



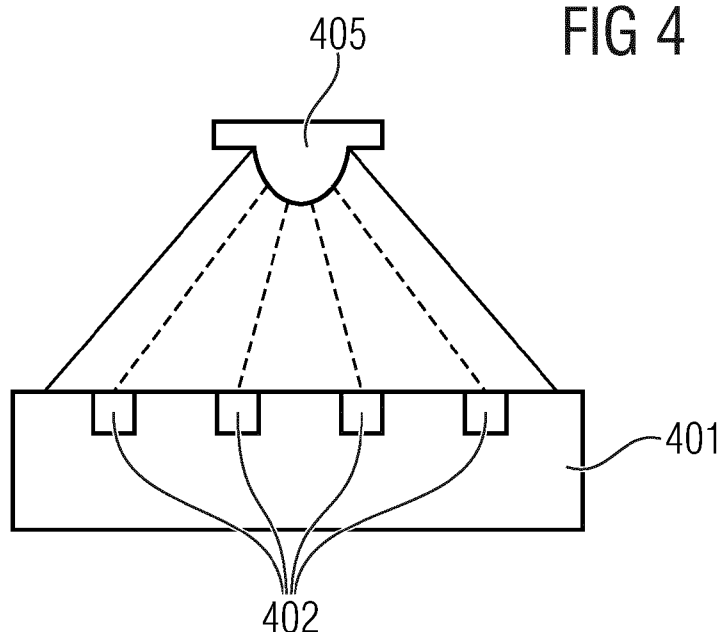
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(54) Title: HIGH FREQUENCY INTEGRATED CIRCUIT AND EMITTING DEVICE FOR IRRADIATING THE INTEGRATED CIRCUIT



(57) Abstract: The invention concerns a high-frequency integrated circuit (402) provided on a III-V compound semiconductor (401), wherein an emitting device (405) is radiation-coupled with the integrated circuit (402) such that the emitting device (405) irradiates the integrated circuit (402), and wherein the integrated circuit (402) comprises at least one of an oscillator, a mixer, a phase shifter, a frequency divider or an amplifier.

High Frequency Integrated Circuit and Emitting Device for Irradiating the Integrated Circuit

Embodiments of the present invention relate to a high-frequency electronic component with
5 the features of claim 1, a high-frequency integrated circuit with the features of claim 19, a
method for operating a high-frequency electronic component with the features of claim 27,
and a method for operating a high-frequency integrated circuit with the features of claim 29.

Electronic components may comprise integrated circuits being provided on semiconductor
chips. In particular compound semiconductors such as, for instance, semiconductors
10 manufactured using a III-V-technology, are able to generate effects with a remarkably large
time-constant. However, at the same time these semiconductors may show a slow transient
response, long settling times for static states and unwanted low-frequent oscillations.

For a highly performant design of such compound semiconductors countermeasures need to
be taken to avoid, or at least to suppress or attenuate the occurrence of these effects.

15 Thus, it is desirable to improve existing electronic components and integrated circuits.

According to a first aspect, a high-frequency electronic component is provided which
comprises a compound semiconductor chip comprising an integrated circuit. The electronic
component further comprises a board on which the semiconductor chip is arranged. The
board comprises a recess that is configured to receive an emitting device for irradiating the
20 integrated circuit. Thus, the inventive device is configured to irradiate the integrated circuit
during operation. As the emitting device is arranged, at least partially, within the recess
provided in the board, the emitting device can be securely retained in the board.
Furthermore, radiation emitted from the emitting device can be easily directed at the
compound semiconductor and at the integrated circuit. Radiation that is received by the
25 integrated circuit reduces the susceptibility of the integrated circuit to large time-constant
effects such as, for instance, low-frequent oscillations. As the compound semiconductor and
the integrated circuit are irradiated, these large time-constant effects are attenuated such
that low-frequent oscillations may be substantially removed from an electronic component.
Stated differently, the irradiation of the compound semiconductor and the integrated circuit
30 allows to attenuate and substantially suppress the occurrence of undesired large time-
constant effects like low-frequent oscillations.

According to a second aspect, a high-frequency integrated circuit is provided on a III-V
compound semiconductor. An emitting device is radiation-coupled with the integrated circuit

such that the emitting device irradiates the integrated circuit. The integrated circuit comprises at least one of an oscillator, a mixer, a phase shifter, a frequency divider or an amplifier. The emitting device emits radiation and thus acts as a radiation transmitter. The emitted radiation irradiates the integrated circuit being provided on the III-V compound semiconductor. Thus, the integrated circuit acts as a radiation receiver. Accordingly, the emitting device (transmitter) is radiation-coupled with the integrated circuit (receiver) and irradiates the latter. This irradiation of the integrated circuit has the technical effect that large time-constant effects are attenuated such that, e.g. low-frequent oscillations may be substantially removed. Stated differently, the irradiation of the integrated circuit allows to attenuate and substantially suppress the occurrence of undesired large time-constant effects like low-frequent oscillations.

According to a third aspect, a method for operating a high-frequency electronic component is provided, wherein the high-frequency electronic component comprises a compound semiconductor chip comprising an integrated circuit, a board on which the compound semiconductor chip is arranged and a recess in the board, wherein the recess is configured to receive an emitting device. The method comprises irradiating the integrated circuit with the emitting device. By irradiating the compound semiconductor chip and the integrated circuit according to the inventive concept, large time-constant effects such as, for instance, low-frequent oscillations are attenuated such that low-frequent oscillations may be substantially removed from an electronic component. Stated differently, irradiating the compound semiconductor chip and the integrated circuit according to the inventive concept allows to attenuate and substantially suppress the occurrence of undesired large time-constant effects like low-frequent oscillations.

According to a fourth aspect, a method for operating a high-frequency integrated circuit is provided, wherein the high-frequency integrated circuit comprises a III-V compound semiconductor and wherein the integrated circuit comprises at least one of an oscillator, a mixer, a phase shifter, a frequency divider or an amplifier. The method comprises irradiating the integrated circuit with an emitting device that is radiation-coupled with the integrated circuit. By irradiating the III-V compound semiconductor chip and the integrated circuit according to the inventive concept, large time-constant effects such as, for instance, low-frequent oscillations are attenuated such that low-frequent oscillations may be substantially removed from an electronic component. Stated differently, irradiating the III-V compound semiconductor chip and the integrated circuit according to the inventive concept allows to attenuate and substantially suppress the occurrence of undesired large time-constant effects like low-frequent oscillations.

According to an embodiment, the emitting device is a radiation emitting device that is configured to emit visible light, infra-red light, ultraviolet light, gamma radiation or x-radiation (roentgen radiation).

5 According to an embodiment, the emitting device is a light emitting device. It is desirable to use a LED (Light Emitting Diode) as the light emitting device, as a LED has a low power consumption and can be easily controlled regarding the emission of various colored light having different wavelengths.

10 According to an embodiment, the LED emits infra-red light at a wavelength between 780 nm and 1400 nm, preferably between 840 nm and 860 nm, and more preferably at a wavelength of 850 nm.

According to a further embodiment, the LED emits red light at a wavelength between 630 nm and 790 nm, preferably between 640 nm and 660 nm, and more preferably at a wavelength of 650 nm.

15 According to still a further embodiment, the LED emits yellow light at a wavelength between 530 nm and 630 nm, preferably between 580 nm and 600 nm, and more preferably at a wavelength of 590 nm.

The above mentioned wavelength spectra, i.e. infra-red light, red light and yellow light, are particularly preferable for illuminating the integrated circuit as undesired large time-constant effects such as, for instance, low-frequent oscillations, are substantially removed.

20 In a further embodiment, the LED emits green light at a wavelength between 480 nm and 580 nm, preferably between 560 nm and 580 nm, and more preferably at a wavelength of 574 nm.

25 In still a further embodiment, the LED emits blue light at a wavelength between 380 nm and 497 nm, preferably between 458 nm and 478 nm, and more preferably at a wavelength of 468 nm.

The above mentioned wavelength spectra, i.e. green light and blue light, are preferable for illuminating the integrated circuit as undesired large time-constant effects such as, for instance, low-frequent oscillations, are measurably attenuated. According to the present invention, the irradiation or illumination of the integrated circuit with either green or blue light
30 provides an attenuation of the low-frequent oscillations by up to 70% compared to a non-illuminated circuit.

In the following, embodiments of the present invention are described in more detail with reference to the figures, in which

- Fig. 1A shows a top view of a high-frequency electronic component according to an embodiment,
- 5 Fig. 1B shows a cross-sectional view of the high-frequency electronic component along the cross-section line I-I shown in Figure 1A,
- Fig. 2A shows a perspective view of a high-frequency electronic component according to an embodiment,
- 10 Fig. 2B shows a side cross-sectional view of the high-frequency electronic component along the cross-section line II-II shown in Figure 2A,
- Fig. 3A shows a side cross-sectional view of a high-frequency electronic component according to further embodiment,
- Fig. 3B shows a side cross-sectional view of a high-frequency electronic component according to further embodiment,
- 15 Fig. 3C shows a side cross-sectional view of a high-frequency electronic component according to further embodiment,
- Fig. 4 shows a high-frequency integrated circuit provided on a III-V semiconductor according to an aspect of the invention,
- 20 Fig. 5A shows a frequency spectrum that has been recorded during operation of an inventive device without irradiation,
- Fig. 5B shows a frequency spectrum that has been recorded during operation of an inventive device with irradiation according to the present invention,
- Fig. 6A shows a frequency spectrum that has been recorded during operation of an inventive device without irradiation,
- 25 Fig. 6B shows a frequency spectrum that has been recorded during operation of an inventive device while irradiating the device with infra-red light,
- Fig. 6C shows a frequency spectrum that has been recorded during operation of an inventive device while irradiating the device with red light,

Fig. 6D shows a frequency spectrum that has been recorded during operation of an inventive device while irradiating the device with yellow light,

Fig. 6E shows a frequency spectrum that has been recorded during operation of an inventive device while irradiating the device with green light, and

5 Fig. 6F shows a frequency spectrum that has been recorded during operation of an inventive device while irradiating the device with blue light.

Equal or equivalent elements or elements with equal or equivalent functionality are denoted in the following description by equal or equivalent reference numerals.

10 Figure 1A shows a top view of a high-frequency electronic component 100 according to an embodiment. The high-frequency electronic component 100 comprises a compound semiconductor chip 101 comprising an integrated circuit 102. The high-frequency electronic component 100 further comprises a board 103 on which the compound semiconductor chip 101 is arranged or mounted.

15 Figure 1B shows the high-frequency electronic component 100 of Figure 1A in a side cross-sectional view along the line I-I. The board 103 comprises a recess 104 in which an emitting device 105 is provided. The emitting device 105 is configured to irradiate the integrated circuit 102. The emitting device 105 may also be configured to at least partially irradiate the semiconductor chip 101.

20 As can be seen, the integrated circuit 102 is provided on a side 101a of the compound semiconductor chip 101 facing away from the board 103. Thus, radiation emitted from the emitting device 105 may at least partially penetrate the compound semiconductor chip 101. Additionally or alternatively, the integrated circuit 102 may be provided on a side 101b of the semiconductor chip 101 facing towards the board 103.

25 The compound semiconductor chip 101 comprises a III-V semiconductor. These compound semiconductors comprise at least one of the chemical group III elements such as, for instance, boron, aluminum, gallium and indium, and at least one of the chemical group V elements such as, for instance, nitrogen, phosphorus, arsenic, antimony and bismuth. These elements can form binary, ternary or quaternary alloys. In an embodiment, the compound semiconductor chip 101 comprises Gallium Arsenide. In an alternative embodiment, the
30 compound semiconductor chip 101 comprises Indium Phosphide or Gallium Nitride.

The integrated circuit 102 is a Monolithic Microwave Integrated Circuit (MMIC). The MMIC is an integrated circuit that operates at high frequencies, i.e. at microwave frequencies or RF

frequencies. The MMIC is operated at frequencies between 100 MHz and 300 GHz. In a preferred embodiment, the MMIC is operated at frequencies between 1 GHz and 6 GHz, and more preferably between 2,3 GHz and 5,1 GHz.

5 In an embodiment, the integrated circuit 102 comprises at least one of a frequency mixer, a phase shifter, an oscillator, a frequency divider or an amplifier.

Figure 2A shows a bottom perspective view of an embodiment of a high-frequency electronic component 200, wherein the compound semiconductor chip 201 is an unhoused semiconductor chip that is arranged at least partially within an open cavity 208 provided in a package carrier structure 209.

10 The package carrier structure 209 comprises a bottom side 210 that faces towards the board 203 on which the package carrier structure 209 is to be mounted (see Figure 2B). The package carrier structure 209 further comprises a top side 211 that faces away from the board 203.

The package carrier structure 209 is configured to carry the compound semiconductor chip 201. Thus, the package carrier structure 209 comprises a cavity 208 in which the compound semiconductor chip 201 is at least partially arranged. The cavity 208 is preferably provided as an opening within the package carrier structure 209. Stated differently, the bottom side 210 and the top side 211 each comprise an opening reaching through the package carrier structure 209. It may also be possible that one of the openings formed in the bottom or top sides 210, 211 may be closed. For example, the opening provided in the top side 211 may be covered with part of the package carrier structure 209 or with a separate lid, both of which may comprise a transparent window. The opening provided in the bottom side 210 may be covered with a transparent window material.

25 The compound semiconductor chip 201 is mechanically and electrically coupled and/or connected with the package carrier structure 209 by means of bonding wires 207a, 207b, 207c, 207d. The compound semiconductor chip 201 is spatially distanced from the walls of the cavity 208, i.e. from the inside walls of package carrier structure 209, by the bonding wires 207a-d.

30 Figure 2B shows a side cross-sectional view of the package carrier structure 209 along the cross-section line II-II in Figure 2A. As can be seen, the compound semiconductor chip 201 is approximately arranged in the middle of the cavity 208 and connected to the package carrier structure 209 by means of the bonding wires of which only bonding wires 207a and 207c are shown.

The board 203 comprises a recess 204 in which an emitting device 205 is arranged. The recess 204 is provided underneath the cavity 208 of the package carrier structure 209. More precisely, the recess 204 is provided underneath the compound semiconductor chip 201. The measures, i.e. the dimensions or circumference of the recess 204 substantially corresponds to the measures, i.e. the dimensions or circumference of the compound semiconductor chip 201. In other words, the recess 204 and the compound semiconductor 201 may have substantially the same size. In an alternative embodiment, the recess 204 and the cavity 208 provided in the package carrier structure 209 may have substantially the same size.

As mentioned above, the package carrier structure 209 is mounted on the board 203 by means of solder bumps 206. As shown in Figure 2A, the solder bumps 206 are circumferentially arranged along the bottom side 210 of the package carrier structure 209. By said solder bumps 206 the package carrier structure 209 and, thus, the connected compound semiconductor chip 201 comes into mechanical and electrical contact with the board 203. Accordingly, the board 203 comprises a contact area, that may be defined by the contacting solder bumps 206, in which the compound semiconductor chip 201 is in contact with the board 203. As shown in Figure 2B, the recess 204 in the board 203 is provided inside said contact area such that the contact area surrounds the recess 204.

Figure 3A shows a further embodiment of a high-frequency electronic component 300A according to the invention. A compound semiconductor 301 is provided in a package carrier structure 309, as described before with reference to Figures 2A and 2B. The package carrier structure 309, and thus the compound semiconductor 301 being provided in the package carrier structure 309, is mounted on the board 303 by means of solder bumps 306. The upper side of the board 303 on which the compound semiconductor chip 301 is mounted 303 is also referred to as a mounting side 312. The side 313 opposite the mounting side 312 is also referred to as a bottom side 313.

The recess 304 provided in the board 303 is formed as a through-hole extending through the board 303. Accordingly, the through hole 304 extends from the bottom side 312 of the board 303 to the mounting side 312 of the board 303.

An emitting device 305 is provided at the bottom side 313 of the board 303. In this embodiment, the emitting device 305 is a light emitting diode (LED), more particular a reverse-mount LED. The reverse-mount LED 305 comprises an active area 305a which is capable of emitting light, as indicated by dashed lines. The reverse-mount LED 305 further comprises an inactive area 305b that serves as a mounting portion or substrate for the active area 305a of the LED 305.

The inactive area 305b of the LED 305 comes into contact with the bottom side 313 of the board 303. The contacting surfaces of the inactive area 305b of the LED 305 and the bottom side 313 of the board 303 may be connected to each other via an adhesive or by welding, soldering, bonding or the like. The inactive area 305b of the LED 305 is arranged outside the
5 recess or through-hole 304, while the active area 305a of the LED 305 is arranged inside the recess or through-hole 304. Accordingly, the LED 305 extends at least partially into the recess or through-hole 304.

Figure 3B shows a further embodiment of a high-frequency electronic component 300B according to the invention. Same elements are referenced with same numerals as in Figure
10 3A. The difference to the embodiment shown in Figure 3A is that the compound semiconductor chip 301 and the integrated circuit 302 arranged thereon are at least partially arranged inside the recess or through-hole 304.

Figure 3C shows a further embodiment of a high-frequency electronic component 300C according to the invention. Same elements are referenced with same numerals as in Figures
15 3A and 3B. The difference to the embodiments shown in Figures 3A and 3B is that the LED 305, or at least the active area 305a of the LED 305, extends through the recess or through-hole 304 from the bottom side 313 of the board 303 to the mounting side 312 of the board 303. The active area 305a protrudes from the mounting side 312 of the board 303.

Accordingly, in the embodiment shown in Figure 3C, the integrated circuit 302 is optically
20 coupled with the light emitting device 305. Generally speaking, the integrated circuit 302 is radiation-coupled with an emitting device 305. In the embodiments shown in Figures 3A and 3B, the integrated circuit 302 is optically coupled with the light emitting device 305 and the recess 304. Generally speaking, the integrated circuit 302 is radiation-coupled with the emitting device 305 and the recess 304.

As shown in Figure 3A, the emitting device 305 comprises an irradiation angle 314 that is
25 configured to irradiate the entire integrated circuit 302. With respect to the above described LED 305, the light emitting device 305 comprises an illumination angle 314 that is configured to illuminate the entire integrated circuit 302 arranged on the compound semiconductor chip 301. In this embodiment, the LED 305 also illuminates the entire compound semiconductor
30 chip 301. Though not explicitly shown, the same applies to the light emitting devices 305 as shown in Figures 3B and 3C.

Figure 4 shows a further embodiment according to a second aspect of the invention, wherein a high-frequency integrated circuit 402 is provided on a III-V compound semiconductor 401. An emitting device 405 is provided that is radiation-coupled with the integrated circuit 402,

indicated by dashed lines. Thus, the emitting device 405 irradiates the integrated circuit 402. The integrated circuit 402 comprises at least one of an oscillator, a frequency mixer, a frequency divider, a phase shifter or an amplifier.

In an embodiment, the high-frequency integrated circuit 402 is a Monolithic Microwave Integrated Circuit (MMIC). The III-V compound semiconductor 401 preferably comprises Gallium Arsenide. The emitting device 405 may be a light emitting diode (LED).

All of the embodiments shown throughout Figures 1 to 4 solve the problem of improving existing electronic components and integrated circuits such that large time-constant effects, for example low-frequent oscillations, are attenuated or even avoided. Experiments have been made in order to prove the technical effect of the inventive concept. The results of these experiments shall be discussed in detail in the following with reference to Figures 5A to 6F.

Figure 5A shows a frequency spectrum 500A that has been recorded while operating a device according to the present invention as it has been described, for example, with reference to Figures 1 to 4 but with the emitting device being switched off. An RF semiconductor design has been examined that was not irradiated with an emitting device.

The emitting device has been a light emitting device, in particular a LED. As can be seen in the frequency spectrum 500A, the oscillations present occur in the frequency range of 0.5 kHz to 4 kHz. When operating the device, without irradiating it, this oscillation gets upconverted towards the RF frequency as shown in Figure 5A. As can be seen, there is a main peak 501 at about 2,9499755 MHz. Two peaks 502, 503 of less intensity occur left and right from the main peak 501, which two lower level peaks 502, 503 represent the upconverted low-frequent oscillations.

Figure 5B shows a frequency spectrum 500B that has been recorded while operating the same inventive device but with the emitting device, i.e. the LED, being switched on, i.e. the examined RF semiconductor has been irradiated by the emitting device. As can be seen, the upconverted low-frequent oscillations 502, 503 are no longer measurably existent. Accordingly, the large time-constant effects have been attenuated. In this case, they have even been removed from the frequency spectrum.

Figures 6B to 6F show further frequency spectra that have been recorded during operation of an inventive device while illuminating said device with light of different wavelengths.

Figure 6A serves as a reference, where the examined inventive device was not illuminated by a light emitting device according to the invention. As described above with reference to

Figure 5A, the signal 601 at the marker position (marked with number '1') is the only intended one. The peaks left and right from the marked signal 601 represent undesired signals resulting from large time-constant effects.

5 Figure 6B shows the results of an evaluation in which the inventive device was illuminated with a LED emitting infra-red light with a lambda peak of 850 nm. As can be seen, the desired signal 601 is clean and the undesired side signal peaks are removed.

Figure 6C shows the results of an evaluation in which the inventive device was illuminated with a LED emitting red light with a lambda peak (λ_{PEAK}) of 650 nm. As can be seen, the desired signal 601 is clean and the undesired side signal peaks are removed.

10 Figure 6D shows the results of an evaluation in which the inventive device was illuminated with a LED emitting yellow light with a lambda peak (λ_{PEAK}) of 590 nm. As can be seen, the desired signal 601 is clean and the undesired side signal peaks are removed.

Figure 6E shows the results of an evaluation in which the inventive device was illuminated with a LED emitting green light with a lambda peak (λ_{PEAK}) of 574 nm. As can be seen, the
15 undesired side signal peaks are still present but they are attenuated by more than 50% compared to the spectral power in the non-illuminated reference case shown in Figure 6A.

Figure 6F shows the results of an evaluation in which the inventive device was illuminated with a LED emitting blue light with a lambda peak (λ_{PEAK}) of 468 nm. As can be seen, the
20 undesired side signal peaks are still present but they are attenuated by more than 50% compared to the spectral power in the non-illuminated reference case shown in Figure 6A.

Although some aspects have been described in the context of an apparatus, it is clear that these aspects also represent a description of the corresponding method, where a block or device corresponds to a method step or a feature of a method step. Analogously, aspects described in the context of a method step also represent a description of a corresponding
25 block or item or feature of a corresponding apparatus.

The inventive decomposed signal can be stored on a digital storage medium or can be transmitted on a transmission medium such as a wireless transmission medium or a wired transmission medium such as the Internet.

Depending on certain implementation requirements, embodiments of the invention can be
30 implemented in hardware or in software. The implementation can be performed using a digital storage medium, for example a floppy disk, a DVD, a CD, a ROM, a PROM, an EPROM, an EEPROM or a FLASH memory, having electronically readable control signals

stored thereon, which cooperate (or are capable of cooperating) with a programmable computer system such that the respective method is performed.

Some embodiments according to the invention comprise a non-transitory data carrier having electronically readable control signals, which are capable of cooperating with a programmable computer system, such that one of the methods described herein is performed.

Generally, embodiments of the present invention can be implemented as a computer program product with a program code, the program code being operative for performing one of the methods when the computer program product runs on a computer. The program code may for example be stored on a machine readable carrier.

Other embodiments comprise the computer program for performing one of the methods described herein, stored on a machine readable carrier.

In other words, an embodiment of the inventive method is, therefore, a computer program having a program code for performing one of the methods described herein, when the computer program runs on a computer.

A further embodiment of the inventive methods is, therefore, a data carrier (or a digital storage medium, or a computer-readable medium) comprising, recorded thereon, the computer program for performing one of the methods described herein.

A further embodiment of the inventive method is, therefore, a data stream or a sequence of signals representing the computer program for performing one of the methods described herein. The data stream or the sequence of signals may for example be configured to be transferred via a data communication connection, for example via the Internet.

A further embodiment comprises a processing means, for example a computer, or a programmable logic device, configured to or adapted to perform one of the methods described herein.

A further embodiment comprises a computer having installed thereon the computer program for performing one of the methods described herein.

In some embodiments, a programmable logic device (for example a field programmable gate array) may be used to perform some or all of the functionalities of the methods described herein. In some embodiments, a field programmable gate array may cooperate with a microprocessor in order to perform one of the methods described herein. Generally, the methods are preferably performed by any hardware apparatus.

The above described embodiments are merely illustrative for the principles of the present invention. It is understood that modifications and variations of the arrangements and the details described herein will be apparent to others skilled in the art. It is the intent, therefore, to be limited only by the scope of the impending patent claims and not by the specific details presented by way of description and explanation of the embodiments herein.

5

Claims

1. A high-frequency electronic component (100, 200, 300) comprising
a compound semiconductor chip (101, 201, 301) comprising an integrated
5 circuit (102, 202, 302),
a board (103, 203, 303) on which the compound semiconductor chip (101,
201, 301) is arranged,
wherein the board (103, 203, 303) comprises a recess (104, 204, 304) that is
10 configured to receive an emitting device (105, 205, 305) for irradiating the integrated
circuit (102, 202, 302).
2. The high-frequency electronic component of claim 1, wherein the compound
semiconductor chip (101, 201, 301) comprises a III-V semiconductor.
3. The high-frequency electronic component of one of claims 1 or 2, wherein the
compound semiconductor chip (101, 201, 301) comprises Gallium Arsenide.
- 15 4. The high-frequency electronic component of one of claims 1 or 2, wherein the
compound semiconductor chip (101, 201, 301) comprises at least one of Indium
Phosphide and Gallium Nitride.
5. The high-frequency electronic component of one of the preceding claims, wherein the
integrated circuit (102, 202, 302) is a Monolithic Microwave Integrated Circuit.
- 20 6. The high-frequency electronic component of one of the preceding claims, wherein the
emitting device (105, 205, 305) is configured to emit visible light, infra-red light,
ultraviolet light, gamma radiation or x-radiation.
7. The high-frequency electronic component of one of the preceding claims, wherein the
emitting device is a light emitting device (105, 205, 305), in particular a light emitting
25 diode.
8. The high-frequency electronic component of one of the preceding claims, wherein the
emitting device (105, 205, 305) emits infra-red light at a wavelength between 780 nm
and 1400 nm, preferably between 840 nm and 860 nm, and more preferably at a
wavelength of 850 nm.

9. The high-frequency electronic component of one of claims 1 to 7, wherein the emitting device (105, 205, 305) emits red light at a wavelength between 630 nm and 790 nm, preferably between 640 nm and 660 nm, and more preferably at a wavelength of 650 nm.
- 5 10. The high-frequency electronic component of one of claims 1 to 7, wherein the emitting device (105, 205, 305) emits yellow light at a wavelength between 530 nm and 630 nm, preferably between 580 nm and 600 nm, and more preferably at a wavelength of 590 nm.
- 10 11. The high-frequency electronic component of one of claims 1 to 7, wherein the emitting device (105, 205, 305) emits green light at a wavelength between 480 nm and 580 nm, preferably between 560 nm and 580 nm, and more preferably at a wavelength of 574 nm.
12. The high-frequency electronic component of one of claims 1 to 7, wherein the emitting device (105, 205, 305) emits blue light at a wavelength between 380 nm and 497 nm, preferably between 458 nm and 478 nm, and more preferably at a wavelength of 468 nm.
- 15 13. The high-frequency electronic component of one of the preceding claims, wherein the compound semiconductor chip (101, 201, 301) is an unhoused semiconductor chip that is arranged at least partially within an open cavity (308) provided in a package carrier structure (309).
- 20 14. The high-frequency electronic component of one of the preceding claims, wherein the board (103, 203, 303) comprises a contact area in which the semiconductor chip (101, 201, 301) is in contact with the board (103, 203, 303), and wherein the recess (104, 204, 304) in the board (103, 203, 303) is provided inside said contact area such that the contact area surrounds the recess (104, 204, 304).
- 25 15. The high-frequency electronic component of one of the preceding claims, wherein the board (303) comprises a mounting side (312) on which the semiconductor chip (301) is mounted, wherein the recess (304) is formed as a through-hole extending through the board (303), and wherein the emitting device (305) is arranged on the side (313) opposite the mounting side (312) and extends at least partially into said through-hole (304).
- 30 16. The high-frequency electronic component of one of the preceding claims, wherein the integrated circuit (102, 202, 302) is at least partially arranged inside the recess (104,

204, 304) and/or radiation-coupled with the recess (104, 204, 304) and/or radiation-coupled with the emitting device (105, 205, 305).

17. The high-frequency electronic component of one of the preceding claims, wherein the emitting device (105, 205, 305) comprises an irradiation angle (314) that is configured to irradiate the entire integrated circuit (102, 202, 302).

18. The high-frequency electronic component of one of the preceding claims, wherein the integrated circuit (102, 202, 302) comprises at least one of a mixer, a phase shifter, a frequency divider, an oscillator or an amplifier.

19. A high-frequency integrated circuit (102, 202, 302, 402) provided on a III-V compound semiconductor (101, 201, 301, 401),

wherein an emitting device (105, 205, 305, 405) is radiation-coupled with the integrated circuit (102, 202, 302, 402) such that the emitting device (105, 205, 305, 405) irradiates the integrated circuit (102, 202, 302, 402), and

wherein the integrated circuit (102, 202, 302, 402) comprises at least one of an oscillator, a mixer, a phase shifter, a frequency divider or an amplifier.

20. The high-frequency integrated circuit of claim 19, wherein the high-frequency integrated circuit (102, 202, 302, 402) is a Monolithic Microwave Integrated Circuit.

21. The high-frequency integrated circuit of claim 19 or 20, wherein the III-V compound semiconductor (101, 201, 301, 401) comprises Gallium Arsenide.

22. The high-frequency electronic component of one of claims 19 to 21, wherein the emitting device (105, 205, 305, 405) is configured to emit visible light, infra-red light, ultraviolet light, gamma radiation or x-radiation.

23. The high-frequency integrated circuit of one of claims 19 to 22, wherein the emitting device (105, 205, 305, 405) is a light emitting device, in particular a light emitting diode.

24. The high-frequency integrated circuit of one of claims 19 to 23, wherein the emitting device (105, 205, 305, 405) emits infra-red light at a wavelength between 780 nm and 1400 nm, preferably between 840 nm and 860 nm, and more preferably at a wavelength of 850 nm.

25. The high-frequency integrated circuit of one of claims 19 to 23, wherein the emitting device (105, 205, 305, 405) emits red light at a wavelength between 630 nm and 790

nm, preferably between 640 nm and 660 nm, and more preferably at a wavelength of 650 nm.

26. The high-frequency integrated circuit of one of claims 19 to 23, wherein the emitting device (105, 205, 305, 405) emits yellow light at a wavelength between 530 nm and 630 nm, preferably between 580 nm and 600 nm, and more preferably at a wavelength of 590 nm.

27. A method for operating a high-frequency electronic component (100, 200, 300), the high-frequency electronic component comprising

a compound semiconductor chip (101, 201, 301) comprising an integrated circuit (102, 202, 302), a board (103, 203, 303) on which the compound semiconductor chip (101, 201, 301) is arranged, and a recess (104, 204, 304) provided in the board (103, 203, 303), wherein the recess (104, 204, 304) is configured to receive an emitting device (105, 205, 305),

wherein the method comprises irradiating the integrated circuit (102, 202, 302) with the emitting device (105, 205, 305).

28. The method of claim 27, wherein the compound semiconductor chip (101, 201, 301) comprises a III-V semiconductor.

29. A method for operating a high-frequency integrated circuit (102, 202, 302, 402) comprising a III-V compound semiconductor, wherein the integrated circuit (102, 202, 302, 402) comprises at least one of an oscillator, a mixer, a phase shifter, a frequency divider or an amplifier,

wherein the method comprises irradiating the integrated circuit (102, 202, 302, 402) with an emitting device (105, 205, 305, 405) that is radiation-coupled with the integrated circuit (102, 202, 302, 402).

30. The method of one of claims 27 to 29, wherein the compound semiconductor (101, 201, 301, 401) comprises Gallium Arsenide.

31. The method of one of claims 27 to 30, wherein the emitting device (105, 205, 305) is configured to emit visible light, infra-red light, ultraviolet light, gamma radiation or x-radiation.

32. The method of one of claims 27 to 31, wherein the emitting device (105, 205, 305, 405) is a light emitting diode that emits infra-red light at a wavelength between 780

nm and 1400 nm, preferably between 840 nm and 860 nm, and more preferably at a wavelength of 850 nm.

33. The method of one of claims 27 to 31, wherein the emitting device (105, 205, 305, 405) is a light emitting diode that emits red light at a wavelength between 630 nm and 790 nm, preferably between 640 nm and 660 nm, and more preferably at a wavelength of 650 nm.

34. The method of one of claims 27 to 31, wherein the emitting device (105, 205, 305, 405) is a light emitting diode that emits yellow light at a wavelength between 530 nm and 630 nm, preferably between 580 nm and 600 nm, and more preferably at a wavelength of 590 nm.

35. The method of one of claims 27 to 34, wherein the integrated circuit (102, 202, 302, 402) is a Monolithic Microwave Integrated Circuit.

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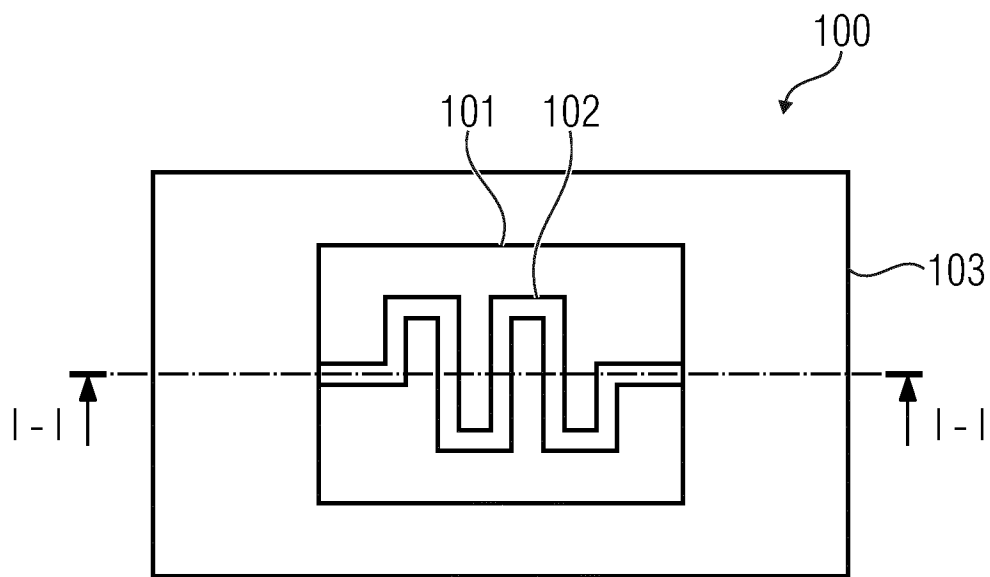


FIG 1A

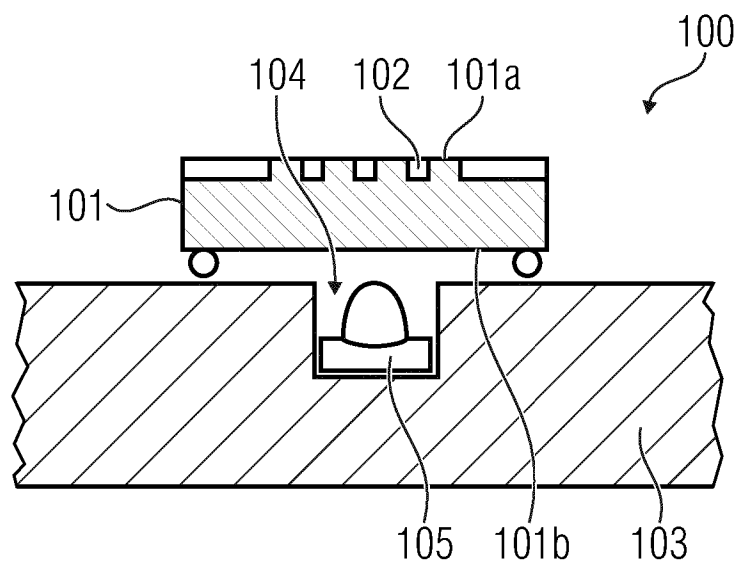


FIG 1B

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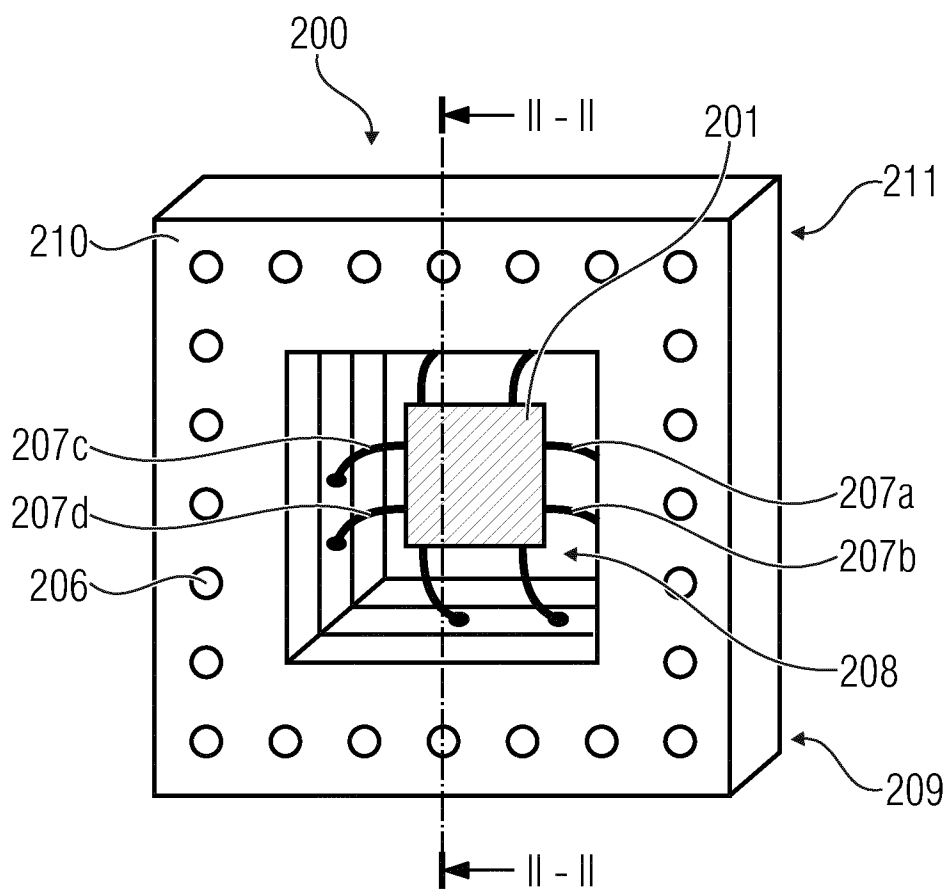


FIG 2A

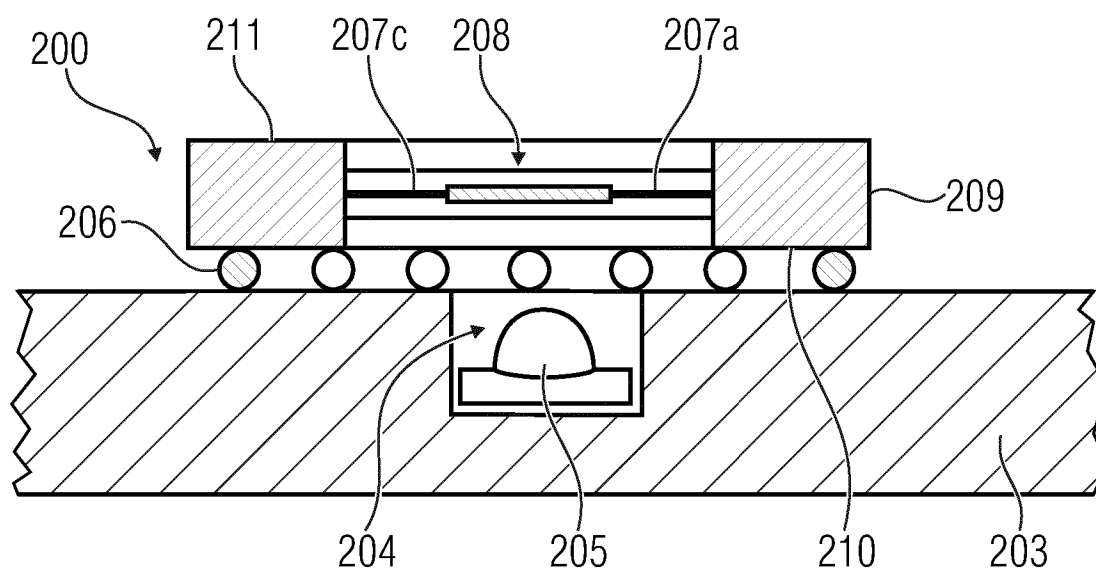


FIG 2B

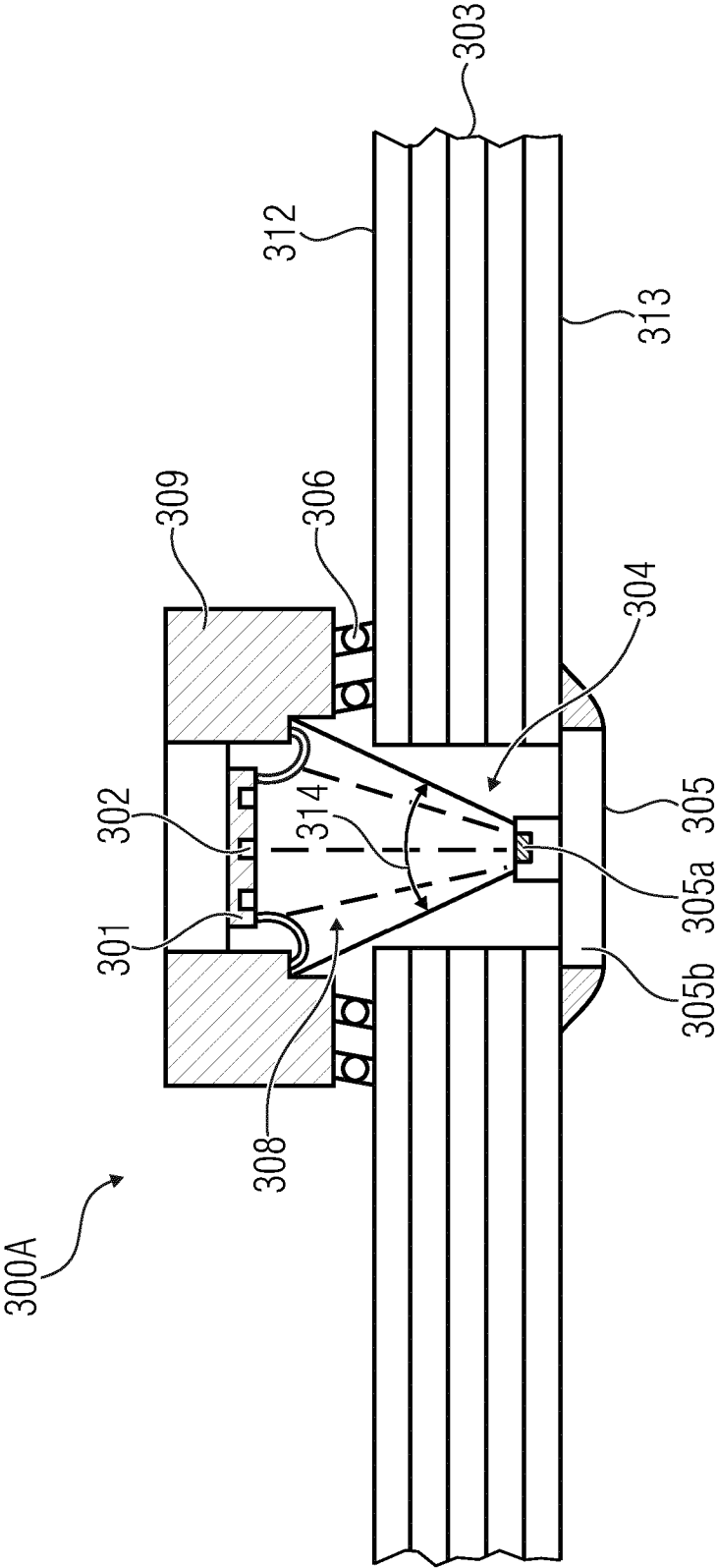


FIG 3A

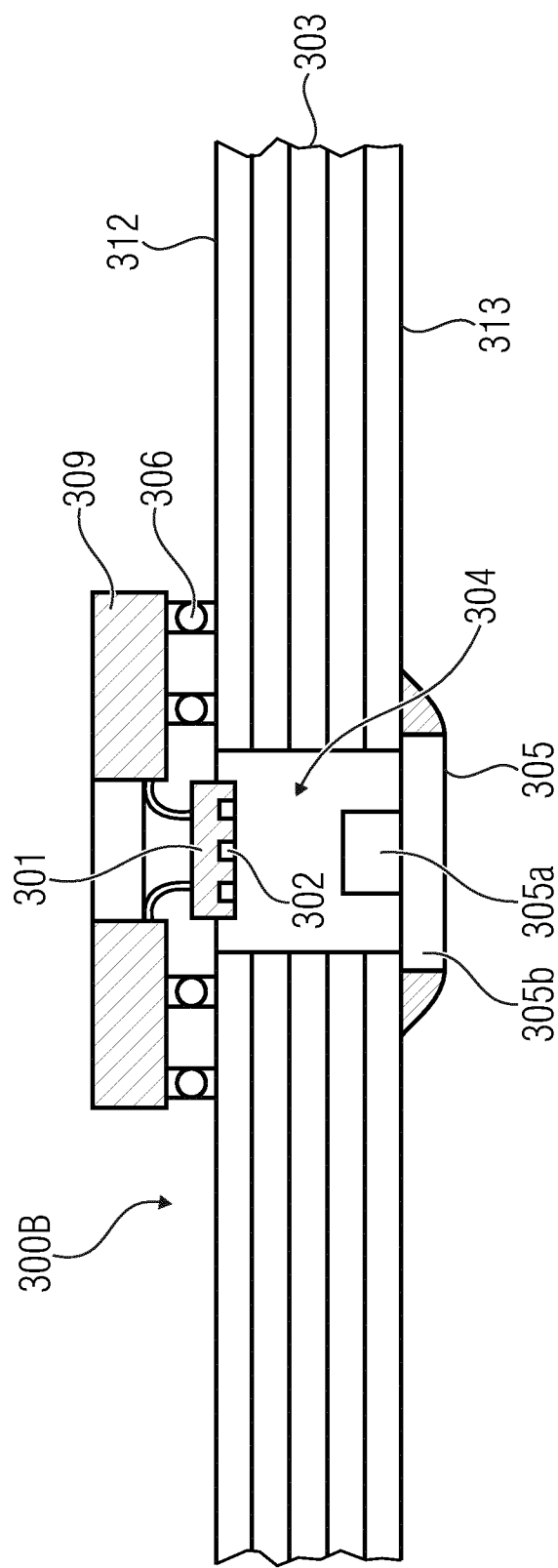


FIG 3B

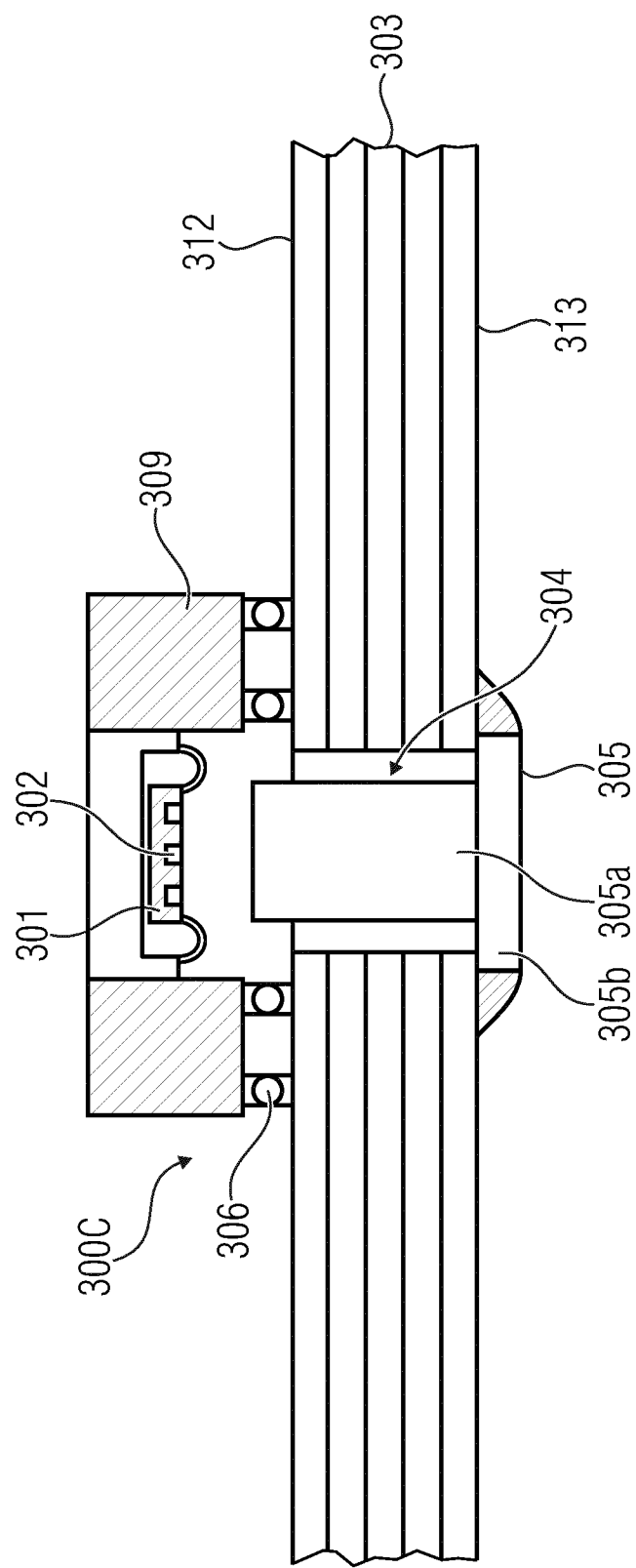


FIG 3C

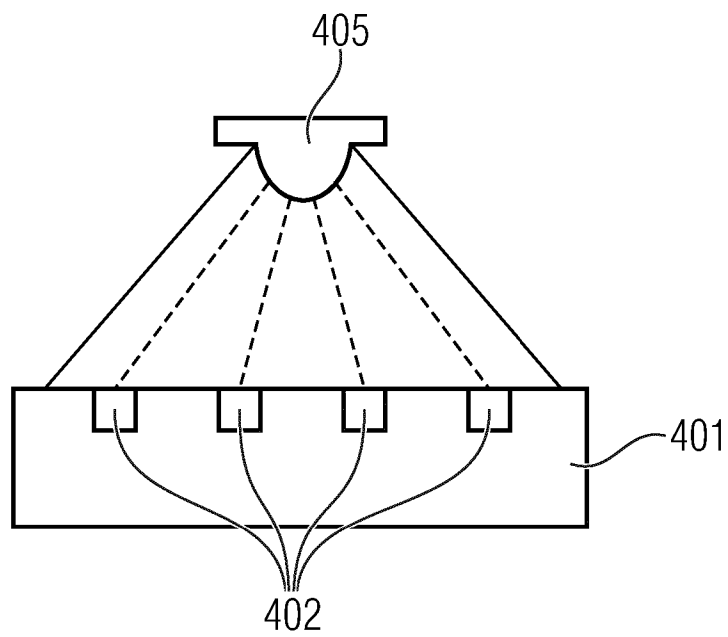


FIG 4

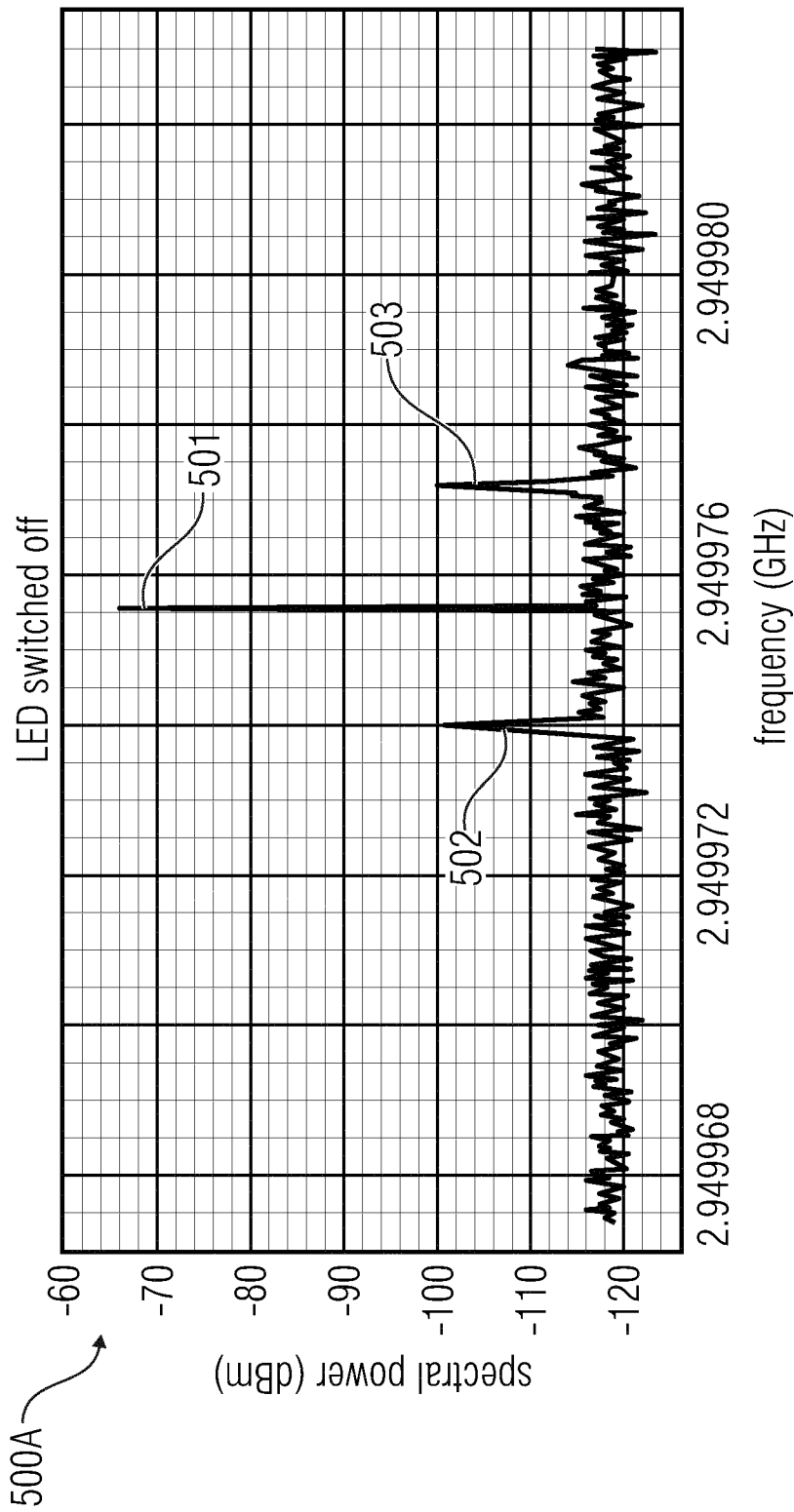


FIG 5A

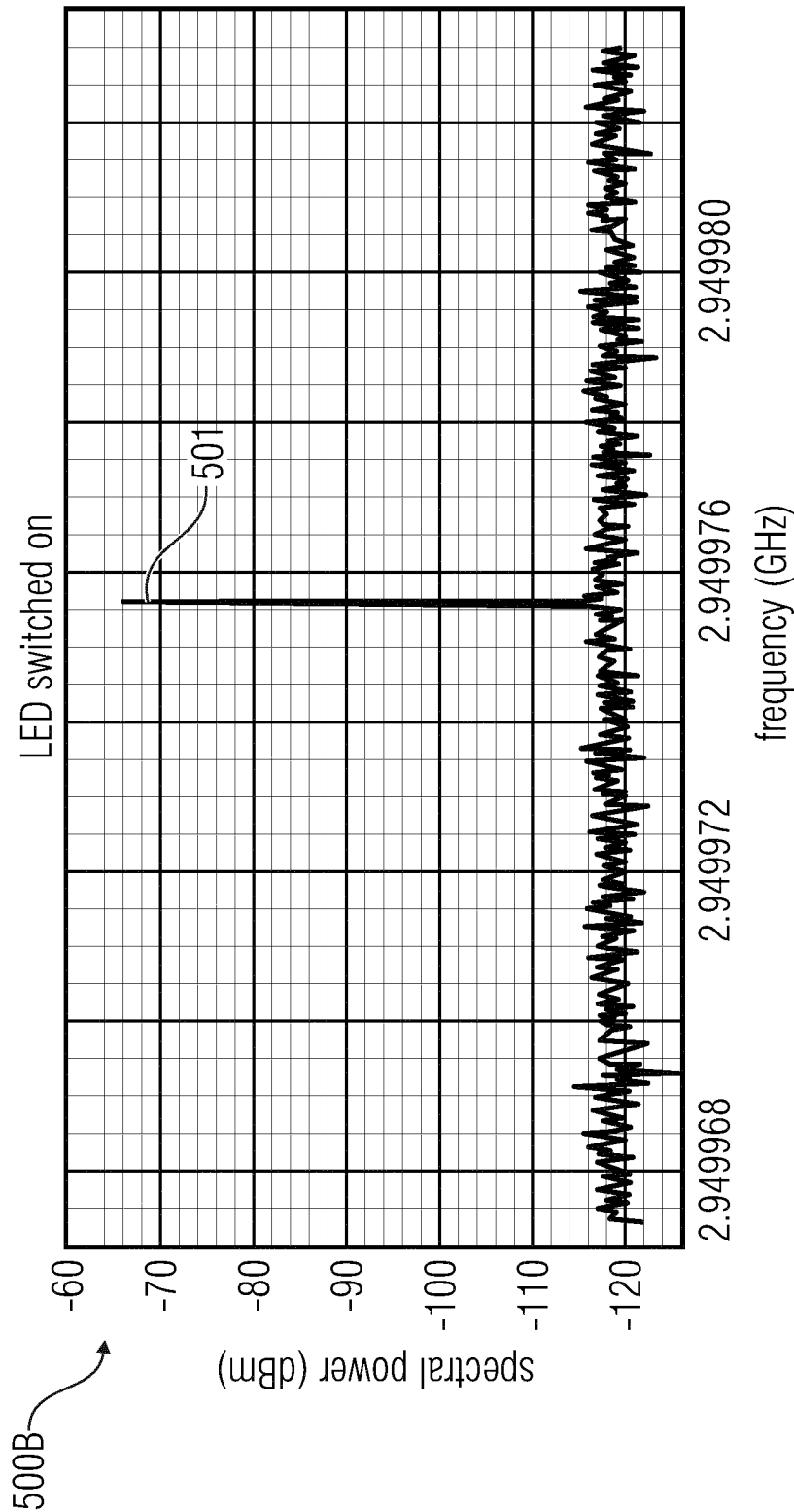


FIG 5B

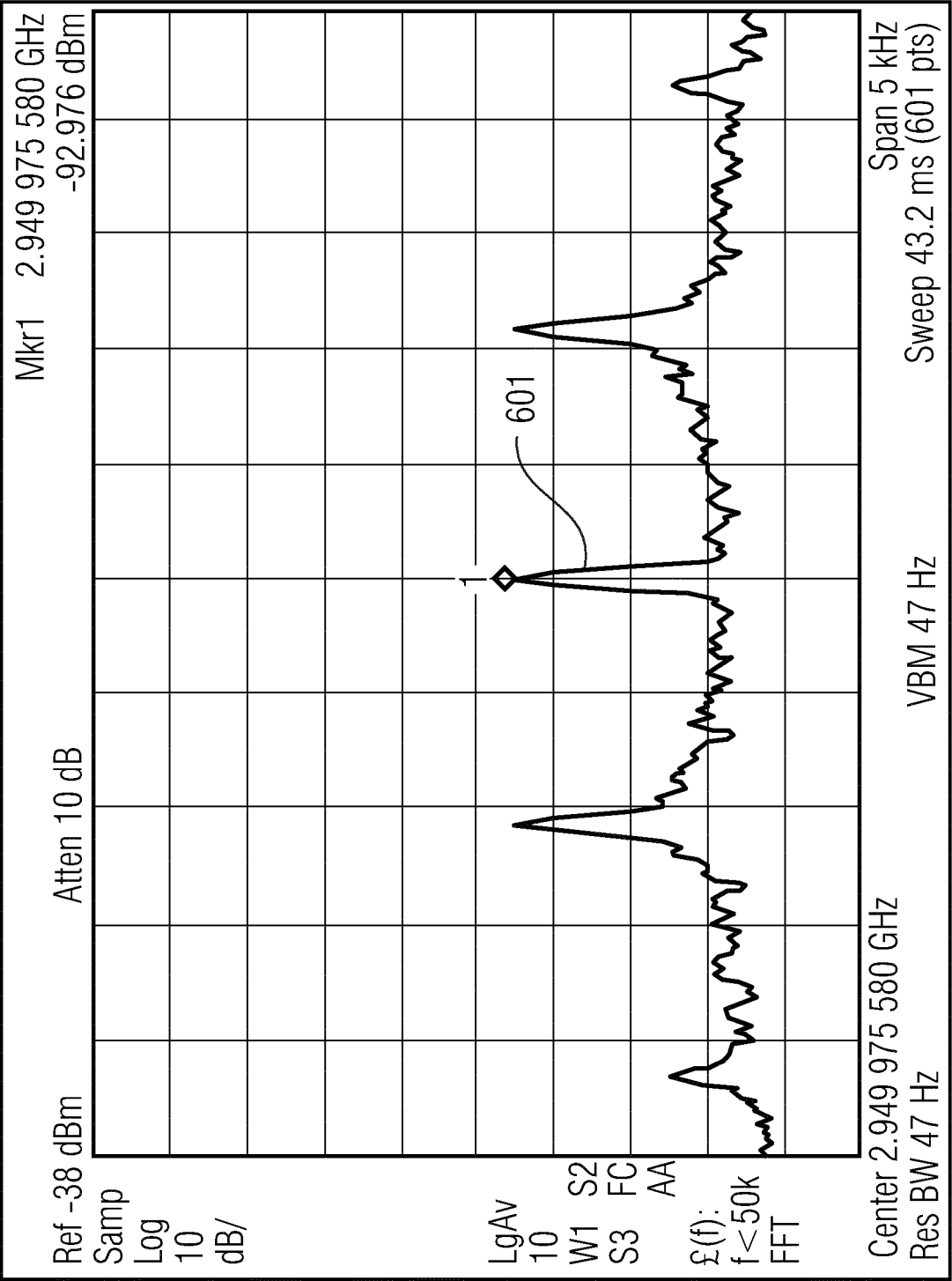


FIG 6A

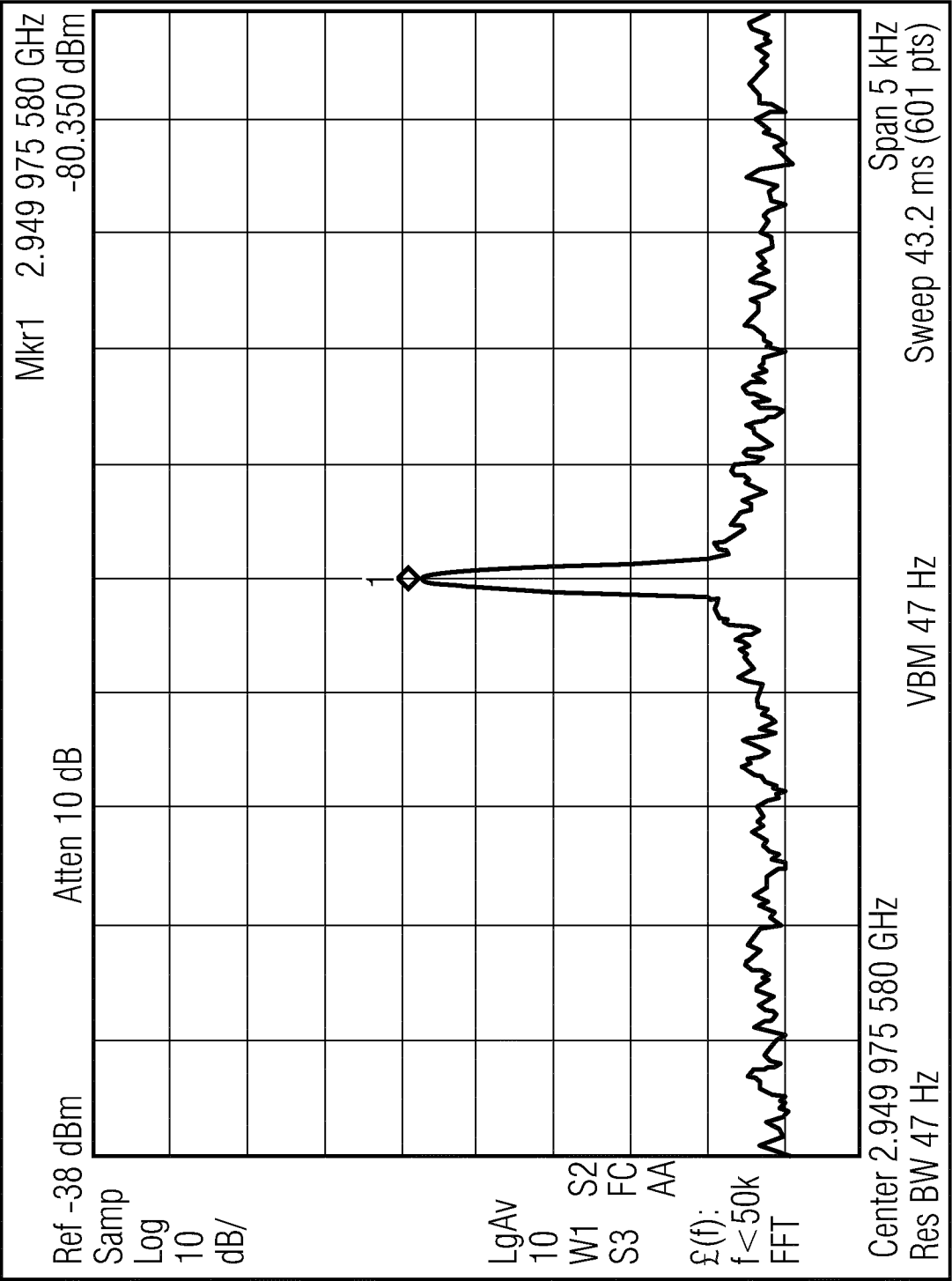


FIG 6B

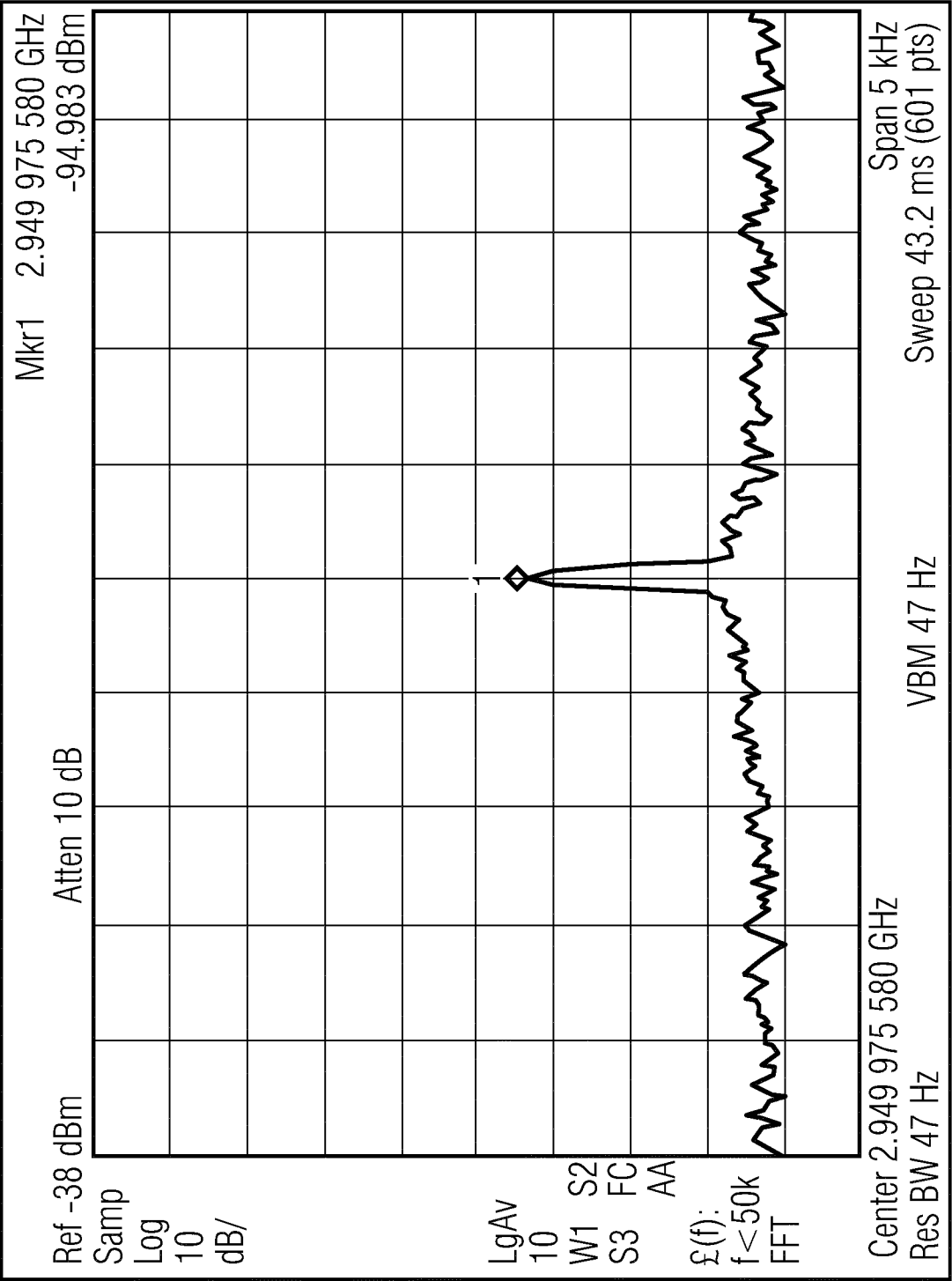


FIG 6C

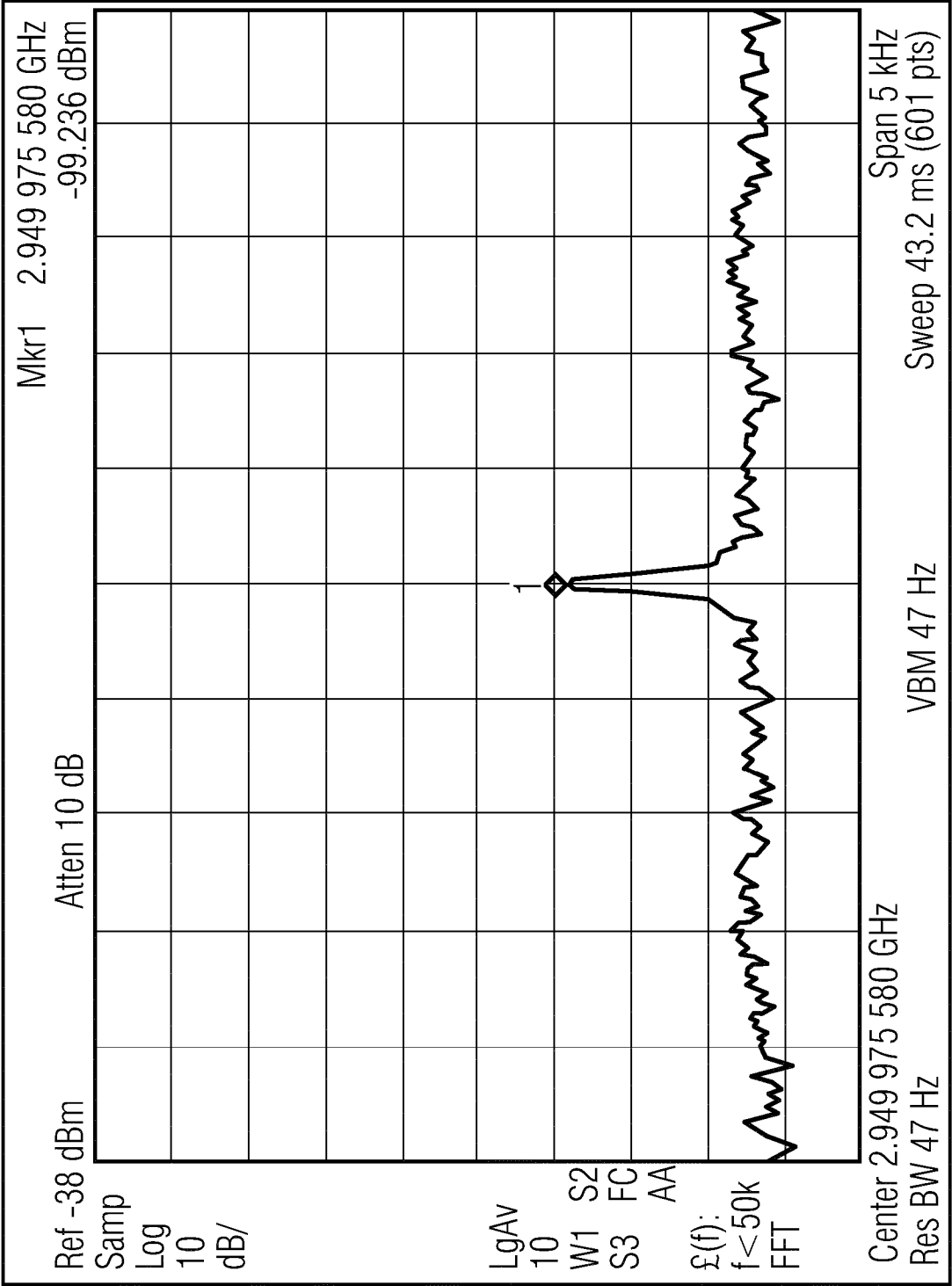


FIG 6D

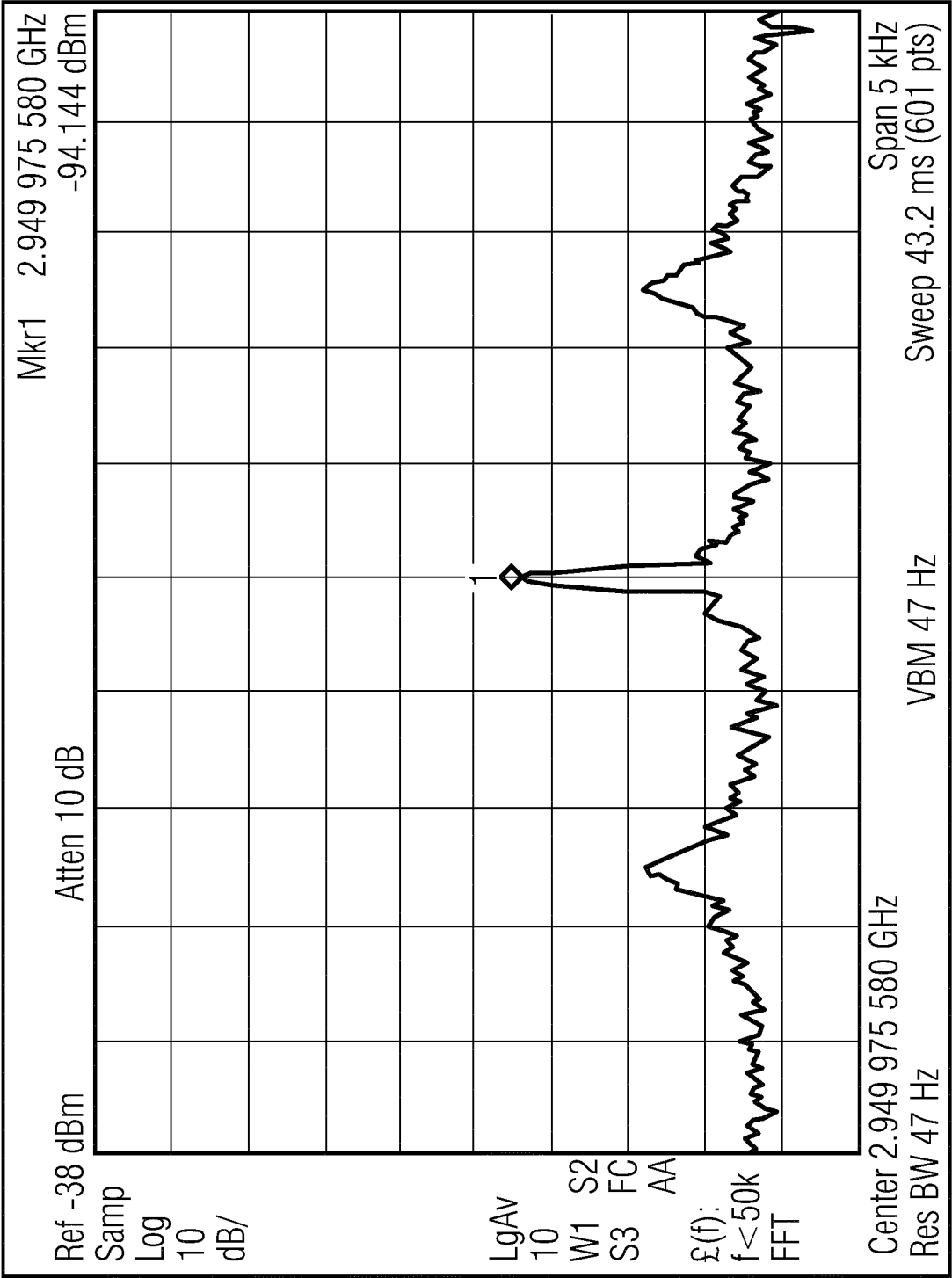


FIG 6E

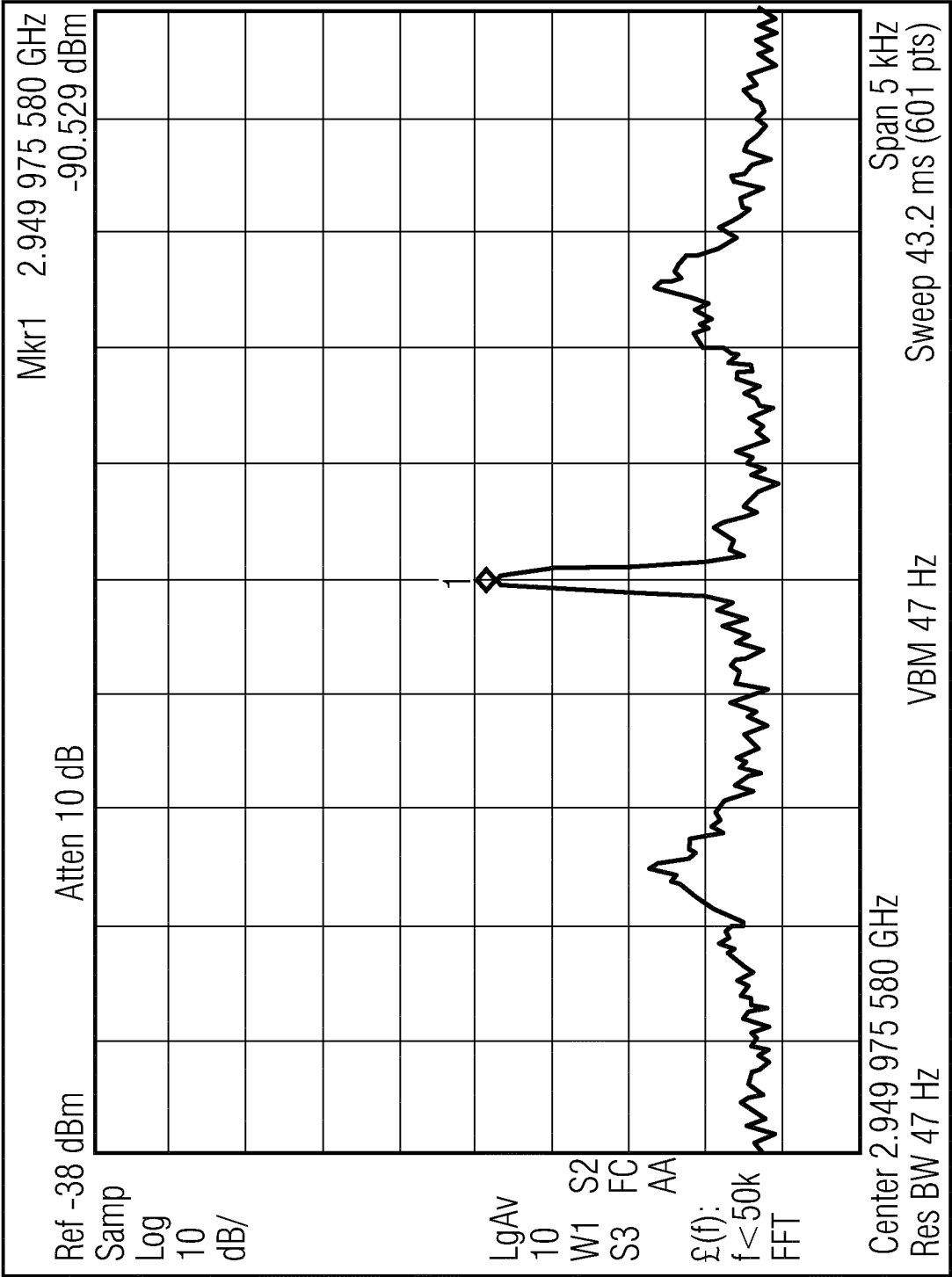


FIG 6F

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/062873

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01L31/16 H01Q1/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 304 429 A (BONIN EDWARD L ET AL) 14 February 1967 (1967-02-14) columns 3,4,7; figures 1-5 -----	1-18,27, 28
X	BHASIN K.B.: "Optically controlled microwave devices and circuits: Emerging applications in space communications systems", NASA TECHNICAL MEMORANDUM, TM-89869, 27 July 1987 (1987-07-27), pages 1-10, XP002752337, pages 1-4; figures 1-2 -----	19-26, 29-35
A	US 2004/036462 A1 (EVERS CHRISTIAN [DE] ET AL) 26 February 2004 (2004-02-26) paragraphs [0022] - [0026], [0030], [0031]; figures 1,3,4 -----	19,20,29



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 December 2015

Date of mailing of the international search report

15/01/2016

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Authorized officer

Chin, Patrick

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/062873

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			US 2004036462 A1 26-02-2004
