Having regard to the so-called **Method I** according to document (3), page 8, line 32 up to page 9, line 14, there was furthermore no doubt that the substrate body had been prepared by pressureless sintering. In the light of document (10) disclosing detailed technical information about the densification process in silicon nitride based two phase systems, it was clear that also in the absence of hard refractory material as a third phase a fully dense ceramic material could be achieved. Moreover, it was within the common knowledge of those skilled in the art to use silicon nitride alone as a basis for cutting tools. There was accordingly no doubt that (3) taught how to produce the highly densified substrate body presently claimed.

As regards the claimed coating of the substrate body, the Respondents took the view that not only was the alleged problem to increase the chemical inertness already solved for example by a TiC-coating of the silicon nitride substrate body according to (2), but also a good adherence of the coating layer was demonstrated by Example 25 thereof. It was generally known from the prior art that a coating layer would strongly influence the working properties of a cutting tool and there was no technical prejudice for those skilled in the art against forming such a coating layer on the substrate bodies disclosed in (1) or (3). Finally, it was contested that the cutting tool according to the patent in suit could be produced at lower cost than the cutting tool known from (3).

The same objections applied to the new Claim 2 relating to a method for the manufacture of the coated ceramic cutting tool.

VII. The Appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of Claims 1 and 2 as filed on 28 May 1990.

The Respondents requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. The current Claims 1 and 2 are formally allowable. The applicant made no objection under Article 100(c) EPC and the Board considers that the requirements of Articles 123(2) and 123(3) EPC are satisfied.

3. Neither of the documents cited during the opposition and appeal procedure, nor any document cited in the course of the examination procedure disclose the specific

combination of substrate and coating defined by Claim 1. The Board is thus satisfied that Claim 1 and method Claim 2 relate to novel subject-matter. In any event, novelty of the said claims was not questioned by the Respondents at the oral proceedings before the Board.

4. The patent in suit relates to coated silicon nitride cutting tools. The Board regards document (3) as the closest prior art, but cannot share the Appellant's view concerning its disclosure.

4.1 The structural principle of the cutting tool according to document (3) may be described as particles of hard refractory materials such as carbides and nitrides of titanium, vanadium, chromium, zirconium, niobium, molybdenum, hafnium, tantalum and tungsten (cf. Claims 1 and 2) uniformly dispersed throughout a host matrix. The matrix comprises a two phase system made up of a first phase of silicon nitride grains and a secondary intergranular continuous phase containing silicon nitride and the densification aid, cf. page 5, lines 10 to 15 and lines page 7, lines 13 to 17. In contrast to this, document (1) describes a two phase system based on silicon nitride in which the secondary phase consists of yttrium-silicon-oxynitride and tungsten silicide, cf. page 5, second paragraph. Having regard to these different descriptions of the microstructure of the sintered material, it is clear that (3) discloses a host matrix composed of a phase system as presently claimed for the substrate body of the cutting tool and thus this document is regarded as a more suitable starting point in the present case.

4.1.1 According to (3) the densification aid is selected from the group consisting of yttrium oxide, zirconium oxide, hafnium oxide and the lanthanide rare earth oxides.

Yttrium oxide and hafnium oxide are preferred additives, cf. Claim 3 and page 7, lines 28-29. The working examples, in particular the Table on page 13 show that densities of 100% of theoretical have been achieved for compacts containing yttrium oxide. In addition to the said densification aids, it is mentioned that the second intergranular phase of the body may contain further components in an amount less than about 5 percent by weight based on the weight of the secondary phase. Silicon dioxide is then considered to be a desirable additive to optimize oxidation resistance, cf. page 4, lines 22 to 35. It is furthermore clear from page 3, lines 7 to 17 and Figure 1 that the volume ratios and the specific type of hard refractory particles distributed in the matrix influence the overall hardness of the cutting tool. From the point of intersection of the plotted data with the "0" volume percent axis of ordinate of said Figure 1, a Rockwell A scale hardness between 92 and 93 for the corresponding host matrix body can be calculated.

4.2 The Appellant has alleged that (3) did not disclose how to produce a pressureless sintered silicon nitride based matrix for a cutting tool. However, it is clearly indicated on page 6, lines 1 to 3 of (3) that the matrix "is compacted to a high density by sintering or hot pressing techniques" and on page 8, lines 18 to 20 with reference to the working examples that the materials "have been prepared by hot pressing or sintering techniques detailed in Methods I and II". In accordance with the Respondents argumentation, the Board is convinced that, in the light of the teaching of (3), in particular of said Method I indicating that "**the green compact is then sintered** to a hard, highly densified product by heating to temperatures of 1700°C - 1850°C, the skilled person could only construe this to mean that the final matrix body is sintered without pressure, i.e. at atmospheric pressure.

4.3 The patent in suit does not comprise any comparative examples nor did the Appellant file further technical information during the proceedings to support the statement in col. 2, lines 9 to 11 that improved cutting tools with respect to the prior art have been prepared. It appears, however, that the Applicant felt the claimed cutting tool to be less expensive and to show improved adherence of a refractory coating layer on a substrate body based on silicon nitride. The Respondents have contested these advantages and no figures have been produced concerning the relative costs between omitting for example titanium carbide and the requirement to use more silicon nitride. Accordingly, such alleged but unsupported advantages cannot be taken into consideration in respect of the technical problem underlying the patent in suit. The nature of the problem should be determined on the basis of objective criteria vis-à-vis the closest prior art (cf. T 01/80 OJ EPO, (7), 1981, 207 and T 20/81 OJ EPO, (6), 1982, 217).

4.3.1 In the light of document (2), **Example 25**, disclosing that a titanium carbide coating layer on a silicon nitride substrate shows a good adherence, the Appellant's statement regarding this matter can only be regarded as subjective.

4.3.2 For the above reasons, the Board cannot concede that the objective technical problem to be solved lay in reducing the manufacturing costs of the cutting tool or in improving the adhesion of the coating to a particular substrate.

4.3.3 Accordingly, the technical problem underlying the patent in suit can only be seen in providing an alternative to the composite ceramic cutting tool known from (3) having properties at least of the same order.

4.4 The problem is solved by a coated ceramic cutting tool comprising a densified silicon nitride substrate body defined in Claim 1. Although the working example only refers to magnesium oxide as densification aid, the Board has no reason to doubt that coated cutting tools comprising a densification aid selected from the group of materials listed in Claim 1 and prepared as indicated in the examples of the patent in suit exhibit overall performances at least comparable to those described in (3). This was also not contested by the Respondents. Therefore, the Board is satisfied that the problem has been solved.

5. It remains to consider whether or not the said solution satisfies the requirements of Article 56 EPC in respect of inventive step.

5.1 The cutting tool according to present Claim 1 differs from that disclosed in (3) in that

(i) no hard refractory particles are present in the matrix of said substrate and

(ii) the substrate body comprises a refractory metal coating layer thereon.

5.1.1 The Board cannot follow the Appellant's argumentation that a full density of the silicon nitride based host matrix disclosed therein can only be achieved in the presence of hard refractory metal particles such as TiC.

5.1.2 The Board is convinced that even in the light of nothing more than the disclosure of document (3), for example on the basis of the extrapolated hardness data in Figure 1, those skilled in the art would have expected that silicon nitride with the aid of yttrium oxide but without the addition of hard refractory metal particles could be sintered to form a dense ceramic material suitable as a substrate body for a cutting tool. This point of view is supported by the studies of K.H. Jack concerning the densification of silicon nitride, published in document (10). Having regard to the explanations in this document, it is clear that silicon nitride and yttrium oxide in the presence of silica at 1700°C partially react together to give a liquid and that a full densification is achieved after particle rearrangement, solution-diffusion-precipitation, followed by a liquid phase sintering process. The sintered body comprises secondary crystalline or vitreous phases. With regard to phase diagrams of the silicon nitride/magnesia/silica- and silicon nitride/yttria/silica-systems, it is then explained how strength, creep resistance and oxidation resistance of the material can be influenced by the composition of these phases. It is furthermore indicated that the mechanical properties of silicon nitride densified with yttria are superior to those of magnesia-densified material and that the amount of yttria depends very critically upon the amount of silica, cf. pages 126 to 129 as well as Figures 1 to 4. In this context it is to be noted that the Respondents' argumentation that it was in general known in the art to use sintered silicon nitride without the addition of hard refractory metal particles as a basis for cutting tools was not contested by the Appellant, who did not provide any comparative data.

5.1.3 The Respondents have argued that TiC coatings <u>inter alia</u> were well-known in the art to improve the wear resistance of cutting tools having a wide variety of substrates. This was not disputed by the Appellant during the oral proceedings and it is also evident from the introductory part of the patent in suit, in particular column 1, lines 38 to 41, that it was known before the priority date of the patent in suit that the wear resistance may be enhanced by coatings of TiC. Further confirmation is provided by document (2), page 11 (renumbered 15) paragraph: "Die Oberflächenvergütung bzw. -härtung...".

5.1.4 Accordingly, the skilled person faced with the problem of providing an alternative cutting tool on the basis of the host matrix described in (3) and, notwithstanding the considerations above, having doubts whether such deletion of hard refractory particles could be detrimental to the useful life and furthermore knowing that a coating layer of a hard refractory material such as TiC had a positive influence on the wear resistance, would have the incentive to apply such a coating layer in order to compensate any lack of useful life which might have been caused by omitting TiC particles from a silicon nitride substrate.

5.2 It follows from the preceding paragraphs that the subject-matter of Claim 1 lacks inventive step.

5.3 The conclusions above extend not only to the cutting tool according to Claim 1, but in the absence of any additional feature introducing non-obvious subject-matter, also to Claim 2 relating to a method for the manufacture of such a cutting tool.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar: Martorana

P. Martorana

The Chairman:

P.A.M. Lançon

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