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# Datasheet for the decision of 27 April 2018

**Case Number:** T 2242/15 - 3.4.02

**Application Number:** 07705059.9

**Publication Number:** 1977285

**IPC:** G02F1/39, H01S3/082, H01S3/108

**Language of the proceedings:** EN

**Title of invention:**
PARAMETRIC GENERATION USING INTERSECTING CAVITIES

**Applicant:**
The University Court of the University of St. Andrews

**Headword:**

**Relevant legal provisions:**
EPC 1973 Art. 56

**Keyword:**
Inventive step - (yes)

**Decisions cited:**

**Catchword:**

Europäisches Patentamt
European Patent Office
Office européen des brevets

**Beschwerdekammern**

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**Case Number: T 2242/15 - 3.4.02**

# D E C I S I O N
# of Technical Board of Appeal 3.4.02
# of 27 April 2018

| | |
|---|---|
| **Appellant:** (Applicant) | The University Court of the University of St. Andrews<br>College Gate,<br>North Street<br>St. Andrews,<br>Fife KY16 9AJ (GB) |
| **Representative:** | Street, Michael William<br>Marks & Clerk LLP<br>Aurora<br>120 Bothwell Street<br>Glasgow G2 7JS (GB) |
| **Decision under appeal:** | **Decision of the Examining Division of the European Patent Office posted on 16 July 2015 refusing European patent application No. 07705059.9 pursuant to Article 97(2) EPC.** |

**Composition of the Board:**

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|---|---|
| **Chairman** | R. Bekkering |
| **Members:** | A. Hornung |
| | B. Müller |

## Summary of Facts and Submissions

I. The applicant appealed against the decision of the examining division refusing European patent application No. 07705059.9 on the basis of Article 56 EPC.

II. With the statement setting out the grounds of appeal, the applicant requested that the decision of the examining division be set aside and a patent be granted on the basis of a set of claims according to a main request or an auxiliary request, both requests having been filed with the letter dated 29 May 2015 and being identical to the sets of claims underlying the appealed decision.

III. The present decision refers to the following documents:

D1: "Terahertz wave parametric source", Kodo Kawase et al., Journal of Physics D: Applied Physics 35 (2002) R1-R14.

D4: "Passively Q-Switched Solid-State Lasers with Intracavity Optical Parametric Oscillators", Guohua Xiao et al., IEEE JOURNAL OF QUANTUM ELECTRONICS, vol. 34, no. 11, November 1998, pages 2241-2245;

D5: "Compact intracavity pumped continuous-wave singly resonant PPLN OPO", Yingxin Bai et al., LASERS AND ELECTRO OPTICS, 2004 (CLEO), vol. 1, 17 May 2004, pages 109-110;

D6: "Hyperspectral imaging of gases with a continuous-wave pump-enhanced optical parametric oscillator", Stothard D J M et al., OPTICS EXPRESS, vol. 12, no. 5, 8 March 2004, pages 947-955;

D7: WO 2004/107033 A

D8: "Broadly tunable high repetition rate femtosecond optical parametric oscillator", Edelstein D C et al., APPLIED PHYSICS LETTERS, vol. 54, no. 18, 1 May 1989, pages 1728-1730.

IV. Independent claim 1 reads as follows:

"A parametric device having a non-linear material (4) for generating idler and signal (16) waves in response to a pump wave (14), the pump, idler and signal waves being non-collinear, and the signal wave is subject to absorption by the non-linear material, and exits the non-linear material laterally, the device having a cavity (10,11) which is resonant at the pump wavelength and which contains the nonlinear material (4), and means for varying the angle between the propagation directions of the pump and idler waves to tune the signal wavelength."

The main request further comprises claims 2 to 6, all referring back to claim 1.

## Reasons for the Decision

1. Amendments

No objection of added subject-matter was raised in the contested decision against the present set of claims. The board does also not see any reason for objecting to the amendments of the claims. Indeed, the board is satisfied that the present amended set of claims 1 to 6 fulfills the requirements of Article 123(2) EPC.

2. Inventive step

2.1 During the first-instance proceedings, the examining division and the applicant considered that D1 represented the closest prior art. The board agrees with this finding.

2.2 The claimed subject-matter differs from the parametric device of D1 in that it comprises a cavity which is resonant at the pump wavelength and which contains the non-linear material.

2.3 Due to the cavity being resonant at the pump wavelength and containing the non-linear material, the pump beam energy inside the non-linear material is higher than in a configuration where the pump beam would be generated in an external cavity and simply coupled into the non-linear material by conventional means. Hence, the technical effect of the distinguishing feature is to provide a system that "reduces the pump power/energy required to reach oscillation threshold" (cf. page 6, lines 7 and 8, of the description as filed), i.e. to improve the efficiency with which energy is pumped into the non-linear material.

2.4 Starting from D1, the objective technical problem to be solved by the skilled person may, therefore, be considered as how to improve the pumping efficiency of the THz-wave parametric oscillator shown in figure 3 of D1.

2.5 In view of the known problem that "most of the generated THz waves are absorbed or totally reflected inside the crystal due to a large absorption coefficient" (see D1, page R2, left column, lines 30 to 33), D1 is indeed concerned with the problem of providing a sufficiently strong pump excitation (see D1, page R2, left column, last paragraph, second sentence).

2.6 In order to solve the problem, D1 discloses a parametric device in which the following ideas are implemented:

(i) the non-collinear phase matching geometry ensures that the THz-signal wave exits laterally (see figure 3 of D1);

(ii) "the pump beam entered the x-surface of the crystal and passed through the $LiNbO_3$ crystal close to the surface of the grating coupler to minimize the absorption loss of the THz radiation ($\alpha > 10\ cm^{-1}$)" (see D1, page R4, right column, lines 12 to 15);

(iii) "a grating structure on the surface of $LiNbO_3$ (...) to couple out the THz wave directly to the free space with almost thousand times higher efficiency" (see D1, page R4, left column, first paragraph, last sentence).

2.7 D1 discloses some further possible means to improve pumping efficiency:

(iv) "the gain is enhanced by cooling the crystal" (see D1, figure 2);

(v) "it is also possible to increase the parametric gain, either by increasing the pump intensity ..."

(vi) "... or by using a shorter-wavelength pump source" (see D2, page R3, right-hand column, second paragraph, last sentence).

2.8 The skilled person, confronted with the problem of improving the pumping efficiency, would follow the teaching of D1 and consider any of the three possible means (iv) to (vi) for improving the pumping efficiency. This is because, in view of this teaching, there is no apparent reason for the

skilled person to look for still further means for improving the pumping efficiency.

2.9 Even if the skilled person did look for further improvement, there are, in the relevant technical field of D1, i.e. in the field of parametric devices using a non-collinear phase matching geometry for generating a tunable THz-signal wave, no further prior art documents available in the file disclosing means for improving the pumping efficiency (see point 2.13 below).

2.10 It follows from the foregoing that the disclosure of D1 would not lead the skilled person in an obvious manner to the claimed subject-matter comprising the distinguishing feature as set out in point 2.2 above.

*The appealed decision*

2.11 According to the appealed decision, "parametric devices having a cavity resonant at the pump wavelength and containing the non-linear material are well known in the art" (see point 1.3 of the appealed decision). In order to provide evidence for this statement, the examining division referred to the five prior art documents D4 to D8.

In view of this common general knowledge, the skilled person would modify the pump source of D1 in such a way that the non-linear material was contained within the pump cavity, thereby arriving in an obvious manner at the claimed parametric device.

2.12 The applicant acknowledged that parametric devices having a cavity resonant at the pump wavelength were known in the art (see statement of grounds of appeal, page 3, fifth paragraph). However, it was not known to use such cavities in the present field of non-collinear parametric devices

wherein the angles involved are such that the signal wave exits the non-linear material laterally. Indeed, D4 to D7 related to collinear phase matched parametric devices and D8 related to a non-collinear geometry not suitable for letting the signal wave exiting laterally.

According to the applicant, due to the fundamentally different set-up of the parametric devices, the skilled person would not consider applying the teaching of any of the documents D4 to D8 to the device of D1.

2.13 The board, in addition to the applicant's convincing argumentation about the fundamentally different set-up of the parametric devices, notes that the devices of D4 to D8 provide signal waves having a wavelength in the infrared spectral region, contrary to the device of D1 providing a THz-signal wave.

Therefore, in view of the fact that both the phase matching geometry and the spectral domain of the devices of D4 to D8 differ substantially from those of the device of D1, the board agrees with the applicant that the skilled person would not consider applying the teaching of any of documents D4 to D8 to the parametric device of D1.

2.14 In view of the above considerations, the board comes to the conclusion that the parametric device of claim 1 involves an inventive step over the available prior art (Article 56 EPC 1973).

3. In conclusion, the board is satisfied that the application documents according to the present main request and the invention to which they relate meet the requirements of the EPC and that a patent can be granted on the basis thereof.

## Order

## For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance with the order to grant a patent on the basis of the following documents:

   Claims: Nos. 1 to 6 of the main request as filed with the letter of 29 May 2015,

   Description: Pages 1 to 11 as originally filed,

   Drawings: Sheets 1/5 to 5/5 as originally filed.

The Registrar: The Chairman:

M. Kiehl R. Bekkering

Decision electronically authenticated