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D E C I S I O N
of 28 February 2001

Case Number: T 0037/95 - 3.4.1

Application Number: 86904884.3

Publication Number: 0269624

IPC: H01S 3/06

Language of the proceedings: EN

Title of invention:
Fibre-optic lasers and amplifiers

Applicant:
BTG INTERNATIONAL LIMITED

Opponent:
-

Headword:
Silica glass fibre laser/BTG

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes - after amendments)"

Decisions cited:
-

Catchword:
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0037/95 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 28 February 2001

Appellant: BTG INTERNATIONAL LIMITED
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 22 August 1994 refusing European patent application No. 86 904 884.3 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Davies
Members: U. G. O. Himmler
M. G. L. Rognoni

Summary of Facts and Submissions

I. The appellant lodged an appeal, received on 14 October 1994, against the decision of the Examining Division, dispatched on 22 August 1994, refusing the European patent application 86 904 884.3. The fee for the appeal was paid on 17 October 1994 and the statement setting out the grounds of appeal was received on 22 December 1994.

The Examining Division objected that the subject-matter of claim 1 was not patentable under Article 52(1) EPC because it did not involve an inventive step (Article 56 EPC), having regard to the following documents:

(D1) US-A-3 729 690

(D7) J. Stone and C.A. Burrus: "Neodymium-doped silica lasers in end-pumped fiber geometry", Applied Physics Letters, Vol. 23, No. 7, 1 October 1973, pages 388 to 389.

(D9) J. Hegarty et al: "Photon Echoes below 1K in a Nd^{3+}-Doped Glass Fiber", Physical Review Letters, Vol. 51, No. 22, 28 November 1983, pages 2033 to 2035.

II. In reply to a communication of the Board, the appellant filed with a letter dated 21 February 2001 a main and an auxiliary request both including a new set of claims 1 to 15 and amended pages 2 and 3 of the description.

III. The appellant requested that the decision under appeal

be set aside and a patent be granted on the basis of the main request or of the auxiliary request.

The documents of the main request are:

Claims: No. 1 to 15, as filed with the letter dated 21 February 2001

Description: pages 1 and 4 to 16 of the Description of the International Application, published under the PCT, WO 87/01246; pages 2 and 3 as filed with the letter dated 21 February 2001;

Drawings: Figures 1 to 10 as published.

IV. The wording of claim 1 according to the main request reads as follows:

"A fibre-optic laser or amplifier, being an active device of the type in which gain is provided by the stimulated emission of radiation, this device comprising:

a length of silica glass fibre (1) and an optical pump source (11) coupled thereto to inject optical pumping radiation to propagate along the length of the fibre (1) to stimulate emission therefrom;

said fibre having a core and cladding and a single-mode geometry capable of sustaining single transverse mode propagation at emission wavelength;

said fibre incorporating in its core active dopant ions at a low level uniform concentration of up to 900ppm;

said active dopant ions being of a rare-earth or a transition metal; and

said fibre providing an ultra-low transmission loss host for said active dopant ions."

Claims 2 to 15 are dependent on claim 1.

V. The appellant's arguments may be summarised as follows:

The refusal of the Examining Division had been based on the assumption that the combination of documents D1 and D7 was obvious. This combination, however, was a result of ex post facto analysis. Document D1 related to a glass laser device and general glassy material comprising a rare-earth active laser material. Apart from one concrete embodiment disclosed in document D1, relating to a Nd-doped *crown glass rod* and not to a *fibre* made of *silica*, the rest of this disclosure was merely speculative. In particular, because of the very large variety of possible fibre glassy materials disclosed (and not including the material of the invention), doping values (range of more than three decades of magnitude) and doping materials, the skilled person would not have used this document as a starting point for developing a rare-earth doped single-mode fibre. D1 was furthermore not a good document for defining the closest prior art, because the optical pump source in the embodiment of Figures 1 and 2 of D1, the flash tube 14, was not coupled to inject optical pumping radiation to propagate *along* the length of the fibre, but provided *side-pumping* of the laser or amplifier.

Document D7 disclosed a neodymium-doped end-pumped

silica fibre laser. The fibre actually used in this apparatus was a fibre with a neodymium content that, although referred to in D7 as "low", was up to several magnitudes ("less than 1% by weight, i.e. 4500 ppm) larger than the level defined as a maximum in claim 1 ("up to 900 ppm"). D7 did not disclose that the doping should be *uniform*. Furthermore the diameter of the active core of the fibre was 40 µm implying that the fibre was a multi-mode propagating fibre; even the minimum diameter of the possible core range, ranging from 800 to about 15 µm, would still not result in a single-mode fibre. Therefore it was not obvious why the skilled person would have combined the teaching of D1 with that of D7.

As a further proof of inventive activity of the claimed apparatus the long period between the publication dates of D1 and D7 (the year 1973) and the priority year of the present application (1985) must be considered. Although in these years much effort had been put into the development of low-loss communication fibres the particular fibre laser and amplifier apparatus of the present invention had only been realised by the applicants. The only publication documenting that a single-mode silica fibre with the required dopant concentration had been available before the priority date, document D9, showed that these fibres had been in use for an entirely different purpose (the investigation of photon echoes at very low temperatures).

Reasons for the Decision

1. The appeal is admissible.

2. *Article 123(2) EPC*

2.1 Claim 1 differs from claim 1 as published by the features:

(i) the fibre is a ***silica*** glass fibre;

(ii) the optical pump source is coupled to the fibre to inject optical radiation to propagate ***along the length of the fibre*** to stimulate emission therefrom; and

(iii) the active ions are incorporated in the ***fibre core*** at a concentration of ***up to 900ppm***.

Support for feature (i), to select silica glass as the fibre material, can be found on page 5, last paragraph of the published application; on page 7, lines 10 to 11, referring to Figure 5; and on page 8, lines 3 to 11, where reference is made to the fabrication process of the active fibres.

Feature (ii) defines that the fibre is end-pumped by the pump source. Support for this feature can be found in the embodiments shown in Figures 1, 3, 4, 8 and 10 and, for instance, on page 9, line 23 of the published application.

With respect to feature (iii), this defines a further restriction of the feature in claim 1 of the application as published that the active ions are incorporated in the fibre at a "low-level" uniform concentration. The concentration range "no greater than

900ppm" is supported by original claim 9 for neodymium as a dopant ion. Furthermore, it is specified in the description (page 4, lines 7 to 20) that "By using a new manufacturing process ...it is possible now to fabricate single-mode fibres with uniform low dopant concentrations up to 900ppm, whilst maintaining the low-losses which are characteristic of modern telecommunications fibres", and that "it is possible to envisage a new all-fibre laser/amplifier technology". The skilled person understands this passage in the sense that the upper limit of 900ppm applies to every suitable dopant, for instance neodymium, erbium or terbium, the absorption spectra for a fibre doped with these species being shown in Figure 5. Also the further passages in the description disclosing dopant concentrations for particular embodiments (for neodymium: see page 8, line 5; and page 11, line 7; for erbium, see page 15, line 25) are restricted to dopant values below 900ppm. Therefore, in the opinion of the Board, feature (iii) is supported by the original disclosure.

2.2 Other minor amendments equally find their support in the application as originally filed.

2.3 Therefore the Board is satisfied that the application documents are in conformity with Article 123(2) EPC.

3. *Novelty*

3.1 The Board considers that the closest prior art is disclosed in document D7, which shows a fibre-optic laser comprising a length of glass optical fibre (see Abstract and page 389, left column, first paragraph), and incorporating active dopant ions in its core

(neodymium, see Title and Figure 1 embodiment). The fibre is end-pumped by an optical source coupled to inject optical pumping radiation to propagate along the length of the fibre (pulsed dye laser and argon ion laser; see Abstract and page 389, left column, second paragraph). The fibre of the laser in D7 is a silica fibre (see Title and Abstract; see Figure 1 embodiment) and the active dopant ions are ions of a rare-earth metal (neodymium).

3.2 Document D7 refers to the use of fibres having active cores with diameters ranging from about 800 to about 15 µm (see page 389, left column, first paragraph) and, in the embodiment on page 389, left column, second paragraph, a core diameter of 40 µm. Since a single-mode fibre has a core diameter of typically 8 µm or less (see description, page 4, line 24), for instance 3.5 µm (page 11, line 5), it must be concluded that the fibres actually disclosed in D7 are not single-mode fibres. Furthermore, document D7 does not disclose whether the doping of the Nd-ions is **uniform** and is silent on the transmission loss of the fibre.

3.3 Document D1, which in the decision under appeal was considered to disclose the closest prior art, shows in the embodiments of Figures 1 and 2 an optical laser comprising an actively doped fibre (see column 3, line 54 to column 4, line 18). The fibre is made of barium crown glass and the dopant is neodymium (Figure 9). D1 does not disclose or suggest the use of silica as fibre material. Furthermore, as can be seen from Figure 2 of D1, the laser apparatus from D1 is side-pumped, and the radiation of the optical pump does not propagate along the length of the fibre. Therefore the apparatus in Figures 1 and 2 of D1 is more remote

from the subject-matter of claim 1 than that of D7 and cannot be considered to disclose a generic end-pumped fibre laser or amplifier of the type addressed in the application.

The further documents on file appear less relevant for the question of novelty.

3.4 Therefore the subject-matter of claim 1 is novel within the meaning of Article 54 EPC.

4. *Inventive step*

4.1 The subject-matter of claim 1 differs from the fibre-optic laser according to D7 in that:

(a) The fibre has a single-mode geometry and is capable of sustaining single transverse mode propagation at emission wavelength;

(b) the active ions are incorporated in the fibre at a low uniform concentration up to 900ppm; and

(c) the fibre provides an ultra-low transmission loss host for the active dopant ions.

4.2 Starting from the fibre-optic laser known from D7, the technical problem to be solved by the above features (a) - (c) can be seen in improving the compatibility of silica fibre-lasers with single-mode fibre systems (see page 2, lines 13 to 16 of the published application).

4.3 Document D7 suggests that the active fibre could be fabricated with "arbitrarily small core diameters" and that short lengths of active fibres with "core

diameters 15 µm" might be pumped (see page 389 right column, third and fourth paragraphs). Furthermore, since single transverse mode operation is a well known and desirable option in the field of lasers, and since a single-mode fibre has a core diameter of 8 µm or less (see 3.2 above), the skilled person could be expected to follow the suggestion of D7 and consider the possibility of modifying the laser disclosed in this document by means of feature (a).

4.4 As to features (b) and (c), it is noted that D7 discloses an upper limit for the concentration of neodymium dopant ("less than 1% by weight", corresponding to 4500ppm), which is considerably larger than the maximum value defined in claim 1 and that the active length of the laser device shown in D7 is 1 cm.

It could be argued that a person skilled in the art could have envisaged the possibility of increasing the length of the active fibre used in the laser according to D7 in order to make it more compatible with existing fibre devices, and that this skilled person would have correspondingly decreased the dopant concentration to the claimed level in order to achieve a similar absorption of the pump radiation over the whole length of the active fibre.

In the opinion of the Board, however, such skilled person was aware that the selection of a single-mode fibre with increased active length and, consequently, low dopant concentration implied an increase in transmission loss which would have required doped fibres with transmission characteristics not available prior to the filing date of the present application.

In fact, the appellant has convincingly shown that the problem of manufacturing single-mode active silica fibres with a low uniform dopant concentration and ultra-low transmission loss was first solved by the technology referred to in the present application (page 4, from line 7) and not disclosed before its priority date.

In summary, the Board considers that it would not have been obvious to the skilled person to modify the laser device of D7 so as to arrive at a fibre optic laser device falling within the terms of claim 1, because, in the light of the available technology, this would have appeared as a non-viable solution.

4.5 In the decision under appeal, the Examining Division considered that document D1 provided a teaching for features (b) and (c), since this document disclosed a barium crown glass fibre doped at a low level uniform concentration of less than 900ppm (column 11, lines 35 to 59 and column 12, lines 35 to 45). The Board does not concur with this view. Firstly, it appears that the choice of the host material (the specific glass) has an influence on the absorption and fluorescence spectrum (see D7, page 389, left column, last three lines), and therefore the skilled person would not as a routine measure modify the doping concentration disclosed in D7 for silica glass by selecting a concentration recommended for the different type of barium crown glass. Secondly, while D1 discloses a wide range of possible dopant concentrations (0.01% to 30% by weight, see column 12, lines 42 to 45), the actual embodiment specified in column 12, lines 14 to 21 of D1 mentions a value of 2.4% by weight. This would correspond to a dopant concentration more than ten times the maximum

value defined in claim 1.

With respect to the further requirement that the doping should be "uniform", the Division pointed to the passage in column 4, lines 58 to 59 of D1, referring to "homogeneous material". This passage, however, concerns a laser cavity comprising a glass rod and not a fibre laser, the principle of which is explained in a subsequent passage (column 5, lines 19 and following).

Therefore, in the Board's view, the skilled person would not find a clear indication in document D1 to further modify the device disclosed in document D7.

4.6 It is observed that document D9 discloses a single-mode silica fibre with a 6 µm core doped with neodymium in a concentration of less than 10^{-4} mole%, corresponding to 100ppm. The disclosure from D9, however, bears no relation to the field of fibre amplifiers or lasers and, therefore, a combination of document D9 with D7 would not be obvious.

5. For the above reasons, the Board finds that the appellant's main request meets 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 according to the main request:

Claims: Nos. 1 to 15, as filed with the letter dated 21 February 2001

Description: pages 1 and 4 to 16 of the Description of the International Application, published under the PCT, WO 87/01246; pages 2 and 3 as filed with the letter dated 21 February 2001;

Drawings: Figures 1 to 10 as published.

The Registrar: The Chairman:

R. Schumacher G. Davies