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# Datasheet for the decision of 4 February 2010

**Case Number:** T 1565/07 - 3.4.02

**Application Number:** 00830781.1

**Publication Number:** 1219926

**IPC:** G01C 19/66

**Language of the proceedings:** EN

**Title of invention:**
Integrated optical angular velocity sensor

**Applicant:**
Politecnico di Bari

**Opponent:**
-

**Headword:**
-

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

**Relevant legal provisions (EPC 1973):**
-

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

**Decisions cited:**
-

**Catchword:**
-

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Beschwerdekammern | Boards of Appeal | Chambres de recours

**Case Number:** T 1565/07 - 3.4.02

# D E C I S I O N
**of the Technical Board of Appeal 3.4.02**
**of 4 February 2010**

**Appellant**: Politecnico di Bari
Via Amendola, 126 B
I-70125 Bari (IT)

**Representative**: Russo, Saverio
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**Decision under appeal:** **Decision of the Examining Division of the European Patent Office posted 15 March 2007 refusing European application No. 00830781.1 pursuant to Article 97(1) EPC.**

**Composition of the Board:**

**Chairman:** A. G. Klein
**Members:** F. Maaswinkel
C. Rennie-Smith

## Summary of Facts and Submissions

I. The appellant lodged an appeal, received on 14 May 2007, against the decision of the examining division, dispatched on 15 March 2007, refusing the European patent application 00830781.1. The fee for the appeal was paid on 14 May 2007 and the statement setting out the grounds of appeal was received on 4 July 2007.

II. The examining division objected to the set of claims then on file under Article 123(2) EPC and that, apart from the objected features, the claims were not allowable because their subject-matter did not involve an inventive step (Articles 52(1) and 56 EPC 1973) because of an obvious combination of the disclosures in the following documents:

D1: US-A-5 408 492

D2: Patent Abstracts of Japan vol. 009, no. 315 (E-365), 11 December 1985 & JP-A-60 148185.

III. With the statement containing the grounds of appeal the appellant filed amended claims and description pages to be considered by the Board and filed an auxiliary request for oral proceedings.

IV. In a Communication under Article 110(2) EPC 1973 the Board raised objections under Article 84 EPC 1973 since it appeared that the independent claim lacked essential features of the invention, indicating that provisionally a set of claims overcoming these deficiencies could possibly define patentable subject-matter.

V. With a letter dated 9 December 2009 and received 10 December 2009 per facsimile the appellant filed a revised request supported by a new set of claims and revised description pages.

The documents comprising the request include:

| | |
|---|---|
| Claims: | 1 to 8, as received with the letter of 9 December 2009; |
| Description: | pages 1 to 14 as received with the letter of 9 December 2009; |
| Drawings: | Figures 1 to 3 as filed with the letter of 30 December 2005. |

VI. The wording of independent claim 1 reads as follows:

" A miniaturised integrated optical sensor of angular velocity for gyroscope systems comprising

a ring active cavity (1) for generating counter-propagating optical beams,

a U-shaped output waveguide (2), comprising a curved section for coupling said optical beams from the ring cavity (1) and comprising two straight parallel waveguide branches (3, 4),

a push-pull electro-optic modulator (5) positioned above said waveguide branches (3, 4) for calibrating the device and for distinguishing the direction of rotational velocity by application of two respective bias voltages,

a Y-shaped junction (6), comprising two input branches connecting said waveguide branches (3, 4) for producing the beat signal between the optical beams exiting said waveguide branches and an output branch,

an integrated photo-detector (7) arranged at said

output branch for measuring the frequency difference of the beat signal,

wherein the ring cavity, the U-shaped waveguide device and the Y-shaped junction have a multilayer ridge structure including a Multi Quantum Well structure".

The wording of independent claim 8 reads as follows:

"Application of the integrated optical gyroscope based on the integrated sensor as claimed in previous claims in the following systems:
- missile guiding systems;
- navigation systems for any kind of motor vehicles;
- navigation systems for aeroplanes and trains;
- systems to stabilise satellite orbits".

Claims 2 to 7 are dependent claims.

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

Claim 1 has been amended to include the feature that the ring active cavity, the U-shaped waveguide device and the Y-shaped junction have a multilayer ridge structure including a Multi Quantum Well (*in the following: MQW*) structure. Further minor editorial amendments have been made in dependent claims 5 and 7 and documents D1 and D2 have been acknowledged in the description.

In its Decision, the Examining Division had based its objections on documents D1 and D2. The aim of the invention disclosed in Dl is to resolve problems of prior art rotation sensors by means of a ring laser,

utilizing light amplification by stimulated emission, formed in a solid medium provided with phase modulator devices which produce phase modulation of optical waves in the ring in a push-pull fashion thereby enhancing bi-directional lasing, in single longitudinal modes in each direction. Document Dl is provided with a two phase modulator (123, 124) inside the ring resonator (see fig. 1). The present application on the other hand discloses an electro-optic modulator (5) placed outside the ring laser, above the straight waveguides (3,4). In fact in document Dl, the phase modulators (123, 124) are excited in an anti-phase fashion producing push-pull phase motion and are driven by a signal processor (170). The signal processor (170) may apply separate sinusoidal signals, 180° out of phase, to the two separate modulators to achieve the desired modulation (p. 6 lines 1-5). In other words, the push-pull phase modulation works to eliminate the spatial hole burning in the laser gain medium. Thus, it enhances bi-directional lasing in the solid medium ring in a single longitudinal mode in each direction. In the present application the electro-optic modulator is used to calibrate the device (zero output corresponding to zero rotation value), and to distinguish the output signals of the detector 7, corresponding to two rotation velocities of equal module but having opposite directions. To obtain this purpose, no signal processor is required. The present invention further differs from the device of D1 in the properties of the ring laser transverse section. Document Dl discloses (col. 8 lines 5-19) a ring resonator consisting of semiconductor materials, such as In, Ga, As, P and Al (claims 17 — 21), whereas the sensor configuration includes only two active sections (181) and (182) inside the ring

resonator. These two active sections are supplied by the signal processor via electrical connections and produce amplification by injecting carriers into a MQW structure (301). The present invention, on the contrary, discloses a ring active cavity including a gain medium in every part of the structure, therefore providing a MQW-based fully-active cavity. In the sensor defined in claim 1 the ring active cavity simultaneously works both as laser source and as sensitive element. By this difference the claimed device avoids the following detrimental effects involved in the configuration proposed in document Dl, such as:
1) Back-reflection induced by the refractive index contrast between the two active sections and the passive regions into the ring; and
2) polarization conversion (TE, TM) induced by the transit of the beams into both active and passive regions.

These effects, in particular the polarization conversion, may result in a lower signal-to-noise ratio thereby affecting the minimum value of the detectable rotation velocity. Moreover, the scope of the present invention was to find the best trade-off between full integration and high sensitivity. In this sense, the reduction of the detrimental effects induced by the polarization conversion (as allowed by the integrated architecture having an appropriate cross section) is a fundamental and not a trivial design aspect. In the present invention this improvement is obtained by using gain selectivity in the whole ring laser cavity, having an optimised cross section equal to that of the passive waveguides (U-shaped, parallel branches, Y-junction).

The structure of integrated optical sensor of the invention differs from the one in document D2 in the structures of the ring laser and the input and output waveguides which, in the device of D2 (as well as in Dl), are both buried. The structure of the present invention, on the other hand, includes ridge waveguides with appropriate buffer layers, giving unique advantages. The modelling used to design the sensor has shown that the ridge waveguide configuration reduces the optical loss compared to a buried waveguide structure. As is known, the reduction of optical losses induces an improvement of the sensor sensitivity. Furthermore, the active layer of D2 is a double heterostructure. In this respect, the present invention is based on a MQW structure that permits a strong selectivity of the optical gain allowed by the MQW in the laser, giving only one polarization, TE, instead of two polarizations (TM and TE) occurring in a double heterostructure. Therefore the gain selectivity obtained in the present invention placing the MOW gain medium on the whole ring laser is a crucial aspect, since it allows the noise related to the coupling between the two polarizations to be eliminated, with consequent improvement of performance.

In the light of the above arguments, the appellant believes that the present invention as defined in the claims is new and involves an inventive step according to Article 56 EPC.

## Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

The board is satisfied that the amendments in the claims which no longer comprise any of the features objected to by the examining division find support in the originally filed documents, in particular the passage on page 9, lines 1 – 8 in the context of Figure 1, and original claim 2. Also the acknowledgement of the prior art (documents D1 and D2) is found to be admissible under Article 123(2) EPC.

2.1 By including the essential features of the invention in the independent claims the Board is also satisfied that the claims fulfil the requirements of Article 84 EPC 1973.

3. *Patentability*

3.1 *Novelty - Claim 1*

3.1.1 In the decision under appeal there was no objection of lack of novelty against the claims then on file. Present claim 1 defines the further features of the respective cavity, waveguide device and junction relating to its multilayer ridge structure including a MQW structure.

3.1.2 Document D1 discloses three rather different embodiments of ring laser rotation sensors:-

i) Figure 1 shows a ring laser wherein the ring cavity is formed by an optical waveguide in an electro-optic substrate 100 ($LiNbO_3$), the waveguide being doped with a rare earth element and pumped by an external laser diode for obtaining laser action. The optical beams are coupled out via a coupler 132 into a U-shaped output waveguide 130 with waveguide branches 135 and 136. At the end face of substrate 100 optical fibres 144 and 145 are connected to the waveguide branches. Therefore the ring laser cavity and the waveguide device do not comprise a multilayer ridge structure including a MQW structure and the embodiment does not include a Y-shaped junction as defined in claim 1;

ii) The second embodiment (Fig. 5) discloses a ring laser comprising an active (Er-doped) fibre, therefore it is not a waveguide device;

iii) The third embodiment in Figure 8 includes a ring laser in a semiconductor waveguide (InGaAsP) implemented in a semiconductor (GaAs) substrate 300. Differing from the structure of the sensor of claim 1 which comprises a ridge waveguide, the ring cavity of the device shown in D1, Fig. 8, includes a buried waveguide structure. Furthermore the ring of the device in this embodiment of D1 comprises two phase modulators 323 and 324 for eliminating spatial hole burning which are not present in the claimed device; instead the claimed device comprises two electro-optic modulators which, however, have a different function (calibration of the device and distinguishing the rotation direction). Finally the device in Fig.8 of D1 comprises optical fibres in the output area, which fibres, in consequence, are not integrated on the semiconductor

substrate. This device also lacks the Y-shaped waveguide junction.

3.1.3 Document D2 discloses a semiconductor ring laser gyro sensor in which the active layers are in a buried structure. Furthermore this device does not include the electro-optic modulators as defined in claim 1.

3.1.4 Therefore the subject-matter of claims 1 and 8 is novel (Articles 52(1) EPC and 54 EPC 1973).

3.2 *Inventive step*

3.2.1 As assessed in point 3.1.2 and 3.1.3, the subject-matter of claim 1 differs from the devices in documents D1 and D2 in that the ring, the U-shaped waveguide device and the Y-shaped junction have a ridge structure and in the presence of the electro-optic modulator positioned above the branches of the U-shaped waveguide device. According to page 10, lines 1 - 11 of the original description, the multilayer ridge waveguide solves, together with the distributed MQW structure, the problem of reducing absorption losses. Furthermore, as disclosed on page 12, lines 4 - 9, the electro-optic modulator can be used for calibrating the device and for distinguishing the output signals of the detector, corresponding to the two rotational velocities.

3.2.2 Since both prior art documents disclose the use of buried waveguides, the skilled person would not find any motivation in these documents to select a different type of waveguide structure: clearly, ridge waveguide structures are known in the art, but there is no evidence on file that the skilled person would have

selected such a structure for addressing the problem of reducing absorption losses in a ring laser cavity: documents D1 and D2 rather suggest a different solution.

3.2.3 Furthermore, as correctly pointed out by the appellant, neither document D1 or D2 teach or suggest an electro-optic modulator positioned and driven as in the present patent application. The European Search Report does not cite any further documents.

3.3 Therefore the available prior art does not render obvious the subject-matter of claim 1 and, in the opinion of the Board, the subject-matter of this claim involves an inventive step (Articles 52(1) EPC and 56 EPC 1973).

3.4 Claim 8 defines the application of an integrated optical gyroscope comprising the sensor defined in the previous claims and involving corresponding technical features. Therefore this claim is novel and inventive for the same reasons as claim 1.

3.5 The further claims 2 – 7 are dependent claims and are therefore equally allowable.

4. For the above reasons, the Board finds that the appellant's 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:

| | |
|---|---|
| Claims: | 1 to 8, as received with the letter of 9 December 2009; |
| Description: | pages 1 to 13 as received with the letter of 9 December 2009; |
| Drawings: | Figures 1 to 3 as filed with the letter of 30 December 2005. |

The Registrar: The Chairman:

M. Kiehl A. G. Klein