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D E C I S I O N
of 2 June 1999

Case Number: T 0030/94 - 3.4.1

Application Number: 88400541.4

Publication Number: 0282407

IPC: H01L 29/205

Language of the proceedings: EN

Title of invention:
Semiconductor device utilizing multiquantum wells

Applicant:
Fujitsu Limited

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56, 123(2)

Keyword:
"Inventive step (no)"
"Subject-matter extending beyond the content of the application as filed"

Decisions cited:
-

Catchword:
-

Case Number: T 0030/94 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 2 June 1999

Appellant: Fujitsu Limited
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Decision under appeal: Decision of the Examining Division of the European Patent Office dated 9 August 1993 refusing European patent application No. 88 400 541.4 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 13 October 1993, against the decision of the Examining Division, dispatched on 9 August 1993, refusing the European patent application 88 400 541.4. The fee for the appeal was paid on 13 October 1993 and the statement setting out the grounds of appeal was received on 17 December 1993.

The Examining Division objected that claim 1 was not admissible under Article 123(2) EPC. Furthermore, it held that even if this objection were to be overcome the application would still not meet the requirements of Articles 52(1) and 56 EPC, having regard to the following documents:

(D1) IEEE Journal of Quantum Electronics, vol. QE-22, No. 9, September 1986, pages 1853-1869

(D2) EP-A-0 177 374

(D3) Patent Abstracts of Japan, vol. 8, No. 206 (E-267)[1643], 20 September 1984, & JP-A-59 90 978

(D4) Physical Review B, vol. 29, No. 6, 15 March 1984, pages 3740-3743.

With a letter of 30 April 1999, the appellant submitted, inter alia, the following further documents:

(D5) Journal of Applied Physics, vol.58, No. 3, 1 August 1985, pages 1366-1368

(D6) Partial French translation of document D3.

A full translation of D3 in English was made available by the Board with a communication dated 14 May 1999. Hereafter, this translation will be referred to as D6e.

II. Oral proceedings were held on 2 June 1999.

The appellant requested that the decision under appeal be set aside and a patent be granted on the basis of the following documents:

Main request:

Claims	1, 3, 6 and 9 filed with the letter dated 30 April 1999 Claims 2, 4, 5, 7 and 8 as originally filed
Description:	page 2 and pages 5 to 10 as originally filed; Pages 1, 3, 3a and 4 as filed with the letter of 25 May 1992
Figures	1/5 to 5/5 as originally filed

First auxiliary request:

Claims	1 to 18 filed with the letter dated 30 April 1999
Description:	to be adapted
Figures	1/5 to 5/5 as originally filed

Second auxiliary request:

Claim	1 filed with the letter dated 30 April 1999
Claims	2 to 5 as per the Main Request
Description:	to be adapted
Figures	1/5 to 5/5 as originally filed

Third auxiliary request:

Claims	1 to 17 filed with the letter dated 30 April 1999
Description:	to be adapted
Figures	1/5 to 5/5 as originally filed

Fourth auxiliary request:

Claims	1 to 5 filed with the letter dated 30 April 1999
Description:	to be adapted
Figures	1/5 to 5/5 as originally filed

III. The wording of the independent claim 1 according to the **main request** reads as follows:

"A semiconductor device having a first barrier layer (3; 23); a quantum well layer (4, 24) formed on said first barrier layer; a second barrier layer (3, 23) formed on said quantum well layer, said first barrier layer, said quantum well layer and said second barrier layer making up a layer sequence which is repeated a predetermined number of times; a first contact layer (7,30) connected to the first barrier layer in a first of the predetermined number of layer sequences; and a second contact layer (6, 29) connected to the second barrier layer in a last of the predetermined number of layer sequences,

characterized in that each of said layer sequences forms a quantum well having a bottom of conduction band with an energy described by a curve of second order, and in that the electrons have energy levels separated by equal energy intervals, which energy levels coinciding at an appropriate bias voltage between said first and second contact layers to enable electrons to tunnel through said barriers."

The independent claims of the **first auxiliary request** define a light emitting device (claim 1) and a light receiving device (claim 7) essentially comprising the features of the semiconductor device of claim 1 according to the main request; and a hot electron transistor (claim 14) comprising, as a potential barrier between its emitter and base, a semiconductor device as specified in claim 1 of the main request.

Claim 1 according to the **second auxiliary request** relates to a semiconductor device with the features of claim 1 according to the main request, and in addition defines the composition of the well layer and the barrier layers, wherein the Al_x content in the well layer is varied to define an energy curve of second order.

The independent claims of the **third auxiliary request** define a light emitting device (claim 1); a light receiving device (claim 7); and a hot electron transistor (claim 13) as in the independent claims of the first auxiliary request, with the additional feature that the first and second barrier layers should have a thickness which is sufficiently small to maintain the coherence of the electron movement.

Claim 1 of the **fourth auxiliary request** is identical to claim 14 of the first auxiliary request.

IV. The arguments of the appellant may be summarised as follows.

The devices according to all requests comprised a layer sequence which was repeated a number of times. Each of these layer sequences formed a quantum well having a bottom of conduction band with an energy described by a curve of second order. As a result, the energy levels in the wells were equally spaced and by applying an appropriate voltage electrons of different energy levels could tunnel through the barriers between the layer sequences (cf. Figure 3). As a result, the peak current at resonance was large and decreased sharply if the voltage deviated from the appropriate bias voltage. In contrast, D3 (see D6e, page 3, lines 10 to 3 from bottom) disclosed that in the conventional device shown in Figure 2 a resonant tunnel current only flowed between two ground levels 13 in wells adjacent to a high field region 22. D3 furthermore pointed out that in the device of Figure 4 there was a region 44 where a concentrated field drop was produced "as in the conventional superlattice shown in Fig.2" (D6e, page 5, lines 11, 12).

In the device shown in Figure 4, three energy levels on either side of the region 44 matched and a current flowed exclusively between the first and the second wells, as clearly indicated by the arrows between said wells. The absence of arrows between the other wells was a clear indication that there was no current between them. Although it could not be excluded that electrons might be transported via a statistical distribution through the device, D3 did not disclose a continuous flow between all wells as in the present application.

Although it was specified in D3 that the sinusoidal energy profile resulted in "approximately regular intervals", no basis for this expression could be found either in the French translation D6 or in the English translation (D6e). D6 (page 3, last paragraph) disclosed that the intervals between the energy levels were "quasiment équivalentes", whereas D6e (page 5, lines 15 to 17) specified that the "potential well levels... become matched in plural sets". Since the device according to D3 already showed matching energy levels in two adjacent wells, the skilled person would not have any reason to modify the energy profile.

With respect to a possible combination of D3 with document D1 or D4, the parabolic profile in Figure 3b of D1 related to a **single** well. Furthermore, the parabolic wells referred to in D1 were not used with an applied electric field. In fact, D1 pointed out that an electric field in a symmetric double barrier structure would result in a decrease of the transmission (see page 1856, right column, lines 15 to 16 of Section "D"). This teaching was also confirmed in D5 (reference [32] of D1) (page 1366, left column, 2nd paragraph). Therefore, documents D1 and D5 expressed a clear prejudice against the use of a parabolic profile together with an electric field.

A further reason why the skilled person would not have considered the teaching of D1 was that it suggested a different solution to the problem addressed by the present application. In fact, D1 taught that, in order to improve its negative differential resistance (NDR) characteristic, an NDR device should be operated at temperatures below 150 K (see page 1863, left column, last paragraph). Therefore, the skilled person wishing to increase the current through an NDR device could equally follow the teaching of D1 and lower the operating temperature. In this context, it should also be noted that the measurements discussed in D4 had been made at the extremely low temperature of 5 K.

Another alternative solution to the problem of increasing the total current through an NDR device would be to increase its size. As a still further possibility of improvement, D1 disclosed the structures in Figures 12, 16 and 17, which showed that selection of potential well structures of different rectangular profiles could equally lead to an increase in the current density. In fact, in the structures shown in Figures 2 and 4 of D3 the electric field was concentrated between the first and second well, as shown by the arrows 21 and 41 to 43. In the structures shown in the above Figures of D1 such regions did not exist, therefore the current could flow without the limitations of the structures of D3. This provided a clear incentive for the skilled person to modify the structure of D3 in the sense of Figure 12, 16 and 17 of D1.

In D4 (see page 3741, section "Discussion") it was found that no particular regularity for the electron energy levels in a parabolic profile could be expected. In particular, it was discussed that equation (4) representing the energy levels of a parabolic profile did not match the experimental values. Therefore, the skilled person could not rely on a parabolic profile to obtain electron energy levels which matched better than those shown in D3.

As to claim 1 of the **first auxiliary request**, D3 did not disclose an optical or light emitting device. Furthermore, D1 related to a theoretical disclosure, and no reason could be seen why the skilled person should combine the photoconductors discussed in Section "IV" of that document with a parabolic well as shown in Figure 3b, which related to a resonant tunnelling transistor.

In contrast to other semiconductor lasers, the light emitting device according to the application was not based on electron-hole recombination but on electrons undergoing transitions between energy levels in an electric field. This principle was illustrated in Figure 4 of the application by the arrow "F" and was explained in column 4, line 64 of the published application.

As to the hot-electron transistor defined in claims 14 to 18 of the first auxiliary request, neither D1 nor D3 showed a quantum well structure between the emitter and the base. In D1 such a structure was only disclosed in the base of the transistor. It was not obvious why a person skilled in the art would replace that structure by the particular structure of the present invention. D2 showed a hot-electron transistor comprising a superlattice disposed between the emitter and the base layer; thus, to arrive at the present invention, it would be necessary to combine the teachings of the **three** documents D1, D2 and D3. This was a clear indication that the subject-matter of claim 14 involved an inventive step.

With respect to the **second auxiliary request**, claim 1 defined in addition to the claim of the main request that the energy curve of second order in the well was obtained by varying the aluminum content in the aluminum gallium arsenide ($Al_xGa_{1-x}As$) composition with a curve of second order. This was not obvious in the light of the prior art, because D1 merely referred to a "grading" from $Al_{0.45}Ga_{0.55}As$ to GaAs; D6e disclosed the sinusoidal variation of the well profile by increasing and decreasing the Al dose sinusoidally with time; and D4 taught the use of alternating layers with varying thicknesses.

With respect to the **third auxiliary request**: the expression "having a thickness which is sufficiently small to maintain the coherence of the electron movement" objected to by the Board under Article 123(2) EPC found support in the published application, column 4, lines 36 to 40, which implied that the motion of the electrons was coherent in order to enable coherent emission in the light emitting device. This information was also deducible from column 5, lines 39 to 40, which disclosed the embodiment in Figure 6 which related to a laser.

The arguments in favour of the **fourth auxiliary request** relating to a hot electron transistor had already been presented in relation to claim 14 of the first auxiliary request.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 Article 123(2) EPC

According to the appellant, claim 1 of the main request is based on the combined features of claims 1 and 10 as filed, and is further supported by column 4, lines 1 to 19 and 53 to 59, of the published application. The dependent claims are equally based on the original dependent claims. The Board is therefore satisfied that the main request meets the requirements of Article 123(2) EPC.

2.2 *Novelty*

2.2.1 The Board considers that the closest prior art is disclosed in document D3, which shows a semiconductor device comprising a quantum well structure including a sequence of quantum wells arranged between respective barrier layers (see Figure 3). Furthermore, the device of D3 comprises means for applying an electric field across the quantum well structure, (cf. Figure 4 and Figure 3).

2.2.2 The material composition of the quantum well structure in the device of D3 is such that the bottom of the conduction band has a potential energy distribution which varies with a sinusoidally shaped curve. According to the English abstract of D3, this energy distribution profile causes an arrangement of the energy levels in the well at "approximately regular intervals", which upon application of a voltage across the device allows a coincidence of a plurality of energy levels between adjacent wells and hence an increase of the resonant tunnel current. This also follows from D6e, page 5, lines 8 to 9.

2.2.3 The subject-matter of claim 1 according to the main request differs from the device according to D3 in that the energy distribution at the bottom of the conduction band is described by a curve of second order whereas the distribution in the device of D3 is sinusoidal. Hence, the subject-matter of this claim is new over the disclosure in D3.

2.3 Inventive step

2.3.1 The technical problem to be solved by the above feature can be seen in increasing the current tunnelling through the barriers between the wells.

As explicitly mentioned in D3, the selection of a sinusoidal profile allows the distribution of energy levels in the wells at approximately regular intervals, which leads to an increase of the resonant tunnel current. A skilled person wishing to increase the tunnel current even further would attempt to arrange the energy levels in the wells at equally spaced intervals to improve the matching of the levels when an electric field is applied. To this aim the skilled person would consult document D1 which is concerned with the same technical problem of optimising resonant tunnelling and perpendicular transport in superlattices (see title of D1). On page 1856, right hand column, last paragraph, D1 discloses that in order to obtain equally spaced resonances (i.e. energy levels) a parabolic potential energy profile, i.e. a curve of second order, should be selected. On page 1857, left column, lines 1 to 2, the authors mention in this respect a reference [38], corresponding to D4, where such a profile has been obtained.

Therefore, by modifying the sinusoidal energy profile in the device of D3 by using the teachings of either D1 or D4 in order to obtain the optimum equidistant energy levels spacing and to maximise the resonant tunnelling current, the skilled person would arrive at the subject-matter of claim 1 of the main request without needing inventive skill.

The same teaching is given in document D5, page 1367, left column, penultimate paragraph, which reads "To achieve equally spaced resonances in the collector current, the rectangular quantum well in the base should be replaced by a parabolic one [Fig.2(b)]".

2.3.2 With respect to the appellant's submission that the skilled person reading the disclosure in D3 would not have had an incentive to increase the tunnelling rate by improving the regularity of the spacing of the energy intervals of the sinusoidal potential profile, the Board is of the opinion that D3 teaches directly and unambiguously that in prior art quantum wells with a square potential profile upon application of an electric field across the device a resonant tunnel current is limited because of the unequal energy intervals, which scale as $(n+1)^2$ (see D6e, page 4, line 5), and that the tunnel current can be improved by selection of the shape of the potential barriers. The solution offered in D3 is to select a sinusoidal potential profile, which, in a series expansion up to the second order, would correspond to a parabolic profile. It is acknowledged that D3 does not explicitly suggest further modifying the profile of the quantum well structure. However, documents D1, D4 or D5, clearly teach that, at least in theory, the ideal potential well shape for providing equidistant energy levels is a parabolic profile. Therefore, it would be obvious to the skilled person to use this information in order to further optimise the resonant tunnelling current in the device of D3 by tailoring the potential profile of the wells to correspond to a second order (parabolic) curve. The applicant's arguments that in particular D4 and D5 would teach against selecting a parabolic profile do not appear convincing. It is noted that D4 addresses some imperfections between the measured and the theoretically expected energy spacings for a parabolic profile. However, it is observed that the information of D4 is more related to refining the theoretical model for the partitioning of the energy-gap discontinuity Q_i in case of a parabolic well which apparently is not identical to the value for Q_i generally assumed for square quantum wells. Furthermore D4 points out that, for arriving at the equidistant energy spacing, the simple model of a parabolic quantum well assumes an infinite barrier height and one effective mass (see page 3742, left hand column, first full paragraph), and that the equations (1) and (4) of that document are only approximations (see page 3740, right hand column, lines 1 to 4). Therefore, D4, which is cited in D1, does not teach away from the parabolic model; it merely shows its imperfections. As a matter of fact, the present application relies on the equation of the harmonic oscillator, which is equivalent to equation (2) in D4, to define the energy levels.

2.3.3 The appellant's argument that the skilled person would not apply the teaching of D1 (Figure 3b) to replace the sinusoidal profile in the series of wells in D3 by a series of parabolic wells, because D1 shows "only one parabolic well" is not convincing, since the effect of the shape of the potential curve does not depend on the number of wells. Furthermore, D4 discusses a multiquantum well sample with ten parabolic potential periods (see page 3740, left hand column, section "Results", second paragraph).

2.3.4 The appellant has argued that D1, and in particular document D5 referred to in D1, teaches away from the use of an electric field in a symmetric double barrier structure because this would significantly reduce its transmission.

However, this teaching in D5 must be read in its proper context, which involves **coherent** tunnelling of the Fabry-Perot type, to be distinguished from the **incoherent** or sequential tunnelling. According to D1, Section IIA, page 1854, negative differential resistance and resonant tunnelling through a double barrier arise from momentum and energy conservation and do not require the presence of a Fabry-Perot effect. In Section IIB, pages 1854 to 1855, it is disclosed that in case of coherent tunnelling in order to achieve unity transmission it is crucial that the well is symmetrical, or that if the structure has an electric bias field the width of the right well barrier has to be optimised, as shown in Table I on page 1855. However, for observing this coherent resonant tunnelling the intrinsic resonance width must exceed or equal the collisional broadening (page 1855, right column, lines 14 to 6 from bottom). Since both document D3 and the application under appeal are silent about any requirement of using the device at very low temperatures, it must be assumed that its use is envisaged at room temperature (300 K). Furthermore, according to D1, a resonance enhancement is only visible for very narrow wells (<50 Å) and barrier thicknesses <30 Å. In this respect, a typical well/barrier width mentioned in D6e is 200 Å or "several hundred Å" (page 3, line 10 and line 17). Also in the application, column 5, lines 26 to 27, discloses a barrier width of 100 Å and a well width of 200 Å. According to D1, see page 1856, Table II, for a AlAs/GaAS structure comprising such well and barrier thicknesses and used at room temperature, the enhancing effect of the Fabry-Perot resonance is completely negligible. Therefore, the skilled person would not expect that an electric field applied across the structure of D3, modified according to the teaching of D1 so as to comprise a series of wells with a parabolic profile, would lead to a reduction of the transmission because resonant tunnelling in this device is based on the mechanism of sequential tunnelling.

Furthermore, D1 discloses (page 1854, Section IIA) that the Negative Differential Resistance is not limited to use of the device at cryogenic temperatures, and, therefore, the skilled person would not be discouraged from using the device at higher (room) temperatures.

2.3.5 Therefore claim 1 of the main request does not meet the requirements of Art.52(1) and 56 EPC.

3. *First auxiliary request*

3.1 Article 123(2) EPC

According to the appellant, support for the independent claims 1, 7 and 14 of this request is to be found in column 2, line 39 (light emitting device) and line 44 (light receiving device) and claim 3 as originally filed together with column 6, lines 37 to 43. The Board is satisfied that also the dependent claims find support in the original disclosure.

3.2 Novelty

The independent claims of this request represent a restriction of claim 1 of the main request. For the reasons given under point 2.2 above the subject-matter of these claims is therefore new.

3.3 Inventive step

3.3.1 Document D3 addresses the problem of increasing the resonant tunnel current in quantum well devices. D1 is also concerned with resonant tunnelling in quantum wells and discloses applications of resonant tunnelling in transistors and in optoelectronic devices (see abstract; see also Section VI). With respect to the light emitting device defined in claim 1 of the first auxiliary request, the application of sequential resonant tunnelling in such devices is shown in Figure 16 of D1.

As to claim 7, defining a light receiving device, the application of sequential resonant tunnelling in a photoconductive detector is shown in Figure 17 of D1.

As to the hot electron transistor defined in claim 14 of this request, resonant tunnelling transistors are discussed in Section IID of D1.

3.3.2 The subject-matters of claims 1 and 7 define a light emitting device and a light receiving device, the further features of these claims being identical to those of the semiconductor device according to the main request. Therefore, the additional technical information conveyed by these claims is the application of the semiconductor device according to the main request to a light emitting and a light receiving device. As shown in point 3.3.1 above, this general concept of the application of sequential resonant tunnelling in optoelectronic devices is extensively discussed in D1. Furthermore, with respect to the mechanism underlying the emission of radiation involved, Figure 16(a) and (b) and the accompanying description show both interwell (Figure 16(a)) and intrawell (Figure 16(b)) transitions, wherein in both cases the effect is based on electron transitions and not electron-hole recombination. Similarly, in Figure 17 of D1 it is shown that the photoconductive effect is based on photoexcitation within a well with subsequently sequential tunnelling to a neighbouring well. It is implicit that the same effects can be obtained with parabolic quantum wells.

As to the hot electron transistor defined in claim 14, document D1 not only discloses a hot electron transistor with parabolic well in the transistor base (page 1857, Figure 3(b)), but also discusses on the same page in the right-hand column, lines 4 to 8, a further embodiment in which the double barrier is placed in the emitter and separates the emitter from the base (cited as reference [40] by Yokoyama). A similar teaching from the same author is also disclosed in document D2. Therefore, before the priority date of the present application it was known that a double barrier tunnelling structure could be implemented in the base of the transistor, as shown in Figure 3(b) of D1, or, equally, at the base-emitter junction, as generally referred to in D1 and more specifically disclosed in D2. It would therefore be within the normal skill of the person skilled in the art to implement the multiquantum well structure of D3 with parabolic wells in the base-emitter junction of a resonant tunnelling transistor. Hence, it would be obvious to the person skilled in the art, who wished to improve resonant tunnelling in the well structure shown in D3, to rely on the parabolic well shape shown in D1 and to consider also the possibility of applying this improved well structure to the different devices referred to in D1. In conclusion, the independent claims of the first auxiliary request do not meet the requirements of Art.52(1) and 56 EPC.

4. *Second auxiliary request*

4.1 Article 123(2) EPC

The Board agrees with the appellant that claim 1 of this request combines the features of claim 1 of the main request and original claims 6 and 7. The requirements of Article 123(2) therefore are met.

4.2 Novelty

Claim 1 of this request involves a further restriction of claim 1 of the main request. For the reasons given under point 2.2 above the subject-matter of this claims is therefore new.

4.3 Inventive step

Claim 1 of the second auxiliary request specifies in addition to the features of claim 1 of the main request that the energy curve of second order in the well is obtained by varying the aluminium content *x* in the aluminium gallium arsenide ($Al_xGa_{1-x}As$) composition with a curve of second order. This feature is considered to be obvious, because D6e (page 5, last paragraph) discloses that a sinusoidal potential profile of the wells is obtained by varying the concentration of aluminium sinusoidally. The fact that in D6e this variation is expressed as a function of time does not render the claimed device inventive because it is to be expected that in the process of electron beam epitaxy referred to in D6e a variation of concentration with time corresponds linearly to a variation with respect to well depth. Since the present application is silent about the actual deposition process, no unexpected effects can be attributed to the claimed solution. Hence, the subject-matter of this claim does not involve an inventive step.

5. *Third auxiliary request*

5.1 Article 123(2) EPC

5.1.1 The independent claims 1, 7 and 13 of this request correspond to the independent claims 1, 7 and 13 of the first auxiliary request with the additional feature "said first and second barrier layers having a thickness which is sufficiently small to maintain the coherence of the electron movement". According to the appellant, support for this additional feature is to be found in column 4, lines 34 to 37.

5.1.2 As to the appellant's submission that coherent motion becomes possible when the barrier layer is sufficiently thin, which may be true in a general sense, no disclosure for such thin well and barrier layers can be found in the present application. On the contrary, the values of the respective thicknesses in the embodiments of Figures 5 and 6 strongly suggest that no coherence of adjacent wells by minibands exists. This follows also from Section III in D1, page 1859, lines 8 to 10, where it is stated that for a period in the order of or exceeding 100 Å the electrons are localised. The period in the embodiments of the present application is 300 Å (200 Å barrier and 100 Å well width), therefore no coherence can be expected.

Column 4, lines 34 to 40, indicated by the appellant relates to the phenomenon of induced emission of the light emitting device (claim 1). This mechanism does not occur in the light receiving device of claim 7, nor in the hot electron transistor of claim 11. It follows that the cited passage does not allow the inclusion of the objectionable feature in the independent claims.

Furthermore, with respect to the light emitting device, the above passage in column 4 discloses that the electrons move ballistically because of the increased tunnelling rate, thereby increasing the quantum efficiency of the device. The phrase "all of the excited electrons are subject to induced emission" does not mean that the movement of the electrons is coherent, because, as already discussed, at least in the embodiments in Figures 5 and 6 of the application, the conditions are such that the tunnelling process is sequential, which excludes any coherence. Rather, the above phrase must be construed in the sense that, as a result of the equidistant energy intervals, all excited electrons will contribute to the induced emission. This does not imply, however, that their motion during the tunnelling process should be coherent. In this context, it appears that the excitation of the electrons to the higher levels is basically similar to the one in other prior art laser systems, in which the pump radiation or pump electron beam incoherently excites the electrons in the laser material, which subsequently under influence of the induced electromagnetic field emit coherently. Therefore it is not the motion of the (ballistic) electrons which is coherent, but the emission of the radiation in the excited levels.

It is concluded that the claims of the third auxiliary request do not meet the requirements of Article 123(2) EPC.

6. *Fourth auxiliary request*

Claim 1 of this request is identical to claim 14 of the first auxiliary request. The claim is therefore not allowable for the reasons already set out in point 3.3 above.

7. In conclusion none of the requests on file meets the requirements of the European Patent Convention.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Beer G. Davies