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Datasheet for the decision of 31 January 2023

Case Number:	T 0954/21 - 3.3.05
Application Number:	16185085.4
Publication Number:	3138829
IPC:	C04B35/56, C04B35/565, C04B35/58, C04B35/80, C04B35/628, F01D5/28, F23R3/00, F23M5/00
Language of the proceedings:	EN

Title of invention:
TURBINE ENGINE COMPONENT COMPRISING A CERAMIC MATRIX COMPOSITE INCLUDING SILICON CARBIDE FIBERS IN A CERAMIC MATRIX COMPRISING A MAX PHASE COMPOUND

Patent Proprietor:
Rolls-Royce High Temperature Composites Inc

Opponent:
Raytheon Technologies Corporation

Headword:
TURBINE ENGINE COMPONENT/Rolls-Royce

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
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Office européen des brevets

Beschwerdekammern

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 0954/21 - 3.3.05

D E C I S I O N
of Technical Board of Appeal 3.3.05
of 31 January 2023

Appellant: (Opponent)	Raytheon Technologies Corporation Pratt & Whitney 400 Main Street East Hartford, CT 06118 (US)
Representative:	Mr. Scott Dehns St. Bride's House 10 Salisbury Square London EC4Y 8JD (GB)
Respondent: (Patent Proprietor)	Rolls-Royce High Temperature Composites Inc 18411 Gothard Street, Unit B Huntington Beach, CA 92648 (US)
Representative:	Ms. Oxley Mewburn Ellis LLP Aurora Building Counterslip Bristol BS1 6BX (GB)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted on 14 April 2021 rejecting the opposition filed against European patent No. 3138829 pursuant to Article 101(2) EPC.**

Composition of the Board:

Chairman	E. Bendl
Members:	J. Roider
	O. Loizou

Summary of Facts and Submissions

I. The opponent's (appellant's) appeal lies from the opposition division's decision to reject the opposition.

II. The following documents, which were already cited in the opposition proceedings, are relevant here:

D1	EP 2 905 271 A1
D2	Radovic, M. and Barsoum, M. W.; *MAX phases: Bridging the gap between metals and ceramics*; American Ceramic Society Bulletin; vol. 92; no. 3; pp. 20-27, 2013
D3	Wan, D.T. *et al.*; *In situ reaction synthesis and characterisation of $Ti_3Si(Al)C_2$/SiC composites*; *Ceramics International*; vol. 32; 883-890, available online on 12 September 2005
D5/D5a	CN 101269966 A / English machine translation
D10	Barsoum, M.; *MAX Phases*; Wiley-VCH; 2013

When citing D5/D5a, the reference applies to the English machine translation.

III. Claim 1 of the main request in the appeal procedure (claims as granted) reads as follows:

"1. A ceramic matrix composite comprising:
a ceramic matrix including silicon carbide and a MAX phase compound having a chemical composition $M_{n+1}AX_n$, where
M is selected from the group consisting of:
Ti, V, Cr, Sc, Zr, Nb, Mo, Hf, and Ta,

A is selected from the group consisting of: Al, Si, P, S, Ga, Ge, As, Cd, In, Sn, TI and Pb,
X is carbon or nitrogen, and
n is an integer from 1 to 3; and
continuous silicon carbide fibers in the ceramic matrix, wherein the MAX phase compound is present in the ceramic matrix at a concentration from 60 wt.% to 99 wt.%, wherein the silicon carbide is present in the ceramic matrix at a concentration from 1 wt.% to 40 wt.%, and wherein the ceramic matrix composite is a turbine engine component."

Dependent claims 2-7 concern particular embodiments of the invention.

IV. The arguments made by the appellant (opponent) can be summarised as follows:

In view of Cr_2GaN, which had a decomposition temperature of 850°C, there were serious doubts that a composite of 99% Cr_2GaN with 1% SiC could be stable in gas turbine applications. A mixture of materials had properties similar to the properties of the pure material if it were contained at 99% in the mixture. Although D5/D5a disclosed that a composite matrix of Ti_3SiC_2 and 10% SiC exhibited improved properties with respect to the pure MAX phase, an improvement in the decomposition temperature was not mentioned and it had to be assumed that it was not improved.

V. The arguments made by the patent proprietor (respondent) can be summarised as follows:

Although exceptionally pure MAX phases may not have been thermally stable, when contained in a composite matrix also comprising SiC, the thermal stability was

provided if the MAX phase was contained in an amount of 99% together with SiC. No evidence to the contrary was presented.
In view of D5/D5a (page 2, paragraph 2) even rather small amounts of SiC in the composite significantly improved the chemical and thermomechanical characteristics, as well as other characteristics.
Moreover, D5/D5a demonstrated that the presence of Al in these examples transformed the MAX phase into a solid solution, which, according to D3, may have had different properties from the MAX phase.

VI. Requests as to the substance:

(a) The appellant (opponent) requested that the decision under appeal be set aside and that the patent be revoked.

(b) The respondent (patent proprietor) requested that the appeal be dismissed (main request), or in the alternative that a patent be maintained in amended form on the basis of one of auxiliary requests 1-4, filed with its reply to the appeal.

Reasons for the Decision

1. Main request, Article 56 EPC

1.1 The patent is directed to a ceramic matrix composite (CMC) which is a turbine engine component.

1.2 The parties consider the example in paragraph [0034] of D1 to constitute the closest prior art.

1.3 Document D1 is directed to components for high-temperature and ultra-high temperature applications, such as in gas turbines, made of CMC. Example 1 discloses a CMC with SiC fibres, which are first coated with a 50 to 1 000 nm Ti_3SiC_2 layer and subsequently infiltrated with SiC to form an SiC/SiC matrix.

D1 is thus suitable for being considered the closest prior art.

1.4 The problem the patent aims to solve is to provide a CMC with increased fracture toughness, improved machinability, high thermal shock resistance and which withstands the high temperatures experienced within the hot gas path of a gas turbine over a long period of usage, i.e. it must be usable as a turbine engine component such as a blade seal segment, blade, vane or combustion liner (paragraphs [0024] and [0037]).

The respondent considers this to be accomplished if the material can withstand temperatures of at least 1 600°C for at least 25 000 hours.

1.5 D1 teaches that CMCs already possess increased crack resistance, elongation and thermal shock resistance properties and concerns a CMC with improved crack initiation and propagation properties such that it can be used in gas turbines at temperatures of about 1 600°C in excess of 25 000 hours (see paragraphs [0001] and [0003]).

D1 therefore solves the problem addressed by the patent, and therefore it must be reformulated into a less ambitious problem, which is to provide an alternative CMC.

1.6 It thus needs to be assessed whether or not the skilled person would, when providing an alternative starting from D1, arrive at the subject-matter of claim 1.

1.7 The appellant argues that from this starting point, in view of document D5/D5a, which discloses an SiC/Ti_3SiC_2 ceramic mix composite for high-temperature applications, the subject-matter of claim 1 was obvious.

1.8 It was undisputed that the production method disclosed in D5/D5a yielded a content of 10% SiC in the matrix. In the oral proceedings, however, it was disputed that the remaining part of the matrix contained Ti_3SiC_2 in an amount such that the matrix as a whole contained at least 60% of it.

1.8.1 The respondent argued that because of the substantial amount of aluminium added to the starting material, most of the reaction product was thus present as a solid solution ($Ti_3Si(Al)C_2$), which, according to D3, may have had different properties.

1.8.2 The appellant argued that only a small amount of the Ti_3SiC_2 was converted into the solid solution; however, it could not quantify an upper limit for it.

1.8.3 According to page 3 of D5/D5a, the starting material is a mixture of Si:TiC:Al of 2:3:(0.2-1) in terms of a molar ratio.
According to the paragraph bridging page 4 and page 5, most of the aluminium is volatilised, while the remaining part enters the Ti_3SiC_2 lattice so as to form a solid solution. Because of the substantial amount of aluminium added to the starting material, in the absence of good reasons to the contrary, it cannot be

concluded that the amount of Ti_3SiC_2 contained in the product is from 60 wt.% to 99 wt.%, as claimed.

The appellant did not provide such reasons, however.

1.9 The appellant further argued that at least some of the MAX phases encompassed by claim 1 of the patent in suit would have degraded far below the necessary temperatures and that CMCs with 99% of these MAX phases would therefore not have been suitable for the claimed purpose.

The appellant is thus of the opinion that the technical problem was not solved.
If this argument were successful, the only consequence would be that the technical problem would have to be reformulated into a less ambitious problem, which is to provide an alternative CMC.
Since the assessment already started from this problem, the conclusion remained the same.

1.10 Therefore, even if the skilled person were to combine D1 and D5/D5a, the subject-matter of claim 1 would not be rendered obvious.

1.11 Document D2 discloses a comparison of MX phases with MAX phases and also some aspects of solid solutions. It does not disclose a MAX phase comprising a certain amount of SiC.

Document D10, a textbook, discloses technology relating to MAX phases but does not disclose anything regarding a MAX phase comprising a certain amount of SiC.

Combining these documents with D1 thus cannot cause the skilled person to arrive at the subject-matter of

claim 1, either.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

C. Vodz E. Bendl

Decision electronically authenticated