(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 December 2012 (27.12.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/176106 A2

(51) International Patent Classification:
H01L 21/66 (2006.01) *H01L 33/00* (2010.01)

(21) International Application Number:
PCT/IB2012/053052

(22) International Filing Date:
18 June 2012 (18.06.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/500,987 24 June 2011 (24.06.2011) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: METHOD AND APPARATUS FOR INSPECTION OF LIGHT EMITTING SEMICONDUCTOR DEVICES USING PHOTOLUMINESCENCE IMAGING

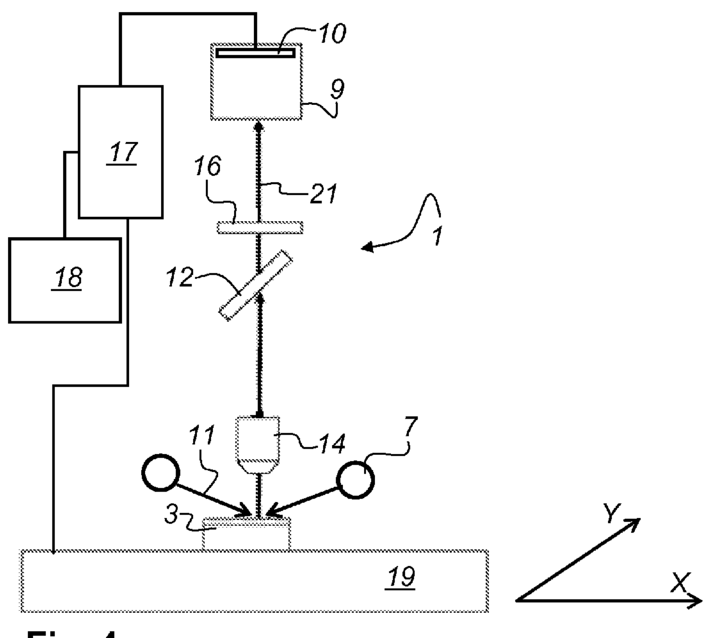

Fig. 4

(57) Abstract: A method and apparatus for the inspection of light emitting semiconductor devices. The semiconductor device is illuminated with a light source, wherein at least an area of the light emitting semiconductor is illuminated with a waveband of light. The waveband of light $\lambda_A + \lambda_B$ can generate electron-hole pairs in the light emitting semiconductor to be inspected. Through an objective lens at least a part of the light λ_C emitted by the light emitting semiconductor is detected. The emitted light is captured with a sensor of a camera that is sensitive to wavelengths of the emitted light, wherein the wavelength of the emitted light is above the width of the waveband. The data of the emitted light, captured with the sensor, are transmitted to a computer system for calculating inspection results of the light emitting semiconductor.

WO 2012/176106 A2

METHOD AND APPARATUS FOR INSPECTION OF LIGHT EMITTING SEMICONDUCTOR DEVICES USING PHOTOLUMINESCENCE IMAGING

CROSS REFERENCE TO RELATED APPLICATIONS

[001] This patent application claims priority of US provisional patent application No. 61/500,987 filed June 24, 2011, the application is incorporated herein by reference.

FIELD OF THE INVENTION

[002] The present invention relates to a method for inspection of light emitting semiconductor devices during and after a production process. The light emitting semiconductor devices can be LEDs.

[003] The present invention also relates to an apparatus for inspection of light emitting semiconductor devices on a substrate.

BACKGROUND OF THE INVENTION

[004] Solid state lighting (SSL) has several advantages compared to conventional lighting. Main advantages are low power consumption, long lifetime, and small form factor. An important element of SSL is the LED (Light-Emitting Diode) die/chip. Basis for LEDs is a semiconductor material that is undergoing a complex production process in order to obtain a LED. Several metrology and inspection steps are done during and after that production process.

[005] Measuring the output power of an LED is typically done using a probing system. In this system, electrical contacts are made to each LED die and a measurement is done of a.o. the generated light output power and optionally the wavelength.

[006] The international patent application WO98/11425 discloses a method and apparatus for detecting defects in a semiconductor or silicon structure at room

temperature, and in an efficient time, using photoluminescence. The invention employs the use of a high intensity beam of light preferably having a spot size between 0,1 mm - 0,5 μm and a peak or average power density of 10^4 - 10^9 W/cm^2 with a view to generating a high concentration of charge carriers, which charge characters detect defects in a semiconductor by interacting with same. These defects are visible by producing a photoluminescence image of the semiconductor. Several wavelenghts may be selected to identify defects at a selective depth as well as confocal optics are used. This method performs probing of a very small volume of the material with one or more laser beams having very small spot size.

[007] Another method is described in US-A-7,504,642 B2 where one or more images are created using filtering and image computation to selectively create a defect image of one selected layer of a wafer, while trying to eliminate unwanted contributions of other layers of the same wafer. The method uses photoluminescence to identify defects in one or more specified material layers of a sample. One or more filtering elements are used to filter out predetermined wavelengths of return light emitted from a sample. The predetermined wavelengths are selected such that only return light emitted from one or more specified material layers of the sample is detected. Additionally or alternatively, the wavelength of incident light directed into the sample may be selected to penetrate the sample to a given depth, or to excite only one or more selected material layers in the sample. Accordingly, defect data characteristic of primarily only the one or more specified material layers is generated.

[008] The international patent application WO 2007/128060 A1 describes a photoluminescence based method for testing of indirect bandgap (e.g. Si) semiconductor materials, based on comparison of several regions in two or more images. The method is suitable for identifying or determining spatially resolved properties in indirect bandgap semiconductor devices such as solar cells. In one embodiment, spatially resolved properties of an indirect bandgap semiconductor device are determined by externally exciting the indirect bandgap semiconductor device to cause the indirect bandgap semiconductor device to emit luminescence, capturing images of luminescence emitted from the indirect bandgap semiconductor device in response to the external excitation, and determining spatially resolved properties of the indirect bandgap semiconductor

device based on a comparison of relative intensities of regions in one or more of the luminescence images.

[009] Quality control of LED is becoming more and more crucial since LEDs are used for illumination. It is important that, e.g., the LEDs used for the back illumination of a TV set are of similar intensities. Therefore a quality control of the light output power of LEDs needs to be done. Such quality control was until now done by electrically contacting the LED (probing) and then measuring the emitted light output power. This has several disadvantages: LEDs may get damaged during probing, probing is slow and requires an additional tool.

SUMMARY OF THE INVENTION

[0010] It is an object of the invention to provide a method for quickly and reliably measure the light power emitted by an LED during a production process. Furthermore, the method should be easy to use and should not influence or destroy the LED to be measured.

[0011] The object is achieved by a method for inspection of light emitting semiconductor devices, comprising the following steps:

- illuminating with a light source at least an area of the light emitting semiconductor with a waveband of light, wherein the waveband of light $\lambda_A + \lambda_B$ can generate electron-hole pairs in the light emitting semiconductor to be inspected;
- detecting through an objective lens at least a part of the light λ_C emitted by the light emitting semiconductor, wherein the emitted light is captured with a sensor of a camera that is sensitive to wavelengths of the emitted light and the wavelength of the emitted light is above the a width of the waveband; and
- transferring data of the emitted light, captured with the sensor, to a computer system for calculating inspection results of light emitting semiconductor.

[0012] It is a further object of the invention to provide an apparatus the light power emitted by an LED during a production process. Furthermore, the apparatus should be easy to use and should not influence or destroy the LED to be measured.

[0013] The object is achieved by an apparatus for inspection of light emitting semiconductor devices on a substrate, comprising:

- a light source;
- an objective lens defining a detection beam path,;
- a camera with a sensor positioned in the detection beam path, for receiving light from the light emitting semiconductor devices via the objective lens; wherein the sensor registers grey scale values of the light emitting semiconductor devices;
- a computer system for calculating a wafermap from data registers by the sensor; and
- a display in order to visually display the wafermap.

[0014] For defect inspection the photoluminescence effect is used as a kind of back light. This illumination effect enables the finding of defects that are buried or at least are not visible in normal inspection. With the inventive setup it is as well possible to find cuts (finger cuts) or interrupts in the metallization layer. Additionally, the invention allows the detection of non-homogeneities of the LEDs. The light emitted from the LED is subjected to a spatial grey value analysis. Some LEDs only emit light in some parts while no light is emitted in other parts (for example: a dark edge at the corner of the LED does not light up).

[0015] According to an embodiment of the invention the light emitting semiconductor devices are illuminated with a light source configured as a ring light. The ring light has a plurality of LEDs. A second filter can be positioned in the detection beam path. The second filter in the detection beam path prohibits the reflections of the incident light to reach the sensor and at least a wavelength of λC passes the second filter.

[0016] A further embodiment of the invention is that a first filter is positioned in an illumination beam path of the light source and is designed to pass a waveband λA + λB. The second filter is in the detection beam path and prohibits the reflections of the incident light to reach the sensor and at least a wavelength of λC passes the second filter. In this case the objective lens defines the illumination beam path and the detection beam path. The light source is a coaxial light source.

[0017] One or several LED die/chips are illuminated with a light source with wavelengths that can generate electron hole pairs in the LED. The light emitted by the LED (caused by the electron hole pair and following recombination process) is captured with a sensor/camera that is sensitive to the wavelengths of the emitted light. The sensor response (gray value) is a measure for the power of the light output of the LED and can for example be used to classify the LEDs according to their light output power.

[0018] The waveband of light λA ± λB for the illumination of light emitting semiconductor devices or the LED die/chips is generated by inserting a first filter prior to the objective lens in an illumination beam path. A second filter is positioned in a detection beam path after the objective lens, so that only the light emitted by the light emitting semiconductor reaches the sensor of the camera. The image acquisition setup, especially the objective lens comprises microscope optics. Various types of illumination can be used in the apparatus for the illumination of light emitting semiconductor devices or the LED die/chips. The light source could be a coaxial light source or a ring light. The illumination light is provided with a plurality of LEDs.

[0019] The inventive method is applied to LED die/chips, which are structures on a substrate or wafer. The inspection result is then a measure for a light output power of a LED or the LED die/chips detected by the sensor of the camera. The output of the sensor is at least one gray value of a matrix of pixels. A range of the gray value establishes function of the light output power per LED in the LED die/chips or in the light emitting semiconductor devices.

[0020] The inventive apparatus has a stage, which moves the substrate with the LED die/chips in a X/Y direction. The movement is controlled by the computer system. With the relative movement between the camera and the substrate, the sensor of the camera captures an image of the entire surface of the substrate. The data from the sensor is sent to the computer system which calculates a wafermap of the surface with the LED die/chips. The wafermap is shown on a display of the computer system, wherein to each class of gray value a separate color code is assigned.

[0021] The function of the light output power per LED is implemented as a look up table. A further embodiment is that the function is implemented as a polynomial. A calibration of look up table or the polynomial is done by measuring the light output power of an LED sample by connecting it to an electrical prober.

[0022] The inspection result generated by the sensor is at least one gray value per LED. The inspection results of the LEDs are sorted in at least two bins according to their registered gray value. In a further form, the inspection result generated by the sensor is at least two gray values per LED die/chip. The variations or differences in gray value of one LED die/chip are used as a quality measure of the LED die/chip.

[0023] The inspection result is at least one gray value per LED die/chip and the method comprises the steps of:

- taking at least two inspection images under same conditions of each LED die/chip;
- taking the images under varying illumination intensity and/or exposure settings which are configurable;
- generating a histogram of the gray values is generated for each LED die; and
- analyzing the histogram distribution in order to establish a pass or a fail criteria.

[0024] As mentioned before, the light emitting semiconductor devices are LED die/chips and the emitted light of the LED is caused by a recombination process of electron hole pairs that are generated by the illumination in an active layer of the LED. The emitted wavelength or waveband has a similar wavelength or waveband as if a forward voltage would be applied to the LED.

[0025] Due to fluctuations in the production process, the LED chips are sorted according to several criteria including center wavelength of the emitted light, power of the emitted light, etc.

[0026] This invention would allow for fast and contactless inspection on an inspection tool which is widely used by LED manufactures for other inspection tasks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which

[0028] Figure 1 is a table showing the bandgap and corresponding wavelength of a III-N semiconductor material system;

[0029] Figure 2 is a typical layer stack of an LED;

[0030] Figure 3 is an embodiment of the apparatus according to the invention for illuminating one or several LED die/chips in order to detect the emitted light from the LED die/chips;

[0031] Figure 4 is a further embodiment of the apparatus according to the invention for illuminating one or several LED die/chips in order to detect the emitted light from the LED die/chips;

[0032] Figure 5 is a simplified view of a wafermap generated with the inventive apparatus.

[0033] Figure 6a is an image of the surface of a wafer with LED die/chips which are illuminated with normal illumination;

[0034] Figure 6b is an image of the InGaN - layer below the surface of the LED die/chips on a wafer which is illuminated with photo luminescence illumination; and

[0035] Figure 7 is a schematic image of the wafermap showing an image of the LED die/chips in the photoluminescence setup.

DETAILED DESCRIPTION OF THE INVENTION

[0036] Same reference numerals refer to same elements throughout the various figures. Furthermore, only reference numerals necessary for the description of the respective figure are shown in the figures. The shown embodiments represent only examples of how the invention can be carried out. This should not be regarded as limiting the invention. The description below refers to LED die/chips which should not be regarded as a limitation of the invention. It is evident for any person skilled in the art that the present invention is applicable to light emitting semiconductor material in general.

[0037] Fig. 1 is a table 100 showing the bandgap and corresponding wavelength of a III-N semiconductor material system. All semiconductor materials exhibit the so-called photoluminescence effect. This effect is seen when the material is illuminated with light of a certain wavelength, and the photons in the light beam will bring electrons from a low energy state to a high energy state (will generate electron-hole pairs). This is called photo-excitation. The incoming light beam should have an energy level above the difference between high-energy state and low energy state. This is typically the bandgap energy of the semiconductor material. The generated pairs will recombine and the recombination process will generate photons (radiative recombination) or phonons (non-radiative recombination). In most LED materials (which are direct semiconductors) such as the GaN system, the radiative recombination process is the dominant one.

[0038] Fig. 2 is a typical representation of a layer stack 101 of an LED. The layer stack 101 has the substrate 3 on which a layer 102 of n-type GaN is formed. The layer 102 of n-type GaN carries an intermediate layer 103 of a InGaN MQW material. A top layer 104 is formed by a p-type GaN material. In order to probe only the intermediate layer 103 of InGaN MQW, the excitation light 110 should not be absorbed by the layer 102 of n-type GaN and the top layer 104 of p-type GaN surrounding it. The excitation light 110 should have an energy level below the GaN energy band level, meaning wavelength above 359nm. For the light to be absorbed by the intermediate layer 103 of InGaN MQW material, the excitation light 110 should have an energy level above 2.75eV i.e. below 450nm. The generated light 120 by the intermediate layer 103 of InGaN MQW material will have a wavelength around 450 nm. In the apparatus 1, described in Fig. 3, a white light source 7 is used. Consequently, the energy levels below 450 nm in the light path have to be filtered out. This means a first low pass filter 15 (pass only wavelength < 450 nm). In order to make clear images and not to be disturbed by the reflections of the incoming light, an additional second filter is needed in detection beam path 21 with high-pass characteristics i.e. pass only wavelength of 450 nm and higher.

[0039] Fig. 3 is a schematic representation of an embodiment of the apparatus 1 for illuminating one or several LED die/chips 5 on a substrate 3 in order to detect the wavelengths of the emitted light from the LED die/chips 5. One or several LED die/chips 5 are illuminated with a light source 7 with wavelengths that can generate an electron hole pairs in the LED. The light emitted by the LED (caused by the electron hole pair and following recombination process) is captured with a camera 9 that is sensitive to the wavelengths of the emitted light. The camera 9 has a sensor 10 and the response (gray value) of the sensor 10 is a measure for the power of the light output of the LED and can for example be used to classify the LEDs according to their light output power.

[0040] The light source 7 is a white-light broadband spectrum light source, is used for illuminating the substrate 3 with the LED die/chips 5. The light from the light source 7 supplied to a microscope 6 via a light guide 8. The microscope 6 defines an illumination beam path 11. A beam splitter 12 directs the illumination beam path 11via an objective lens 14 onto the LED die/chips 5 on the substrate 3. By providing means (not shown) for inserting a respective first filter 15 in the illumination beam path 11, a certain part of the broadband spectrum that is generated by a light source 7, is selected. The light is transmitted through the objective lens 14 (incident light beam) excites the semiconductor material in the LED die/chips 5 on the substrate 3. This could be for example a direct band gap material such as a III-V semiconductor material as used for LED fabrication. The semiconductor material will emit light at a known wavelength and this light is collected in the same objective lens 14. The objective lens 14 defines as well a detection beam path 21.

[0041] In the detection beam path 21 a second filter 16 is positionable in order to make sure that only the light emitted by the LED die/chips 5 on the substrate 3 reach the camera 9 and the sensor 10. The second filter 16 prohibits the reflections of the incident light to reach the camera 9or the sensor 10. The image data collected by the sensor 10 of camera 9 are fed to a computer system 17 which uses an image processing software to derive an average intensity for each LED 4 on the substrate 3. The computer system

17computes a wafermap (see figure 4). A display 18 is assigned to the computer system 17 in order to visually display wafermap 30 to plot the results of all LEDs 4 and their coordinate position on the substrate 3, which is in many cases a wafer.

[0042] The light source 7 is coaxial light source. It is advantageous if the light source 7 is ring light. The illumination light is provided by a plurality of LEDs. The light source 7 is configured as a pulsed light source or a continuous light source. The waveband constraint $(\lambda A + \lambda B) < \lambda C$ is implemented using optical high pass and/or low pass and/or band pass filters. The sensor 10 is a line sensor. The camera 9 is configured as a TDI (time delay integration) line scan camera. The sensor 10 could be as well a 2-dimensional sensor so that an area scan camera results.

[0043] The emitted light of the LED die/chips 5 or LED 4 is caused by the recombination process of electron hole pairs that are generated by the illumination. The emitted light of the LED die/chips 5 or LED 4 is caused by the recombination process of electron hole pairs that are generated by the illumination which has a similar wavelength as if a forward voltage would be applied to the LED die/chips 5 or LED 4. The recombination process takes place in the active layer of the LED die/chips 5 or LED 4. In case of a blue LED an example implementation would be $\lambda A \approx 380$nm, $\lambda B \approx 20$nm and $\lambda C \approx 440$nm.

[0044] A calibration is done to correlate the measured average intensity of the LED material to an output power (density) number. The inventive apparatus 1 uses a white-light source with area illumination. Prior art devices instead use a commonly laser beam source with small spot size, and a camera as a detector. The computer system 17controles as well a X/Y-stage 19. The X/Y-stage 19 moves the substrate 3 in a controlled manner so that the entire surface of the substrate is imaged by the objective lens 14 onto the sensor 10 of camera 9. The position of the X/Y-stage 19 is recorded in order to correlate the visually captured data with the position data on the substrate 3 and to generate the wafermap 30.

[0045] Fig. 4 is a further embodiment of the apparatus 1 for illuminating one or several LED die/chips 5 on a substrate 3 in order to detect the wavelengths of the emitted light from the LED die/chips 5. According to the embodiment shown here the LED die/chips

5 are illuminated with a light source 7 which is configured as a ring light source. The ring light source comprises several LEDs which emit wavelengths that can generate an electron hole pairs in the LED die/chips 5 on a substrate 3. The light emitted by the LED (caused by the electron hole pair and following recombination process) is captured with a camera 9 that is sensitive to the wavelengths of the emitted light. The camera 9 has a sensor 10 and the response (gray value) of the sensor 10 is a measure for the power of the light output of the LED and can for example be used to classify the LEDs according to their light output power.

[0046] The ring light source defines an illumination 11 by which a certain area on the LED die/chips 5 on a substrate 3 illuminated. The embodiment shown in Fig. 4 does not need first filter 15 for the illumination 11, of the surface of the LED die/chips 5. The LEDs of the ring light source are driven in such a way that the required light is emitted in order to generate the electron hole pair in the semiconductor material. The semiconductor material will emit light at a known wavelength and this light is collected by the objective lens 14. The objective lens 14 defines as well a detection beam path 21.

[0047] Fig. 5 is a simplified view of a wafermap 30 generated with the inventive apparatus 1. The X/Y-stage 19 is moved so that an entire image of the surface 3a of the substrate 3 (wafer) is obtained. The computer system 17stitches the individual images, taken with the objective lens 14, together in order to get a representation of the entire surface 3a of the substrate 3 (wafer). In case of the layer stack 101 of an LED as shown in Fig. 2 the intermediate layer 103 of InGaN MQW is visible with the inventive apparatus 1. The intermediate layer 103 of InGaN MQW is now visible below the top layer 104 of p-type GaN. The wafermap 30 is computed to plot the results of all LEDs 4 on their coordinate position on the substrate 3 (wafer). A calibration is done to correlate the measured average intensity of the LED material to an output power (density) number. The representation can be done using different grey scales. An image of the surface 3a of the substrate 3 (wafer) is taken during inspection with an inserted first filter 15 and second filter 16. A spot size (not shown) of the illumination light can be larger than the size of the LED die/chips 5, thus it is possible to illuminate the whole LED 4 and subsequently the related, often subsequent, measurement is a correct representation of the characteristics of the whole LED die/chips 5.

[0048] Fig. 6a is an image of the surface 3a of a substrate 3 (wafer) with the LED die/chips 5 which is illuminated with normal illumination (white light). The image of the surface 3a of a substrate 3 (wafer) with the LED die/chips 5 is taken using standard illumination. With this illumination all LED die/chips 5 appear to be identical. Fig. 6b is an image of the surface 3a of a substrate 3 (wafer) with the LED die/chips 5 wherein the surface 3a is illuminated with the first filter 15 in illumination beam path 11 and the image is captured with the second filter 16 in the detection beam path 21. Due to the photo luminescence the surface 3a of a substrate 3 (wafer) shines in blue light, which is generated by the LED die/chips 5. It is clear from the comparison of Fig. 6a and Fig. 6b that with the photo luminescence setup, inspection features become visible, that are invisible for the “normal” or standard illumination setup (white light). The intermediate layer 103 of InGaN MQW is clearly visible below the surface or the top layer 104 of p-type GaN. Circles 51 with dashed lines indicate LED die/chips 5 with identical appearance under normal illumination (white light), but without response under the photo luminescence setup. All LED die/chips 5 are having the same grey scale value (GV) when using the standard illumination setup (white light), the LED die/chips 5 can have a significantly different GV response when using the photo luminescence setup.

[0049] Fig. 7 is a screenshot of the wafermap 30 showing an image of the LED die/chips 5 in the photoluminescence setup on the display 18. Using software which is implemented in the computer system 17(see Fig. 3 or 4) an inspection of the properties of LEDs or LED die/chips 5 images is possible. This means that it is possible to locate the individual LED die/chips 5 on the images, measure certain properties based on image processing, and then correlate the measurement results to each individual LED die/chip 5. A recipe is set up with rule-based binning ("RBB”). According to the recipe a classification of the LED die/chips 5 according to the average GV of the entire LED die/chip 5 on the substrate 3 is carried out. Each class has a separate color code. In a separate section 31 of the display 18 the various GVs are shown in a histogram 32, which results from the rule-based binning. The inspection of the substrate 3 (wafer) with the LED die/chips 5 shows a signature, that it is possible with the photo luminescence to measure something genuinely different from what can be seen with normal inspection setup. It can also be seen that the response of individual LED die/chips 5, which can be neighboring, can be independent of the wafer-level signature. It is a clear indication that measurement on the die — level is a big additional source of information in the process improvement of LED manufacturing. With the wafermap 30 it can be shown that with a measurement on a partly or fully processed substrate 3 (wafer) with LEDs, using a photoluminescence setup, a quantitative indication of the expected output power for each individual LED is obtained.

[0050] The inventive method is suitable for inspecting at least one LED die/chip 5 or more general a light emitting semiconductor material, which is structured on a substrate 3 or wafer. At least the area of one LED die/chip 5 is illuminated with a waveband ($\lambda A \pm \lambda B$) that can generate electron-hole pairs in the LED die/chip 5 to be inspected. The waveband is obtained with the first filter 15 in the illumination beam path 11. At least a part of the light emitted by the LED die/chip 5 is captured with the sensor 10 of the camera 9. The second filter 16 is positionable in order to make sure that only the light emitted by the LED die/chips 5 on the substrate 3 reach the camera 9 and the sensor 10, so that sensor 10 is sensitive to wavelengths ($\lambda C + \lambda D$) of the emitted light. The wavelength λC is larger than the wavelengths ($\lambda A + \lambda B$). The inspection result is the output of the sensor 10 which is fed to the computer system 17.

[0051] The inspection result is a measure for the light output power of an LED or a LED die/chip 5. The output of the sensor 10 is at least one gray value of at least one pixel. Usually, the gray value is represented by a matrix of pixels. The range of the grey value, e.g. for an 8 bit computer system 17 is between 0 – 255 per LED die/chip 5. The output power is a function of the measured grey values. The function can be implemented as a look up table or as a polynomial. The calibration of the look up table or the polynomial is done by measuring light output power of a LED sample when connected to an electrical prober.

[0052] The inspection result is at least one gray value per LED die/chip 5. The LEDs are sorted in at least two bins according to their gray value (at least one threshold value) here the inspection result is at least two gray values per LED die/chip 5, the variations/differences in gray value of one LED die/chip 5 are used as a quality measure of the LED die/chip 5.

[0053] The inspection result is at least one gray value per LED die/chip 5, of each LED die/chip 5 multiple inspection images (at least two) are taken in order to detect stability and deviations on the emitted light. All images can be taken under same conditions or mages can be are taken under varying illumination intensity and/or exposure settings. That means the first inspection image is taken under condition A, the second under condition B, where conditions A, B, and so on are configurable. Calibration of parameters may be done using the result from electrical prober. A histogram of the gray values is generated for each LED die/chip 5 and a classification into pass/fail is done by analyzing the histogram distribution. Examples: If the histogram distribution is bi-modal then fail. If the histogram distribution uni-modal and has a low gray value then fail. If the histogram distribution is uni-modal and has a large gray value then pass. One of the methods above can be used as pre/post check for the electrical prober.

[0054] The invention has been described with reference to specific embodiments. It is obvious to a person skilled in the art, however, that alterations and modifications can be made without leaving the scope of the subsequent claims.

What is claimed is:

1. A method for inspection of light emitting semiconductor devices, comprising the following steps:

   - illuminating with a light source at least an area of the light emitting semiconductor with a waveband of light, wherein the waveband of light $\lambda_A + \lambda_B$ can generate electron-hole pairs in the light emitting semiconductor to be inspected;
   - detecting through an objective lens at least a part of the light λ_C emitted by the light emitting semiconductor, wherein the emitted light is captured with a sensor of a camera that is sensitive to wavelengths of the emitted light and the wavelength of the emitted light is above the a width of the waveband; and
   - transferring data of the emitted light, captured with the sensor, to a computer system for calculating inspection results of light emitting semiconductor.

2. The method of claim 1, wherein the light source illuminates the area of the light emitting semiconductor directly with the waveband of light $\lambda_A + \lambda_B$ for illumination which is generated by a plurality of LEDs of the light source.

3. The method of claim 2, wherein a second filter is positioned in a detection beam path after the objective lens, so that only the light emitted by the light emitting semiconductor reaches the sensor of the camera.

4 The method of claim 1, wherein the light source illuminates the area of the light emitting semiconductor through an objective lens, wherein the waveband of light $\lambda_A + \lambda_B$ for illumination is generated by inserting a first filter prior to the objective lens in an illumination beam path.

5 The method of claim 4, wherein a second filter is positioned in a detection beam path after the objective lens, so that only the light emitted by the light emitting semiconductor reaches the sensor of the camera.

6. The method of claim 1, wherein the light emitting semiconductor are a plurality of LED die/chips structured on a substrate and the inspection result is a measure for a light output power of a LED in the LED die/chips detected by the sensor.

7. The method of claim 6, wherein the output of the sensor is at least one gray value of a matrix of pixels and a range of the gray value is a function of the light output power per LED in the LED die/chips.

8. The method of claim 6, wherein a stage is moving the substrate with the LED die/chips and the sensor of the camera captures an image of the entire surface of the substrate and a wafermap of the surface with the LED die/chips the is shown on a display of the computer system, wherein to each class of gray value a separate color code is assigned.

9. The method to claim 7, wherein the function is implemented as a look up table.

10. The method to claim 7, wherein the function is implemented as a polynomial.

11. The method of claim 9 or 10, wherein calibration of look up table or the polynomial is done by measuring light output power of an LED sample by connecting it to an electrical prober.

12. The method of claim 6, wherein the inspection result is at least one gray value per LED and the inspection results of the LEDs are sorted in at least two bins according to their gray value.

13. The method of claim 6, wherein the inspection result is at least two gray values per LED die/chip, the variations or differences in gray value of one LED die/chip are used as a quality measure of the LED die/chip.

14. The method of claim 6, wherein the inspection result is at least one gray value per LED die/chip and the method comprises the steps of:

- taking at least two inspection images under same conditions of each LED die/chip;
- and/or taking the images under varying illumination intensity and/or exposure settings which are configurable;

- generating a histogram of the gray values is generated for each LED die; and
- analyzing the histogram distribution in order to establish a pass or a fail criteria.

15. An apparatus for inspection of light emitting semiconductor devices on a substrate, comprises:

- a light source;
- an objective lens defining a detection beam path,;
- a camera with a sensor positioned in the detection beam path, for receiving light from the light emitting semiconductor devices via the objective lens ; wherein the sensor registers grey scale values of the light emitting semiconductor devices;
- a computer system for calculating a wafermap form data registers by the sensor; and
- a display in order to visually display the wafermap.

16. The apparatus of claim 15, wherein a second filter is positioned in the detection beam path.

17. The apparatus of claim 16, wherein the second filter in the detection beam path prohibits the reflections of the incident light to reach the sensor and at least a wavelength of λ_C passes the second filter.

18. The apparatus of claim 17, wherein the light source is a ring light.

19. The apparatus of claim 18, wherein the ring light has a plurality of LEDs.

20. The apparatus of claim 15, wherein a first filter in an illumination beam path of the light source is designed to pass a waveband $\lambda_A + \lambda_B$ and the second filter in the detection beam path prohibits the reflections of the incident light to reach the sensor and at least a wavelength of λ_C passes the second filter.

21. Apparatus of claim 20, wherein the light source is a coaxial light source.

22. Apparatus of claim 15, wherein the light source is a pulsed light source or a continuous light source.

23. Apparatus of claim 20, wherein the waveband constraint $(\lambda_A + \lambda_B) < \lambda_C$ is implemented using optical first filter and second filter.

24. Apparatus of claim 15, wherein a stage, movable in the X/Y-direction is provided and the computer system provides a controlled movement of the stage so that an entire surface of the light emitting semiconductor devices on the substrate is imaged via the objective lens in the sensor of the camera.

25. Apparatus of claim 15, wherein the light emitting semiconductor devices are LED die/chips and the emitted light of the LED is caused by a recombination process of electron hole pairs that are generated by the illumination in an active layer of the LED and has a similar wavelength as if a forward voltage would be applied to the LED.

26. An apparatus for inspection of light emitting semiconductor devices on a substrate comprises:

- a light source, configured as a ring light source;
- an objective lens defining a detection beam path;
- a camera with a sensor positioned in the detection beam path, for receiving light from the light emitting semiconductor devices via the objective lens and a second filter; wherein the sensor registers grey scale values of the light emitting semiconductor devices;
- a computer system for calculating a wafermap from data registers by the sensor; and
- a display in order to visually display the wafermap.

27. An apparatus for inspection of light emitting semiconductor devices on a substrate, comprises:

- a light source which is a coaxial light source;

- an objective lens defining an illumination beam path, wherein a first filter is positionable prior to the objective lens in the illumination beam path;
- a camera with a sensor positioned in a detection beam path, for receiving light from the light emitting semiconductor devices via the objective lens and a second filter; wherein the sensor registers grey scale values of the light emitting semiconductor devices;
- a computer system for calculating a wafermap form data registers by the sensor; and
- a display in order to visually display the wafermap.

Material	Bandgap energy [eV]	Wavelength [nm]
GaN	3.45	359
InN	0.8	1550
$In_{0.26}Ga_{0.74}N$ (blue LED)	2.75	450

100

Fig. 1

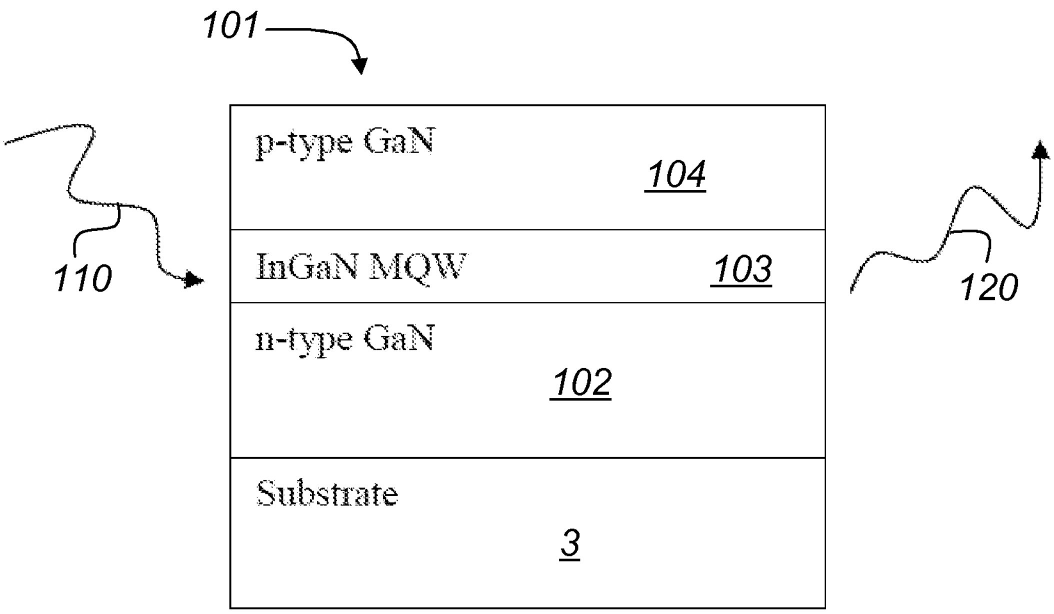

Fig. 2

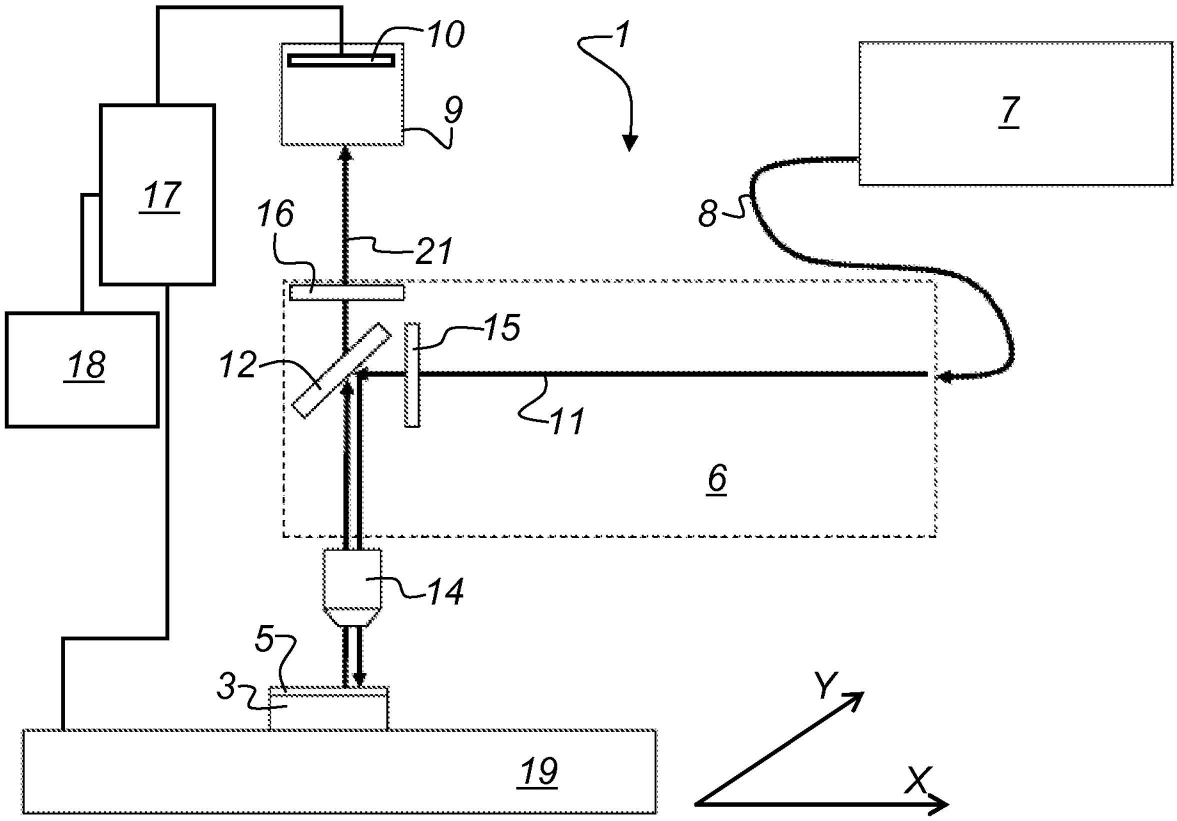

Fig. 3

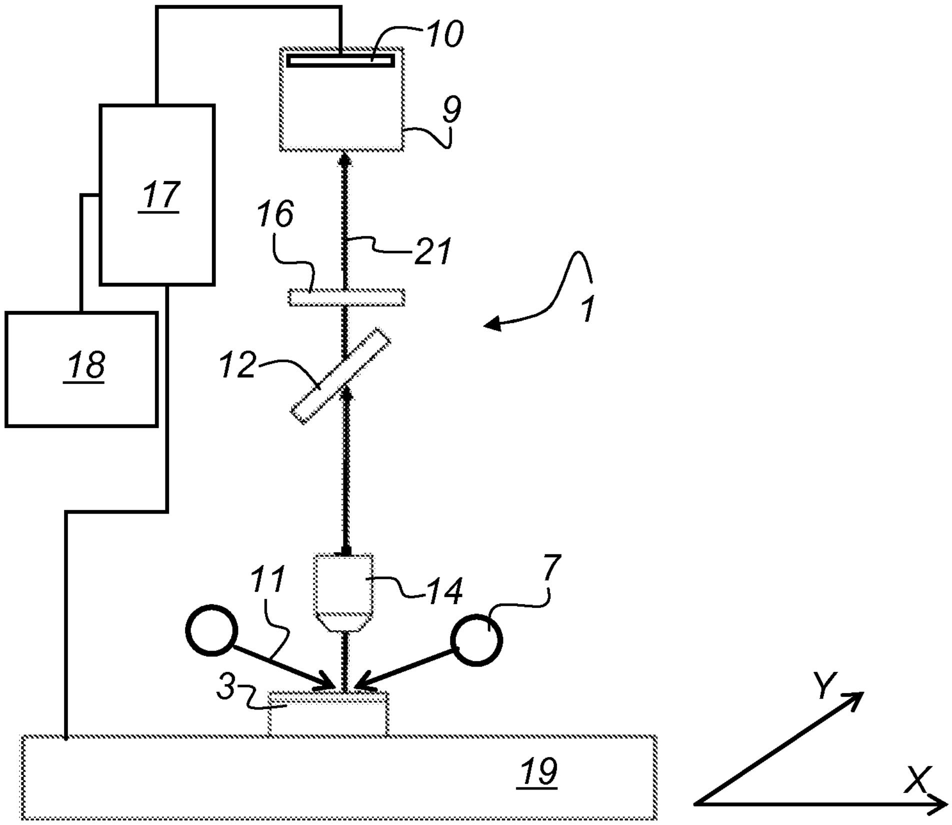

Fig. 4

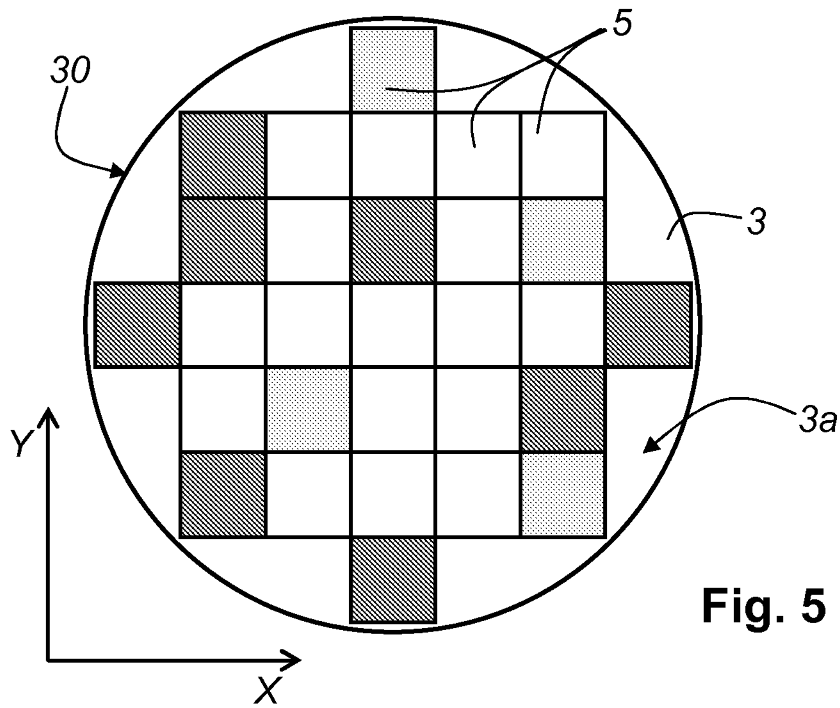

Fig. 5

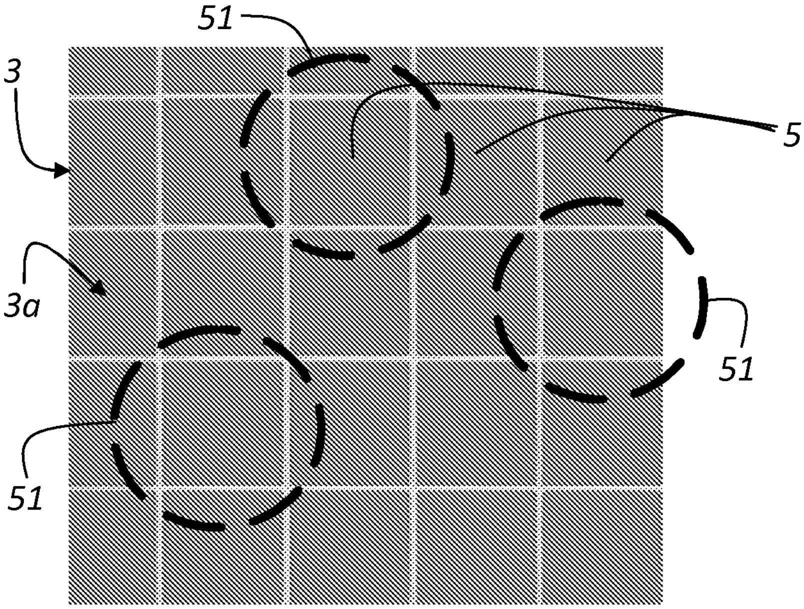

Fig. 6a

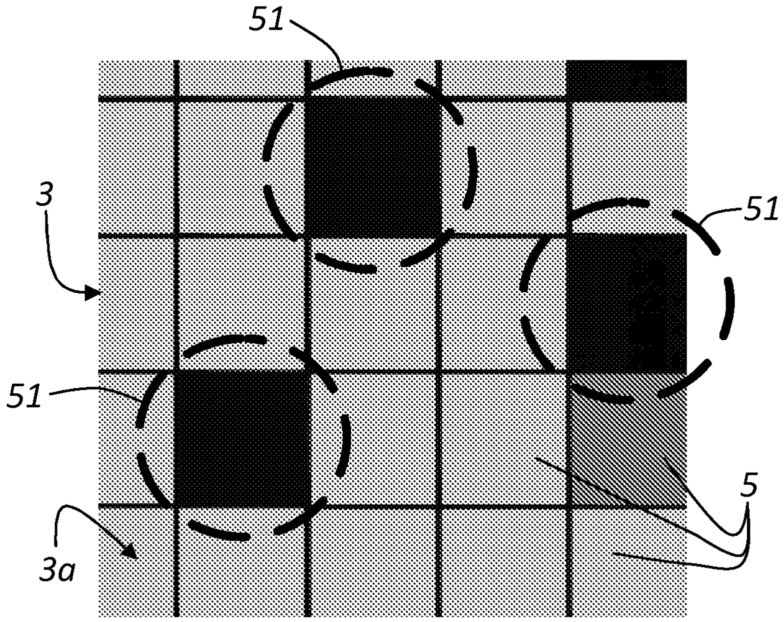

Fig. 6b

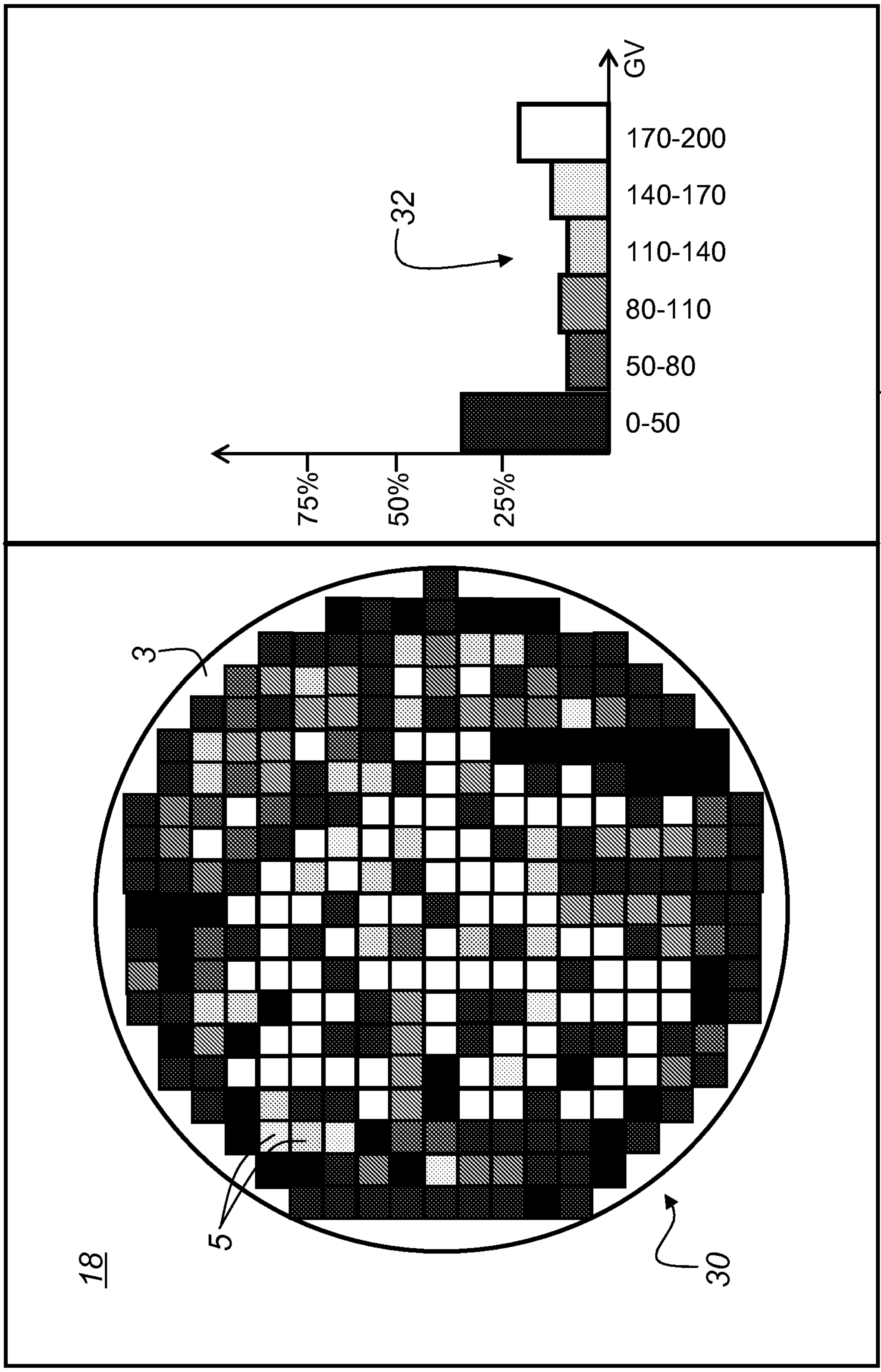

Fig. 7