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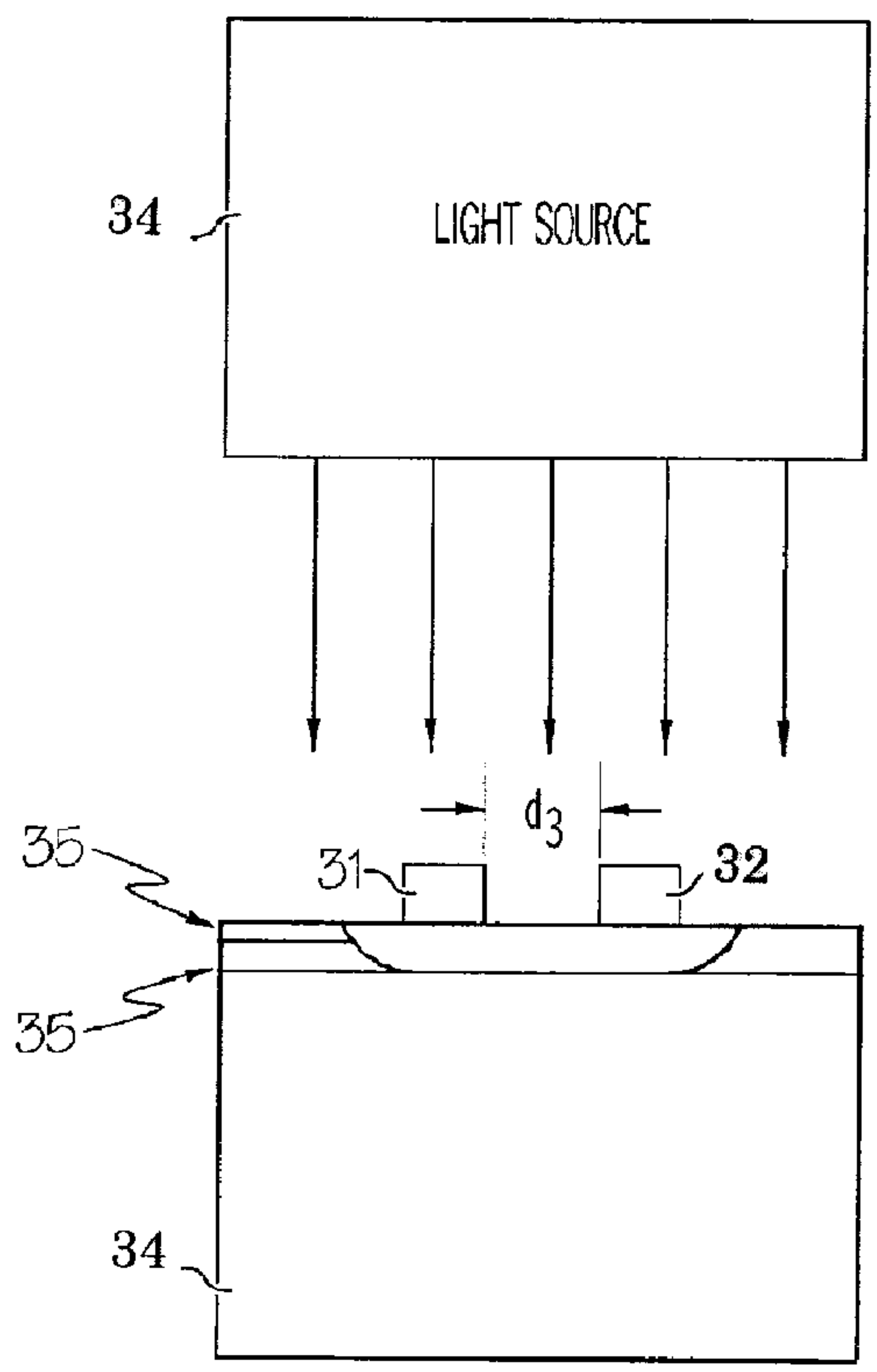
(54) **Titre : PROCEDE DE TRAITEMENT THERMIQUE LATERAL DE FILMS MINCES SUR DES SUBSTRATS A BASSE TEMPERATURE**

(54) **Title: METHOD FOR PROVIDING LATERAL THERMAL PROCESSING OF THIN FILMS ON LOW-TEMPERATURE SUBSTRATES**



(57) **Abrégé/Abstract:**
A method for thermally processing a minimally absorbing thin film in a selective manner is disclosed. Two closely spaced absorbing traces are patterned in thermal contact with the thin film. A pulsed radiant source is used to heat the two absorbing traces, and the thin film is thermally processed via conduction between the two absorbing traces. This method can be utilized to fabricate a thin film transistor (TFT) in which the thin film is a semiconductor and the absorbers are the source and the drain of the TFT.

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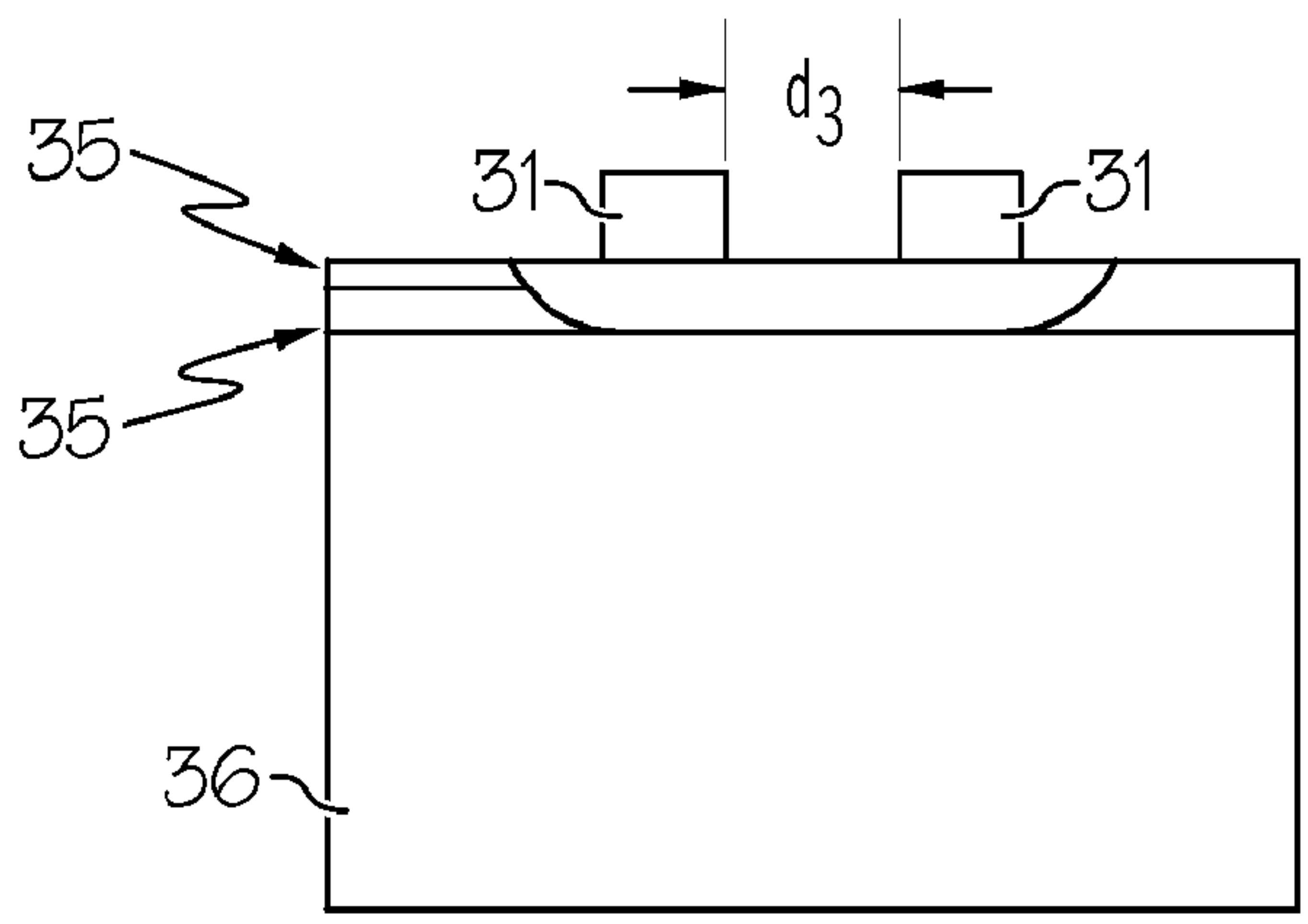


FIG. 3B

(57) **Abstract**: A method for thermally processing a minimally absorbing thin film in a selective manner is disclosed. Two closely spaced absorbing traces are patterned in thermal contact with the thin film. A pulsed radiant source is used to heat the two absorbing traces, and the thin film is thermally processed via conduction between the two absorbing traces. This method can be utilized to fabricate a thin film transistor (TFT) in which the thin film is a semiconductor and the absorbers are the source and the drain of the TFT.

WO 2011/153357 A1

METHOD FOR PROVIDING LATERAL THERMAL PROCESSING OF THIN FILMS ON LOW-TEMPERATURE SUBSTRATES

BACKGROUND OF THE INVENTION

1. Technical Field

The present invention relates to a method for curing thin films on substrates in general, and, in particular, to a method for thermally processing thin films on low-temperature substrates.

2. Description of Related Art

In general, thermal processing encompasses sintering, annealing, curing, drying, crystallization, polymerization, chemical reaction initiation and modulation, dopant drive-in, degasification, etc. Thermal processing of semiconductor thin films is typically performed in high temperature environments. For example, amorphous silicon (a-Si) is annealed at 1,100 °C, and silicon nanoparticle films are sintered at 900 °C. Thus, the high-temperature requirement for processing semiconductor thin films often mandates the usage of high-temperature substrates, such as fired ceramics or quartz, as the choice substrates for carrying semiconductor thin films.

Needless to say, it is more desirable to use low-temperature substrates, such as borosilicate or soda lime, as the choice substrates for carrying semiconductor thin films if possible because of their relatively low cost. Even more desirable substrate materials would be plastic (*i.e.*, polycarbonate, polyimide, PET, PEN, etc.) or paper because their cost is even lower.

However, the usage of equipment that can provide an equilibrium process, such as an oven, is not a viable option for thermally processing a semiconductor thin film on a low-temperature substrate. This is because the required temperature for annealing and sintering most, if not all, semiconductor thin films are considerably higher than the maximum working temperatures of low-temperature substrates such as polyimide and PET, which are around 450 °C and 150 °C, respectively.

The present disclosure provides a method for thermally processing thin films on low-temperature substrates.

SUMMARY

In accordance with a preferred embodiment of the present invention, two absorbing traces spaced apart are in thermal contact with a thin film located on top of a substrate. Pulsed radiation is utilized to heat the two absorbing traces, and the heat from the two absorbing traces is subsequently conducted in the plane of the thin film to the thin film between the two absorbing traces to thermally process the thin film.

Certain exemplary embodiments can provide a method for thermally processing a thin film, said method comprising: patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of ceramic, wherein said thin film is located on top of a substrate; irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces; and allowing heat from said two absorbing traces to thermally process said thin film.

Other exemplary embodiments can provide a method for fabricating a thin film transistor, said method comprising: patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of ceramic, wherein said thin film is located on top of a substrate; irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, and allowing heat from said two absorbing traces to thermally process said thin film; depositing a dielectric layer on said two absorbing trace and said thin film; and forming a gate by depositing a conductive trace on top of said dielectric layer.

Other exemplary embodiments can provide a method for thermally processing a thin film, said method comprising: patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of metal, wherein said thin film is located on top of a substrate; irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, wherein a pulse length of said at least one electromagnetic pulse is shorter than a thermal equilibration time of said substrate; and allowing heat from said two absorbing traces to thermally process said thin film.

Other exemplary embodiments can provide a method for fabricating a thin film transistor, said method comprising: patterning two absorbing traces adjacent to a thin film, wherein said two absorbing traces are made of metal, wherein said thin film is located on top of a substrate; irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, wherein a pulse length of said at least one electromagnetic pulse is shorter than a thermal equilibration time of said substrate, and allowing heat from said two absorbing traces to thermally process said thin film; depositing a dielectric layer on said two absorbing trace and said thin film; and forming a gate by depositing a conductive trace on top of said dielectric layer.

The above-mentioned process may be used to fabricate a thin film transistor (TFT). For example, two absorbing traces, which may be composed of metal or ceramic, can be used to form a source and drain of a TFT, and a semiconductor thin film can be used to form an active channel of the TFT.

All features and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention itself, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figures **1a-1b** depict a method for thermally processing a thin film, in accordance with one embodiment of the present invention;

Figures **2a-2b** depict a method for thermally processing a thin film, in accordance with another embodiment of the present invention;

Figures **3a-3b** depict a method for thermally processing a very thin film on a low-temperature substrate, in accordance with one embodiment of the present invention;

Figure **4** shows a thin film transistor (TFT) manufactured by the methods of the present invention;

Figure **5** shows a Raman spectrum of an e-beam coated amorphous silicon on a borosilicate glass before and after being exposed to pulsed radiation;

Figure **6** is a graph showing the selectivity of the pulsed radiation lateral thermal processing method of the present invention; and

Figure **7** is a graph showing drain current versus drain-source voltage for the TFT from Figure **4**.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

When using a pulsed radiation thermal processing technique to thermally process a thin film on a substrate, the pulsed radiation emitted from flashlamps, directed plasma arcs (DPAs), lasers, microwaves, induction heaters or electron beams has the ability to preferentially heat the thin film over its substrate. In addition, because the heat capacity of the substrate is much larger than that of the thin film, and the time of heating is much shorter than the thermal equilibration time of the substrate, the substrate can serve as a heat sink to rapidly cool the thin film immediately after thermal processing.

Although pulsed radiation thermal processing allows a thin film to be heated to a much higher temperature than its substrate can normally withstand at thermal equilibrium, such thermal processing technique generally depends on the ability of a thin film to absorb the radiation that is used to heat the thin film. Thus, when a thin film is very thin and/or somewhat transparent, it is quite difficult to thermally process the very thin film directly with the pulsed radiation thermal processing technique because the very thin film typically absorbs minimal radiation. Consequently, an improved method is required to thermally process a very thin film.

Referring now to the drawings, and in particular to Figures **1a-1b**, there are depicted a method for providing pulsed radiation thermal processing on a very thin film, in accordance with one embodiment of the present invention. Initially, a very thin film **12** is deposited on a substrate **14** via well-known vacuum techniques. Very thin film **12** may also be coated or printed on substrate **14**. Very thin film **12** can be a fully dense film or a particulate film. The thickness of very thin film **12** is preferably less than 10 microns. Next, an absorbing trace **11** is deposited on top of very thin film **12** to form a thin film stack **10**, as shown in Figure **1a**. Absorbing trace **11** is preferably made of a material that is more absorptive of pulsed radiation than very thin film **12**. Examples of absorbing trace **11** include metals or ceramics.

When thin film stack **10** is transiently irradiated (*i.e.*, via pulsed radiation) by a light source **15**, absorbing trace **11** is preferentially heated before very thin film **12**. Light source **15** can be a flashlamp, directed plasma arc (DPA), laser, microwave generator, induction heater or electron beam. As a result, the area (shaded area) within very thin film **12** and substrate **14** located underneath and adjacent to absorbing trace **11** is thermally processed by the heated absorbing trace **11**, as shown in Figure **1b**. The distance d_1 within very thin film **12** that is thermally processed can be tens of microns.

With reference now to Figures **2a**-**2b**, there are illustrated a method for providing pulsed radiation thermal processing on a very thin film, in accordance with another embodiment of the present invention. Initially, a very thin film **23** is deposited on a substrate **24** via well-known vacuum techniques. Very thin film **23** can also be coated or printed on substrate **24**. Very thin film **23** can be a fully dense film or a particulate film. The thickness of very thin film **23** is preferably less than 10 microns. Next, absorbing traces **21, 22** are deposited on very thin film **23** to form a thin film stack **20**, as shown in Figure **2a**. Similar to absorbing trace **11** in Figure **1a**, absorbing traces **21, 22** are preferably made of a material that is more absorptive of pulsed radiation than very thin film **23**. Examples of absorbing traces **21, 22** include metals or ceramics. Although absorbing traces **21, 22** are shown to be formed on top of very thin film **23**, absorbing traces **21, 22** can be formed underneath very thin film **23** instead.

Upon being exposed to pulsed radiation from a light source **25**, absorbing traces **21, 22** are preferentially heated over very thin film **23**. The heat from absorbing traces **21, 22** is then conducted to the area of very thin film **23** underneath and/or adjacent to absorbing traces **21, 22**, as shown in Figure **2b**. In Figure **2b**, an area d_2 within very thin film **23** located between absorbing traces **21, 22** becomes thermally processed. The gap distance that can be thermally processed between absorbing traces **21** and **22** (*i.e.*, area d_2) is generally larger than d_1 from Figure **1b** since it is the overlap of the heat being conducted by two absorbing traces **21, 22** and is preferably less than 100 microns. Furthermore, since the area within very thin film **23** located between absorbing traces **21** and **22** is thermally processed by the overlapping of heat being conducted from two absorbing traces **21**, **22**, very thin film **23** tends to be more uniformly processed than the area of a thin film adjacent to only one absorbing trace (such as in Figure **1b**).

Substrate **14** in Figures **1a**-**1b** and substrate **24** in Figures **2a**-**2b** are preferably high-temperature substrates. However, thermal processing of very thin films can also be performed on low-temperature substrates (*i.e.*, maximum working temperatures of 150 °C or less) by applying heat spreading films before or after the application of the absorbing traces. Since the thermal conductivity of the heat spreading film is higher than that of the low temperature substrate, heat is preferentially conducted in the plane of the very thin film and the heat spreading film instead of the low temperature substrate after absorbing traces have been heated. The heat spreading film also acts as a thermal barrier layer to protect the low temperature substrate. In addition, the preferential conduction of heat in the plane of the very thin film increases the distance at which absorbing traces can be placed from each other. As a result, a lower energy light pulse can be used to process the very thin film, thus making the process more gentle on the low-temperature substrate. The heat spreading film is generally thicker than the very thin film and is generally transparent to the light used to heat the absorbing traces.

Referring now to Figures **3a**-**3b**, there are illustrated a method for thermally processing a very thin film on a low-temperature substrate, in accordance with one embodiment of the present invention. Initially, a heat spreading film **35** is deposited on a substrate **34** via well-known vacuum techniques. Heat spreading film **35** may be coated or printed on substrate **34**. A very thin film   is then deposited on top of heat spreading film **35** via well-known vacuum techniques. Very thin film   may be coated or printed on heat spreading film **35**. Very thin film   can be a fully dense film or a particulate film. The thickness of very thin film   is preferably less than 10 microns. Next, absorbing traces **31**, **32** are deposited on very thin film   to form a thin film stack **30**, as shown in Figure **3a**. Similar to absorbing traces **21**, **22** in Figure **2a**, absorbing traces **31**,

32 are preferably made of a material that is more absorptive of pulsed radiation than very thin film. Examples of absorbing traces **31**, **32** include metals or ceramics.

Although absorbing traces **31**, **32** are shown to be formed on top of very thin film, absorbing traces **31**, **32** can be formed underneath very thin film. Although heat spreading film **35** is shown to be formed underneath very thin film, heat spreading film **35** can be formed on top of very thin film or absorbing traces **31**, **32**.

Upon being exposed to pulsed radiation from a light source **34**, absorbing traces **31**, **32** are preferentially heated over very thin film and heat spreading film **35**. The heat from absorbing traces **31**, **32** is then conducted to the area of very thin film and heat spreading film **35** underneath and/or adjacent to absorbing traces **31**, **32**, as shown in Figure **3b**. In Figure **3b**, an area d_3 within very thin film and heat spreading film **35** located between absorbing traces **31**, **32** becomes thermally processed. The gap distance that can be thermally processed between absorbing traces **31** and **32** is preferably less than 100 microns.

There is a host of materials suitable for being heat spreading film **35**. For a low-temperature substrate such as PET, those materials may include high-temperature polymers (such as polyimide) or inorganic coatings such as sputtered metal oxides or spin on glass (SOG). For higher-temperature substrates such as polyimide, more suitable materials for heat spreading film **35** include inorganic coatings such as sputtered metal oxides or SOG. It is preferable that heat spreading film **35** be somewhat transparent in order to maintain transparency of the very thin film and still allow the selective heating to occur. The required thickness of heat spreading film **35** is a function of its thermal properties, the thickness and thermal properties of the underlying low temperature substrate, the desired processing temperature of very thin film, the dimensions and spacing of absorbing traces **31**, **32**, and the input radiant heating profile.

One approach of applying a heat spreading film to a high-temperature substrate is to first apply a polymeric coating, which has lower thermal conductivity than the high-temperature substrate, to the high-temperature substrate followed by the application of a heat spreading film. This practice retards the diffusion of heat into the thermally conductive substrate and allows a very thin film to be processed. An alternative to the polymeric coating is to use a high-temperature, low-thermal conductivity inorganic film so that it can withstand a higher temperature during thermal processing.

One method to achieve a high-temperature, low-thermal conductivity inorganic film is to make the inorganic film porous by using a SOG and load it with porous particles. For example, such an inorganic film can be made by using silica aerogel nanoparticles loaded in a SOG. The resulting inorganic film appears to have a thermal conductivity of the order of (or even lower than that of) PET (*i.e.*, 0.24 W/m-°K). Since the aerogel particles have the SOG matrix, the inorganic film is much more durable than a typical aerogel film.

The thermal processing of the very thin film can be tuned by varying the power and length of the pulsed radiation. Multiple pulses can be used as well as adjusting the pulse repetition frequency. The shape of the pulse can be changed using pulse width modulation to further adjust the heating profile. When the pulse length is shorter than the thermal equilibration time of the low-temperature substrate, that is, perpendicular to the plane of the low-temperature substrate, a stronger thermal gradient and higher peak temperature can be generated in it, thereby preferentially heating the very thin film adjacent to the absorbing traces. The temperature in the very thin film is more intensely processed near the absorbing traces relative to regions farther away from the absorbing traces. Furthermore, pulsed radiation allows the peak processing temperature to be greater than the maximum equilibrium working temperature of a substrate. For example, 150 micron thick PET thermally equilibrates across its thickness in about 35 ms. Thus, a stronger thermal processing gradient as well as a higher peak temperature can be produced without damaging the low-temperature substrate with a 300 μs pulse than with a 10 ms pulse. A 100 ms pulse can still heat the very thin film located between the absorbing traces, but the peak temperature that can be maintained is very close to its maximum equilibrium working temperature of 150 °C. In sum, the maximum peak temperature that can be achieved in the very thin film without damaging the low-temperature substrate of a longer pulse is less than that of a short pulse, but the lateral processing length is correspondingly longer also. Since the thermal processing of the very thin film is usually Arrhenius in nature, *i.e.*, the thermal processing is generally related to the exponential of the processing temperature times time, a shorter pulse can process the very thin film more effectively than a longer pulse without damaging the low-temperature substrate.

The thickness, width, and spacing of absorbing traces as well as the thickness and thermal properties of a very thin film and underlying layers also contribute to the heating profile seen by the very thin film upon being exposed by pulsed radiation.

The method of the present invention can process very thin films that are not particularly radiation absorbing. This is particularly relevant to the fabrication of thin film transistors (TFTs) that are very desirable because of their low cost and high performance.

Referring now to Figure **4**, there is depicted a TFT **40** manufactured by the above-mentioned pulsed radiation thermal processing technique. As shown, a thin dielectric layer **44** is placed on top of two absorbing traces **41** and **42** that are located adjacent to a very thin film **43**. A conductive trace **45** is located on top of dielectric layer **44** and absorbing traces **41** and **42**. Absorbing traces **41**, **42** are electrically conductive and form the source and the drain of a TFT, respectively. Conductive trace **45** forms the gate of the TFT. The area located between absorbing traces **41** and **42** within very thin film **43** that has been thermally processed is a semiconductor forms the active channel of the TFT. As shown in Figure **4**, the cured area (shaded area) includes the gate oxide and the gate. However, both the gate oxide and the gate are applied after the curing of the very thin film **43**.

Very thin film **43** is cured primarily between absorbing traces **41** and **42**. Thus, sources and drains can be patterned (or printed) on a very large area, and very thin film **43** can even be coated over an entire substrate **46**. Since a cured semiconductor generally has a higher conductivity than an uncured one, the fact that the semiconductor becomes cured primarily in the channel of the TFT, the parasitic capacitance of the semiconductor is reduced. The reduced need for registration and critical dimensions means that the above-mentioned TFT can be completely printed *en mass*.

An example of a method for making a TFT, such as TFT **40**, is described as follows. When making a TFT, microcrystalline silicon (μx-Si) is more desirable as a semiconductor than amorphous silicon (a-Si) because μx-Si has higher mobility and therefore enables a faster switching TFT. It is usually easier to deposit a-Si followed by a thermal anneal to convert a-Si to μx-Si than to deposit μx-Si directly. For example, a 200 nm film of a-Si on a 500 μm borosilicate wafer can be converted to μx-Si (with an N2 purge) by using a light pulse from a PulseForge® 3300 system (manufactured by NovaCentrix in Austin, Texas) at a threshold voltage of 650 V and a pulse length of 100 μs. The light pulse has an intensity of about 35 kW/cm^2, which corresponds to a radiant exposure of about 3.5 J/cm^2.

With reference now to Figure **5**, there is illustrated a Raman spectrum of 200 nm a-Si film that was e-beam sputtered coated on a borosilicate glass before and after being exposed to the above-mentioned light pulse. The a-Si film is annealed by the light pulse and is converted to μx-Si. The light pulse is needed to overcome the fact that a 200 nm a-Si coating only absorbs a portion of the emitted light.

An identical borosilicate wafer is patterned with gold contact source/drain lines to form an eventual TFT of various widths (5-50 μm) and separations (5-50 μm). All traces are 5 mm long. The gold patterning is followed by an identical broadcast electron beam sputtered deposition of 200 nm of a-Si described above over the borosilicate wafer. The borosilicate wafer is then processed via the above-mentioned PulseForge® 3300 system at a much lower voltage (*i.e.*, 550 V for 250 μs). The radiant power was 24 kW/cm^2, and the radiant exposure was 5.9 J/cm^2. Note that this level of power is below the threshold intensity described above for converting a-Si to μx-Si. Since gold is very absorbing of the light pulse, more energy is absorbed at those locations.

Referring now to Figure **6**, there is illustrated the selectivity of the pulsed radiation thermal processing method of the present invention. The graph shows a comparison of the Ramen spectrum of the thin silicon film between two different gold line pair widths (50 μm and 20 μm) and identical spacing (50 μm) between the gold traces. The graph shows that the space between the 50 μm traces has been converted to μx-Si, whereas the space between the 20 μm wide traces is unconverted. Similarly, the silicon film on the rest of the wafer is unconverted. This technique has converted the a-Si to μx-Si only between the gold patterned traces and nowhere else achieving automatic registration.

After selective conversion of a-Si to μx-Si between the absorbing traces has been achieved, a TFT device can be fabricated using a spin-on barium-strontium-titanate (BST) ceramic as the dielectric layer. This dielectric material has a relatively high dielectric constant k (~300), which allows a high electric field to be imparted to the field-effect channel of the TFT at low gate voltage. A silver gate metal is vacuum deposited onto the BST gate dielectric layer to complete the TFT.

Electrical testings can be performed on the TFT to determine if the drain current can be enhanced by applying a positive gate voltage. Since μx-Si is slightly n-type, a positive gate voltage should enhance the electron concentration in the channel and result in an increased drain current (I_d).

With reference now to Figure **7**, there is illustrated a graph showing drain current (I_d) versus drain-source voltage (V_{ds}) for TFT **40** from Figure **4**. Note that at positive gate voltage (V_g), the drain current (I_d) is enhanced and has the saturation shape one expects for a field-effect TFT. The linear I-V characteristic observed at negative gate voltage indicates TFT **40** is behaving as a regular resistor when the negative gate voltage is applied. Reasons for this are unknown at this time but may be due to hole injection from the source and drain contacts. This effect, if present, is normally reduced/eliminated by suitably doping the contact regions in order to "block" hole injection.

In summary, using pulsed light annealing of an a-Si thin film with laterally positioned metal source-drain contacts can be "sub-threshold" annealed to a microcrystalline state within the region between the source-drain contacts. This has great benefit for the microelectronics industry since micro (and nano)-crystalline silicon films have high carrier mobility and other desirable features that enhance the performance of thin film devices. Furthermore, since one can convert only the a-Si in the region between source/drain contacts, leaving the surrounding regions of the a-Si to remain in a high-resistance amorphous state, and thus not require patterning or otherwise isolation to limit such deleterious effects as parasitic capacitances which limit device speed and increase power dissipation.

As has been described, the present invention provides a method for thermally processing thin films on low-temperature substrates. The method of the present invention also enables a TFT to be manufactured in a top gate configuration (*i.e.*, gate on top) with minimal registration. Two absorbing traces form a source and drain of a TFT. Before the application of the gate oxide and the gate, the thin film material is preferentially thermally processed between the two absorbing traces. The method of the present invention has the effect of selectively curing the thin film material without the need to precisely deposit the material in the channel of the TFT.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention.

CLAIMS

1. A method for thermally processing a thin film, said method comprising:

patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of ceramic, wherein said thin film is located on top of a substrate;

irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces; and

allowing heat from said two absorbing traces to thermally process said thin film.

2. The method of claim 1, wherein said substrate has a maximum working temperature of less than 450° C.

3. The method of claim 1, wherein said two absorbing traces are made of materials more absorptive of said electromagnetic pulse than said thin film.

4. The method of claim 1, wherein said two absorbing traces are made of metal.

5. The method of claim 1, wherein said method further includes providing a heat spreading layer adjacent to said thin film.

6. The method of claim 5, wherein said method further includes providing a high-temperature, low-thermal conductivity film between said heat spreading layer and said substrate.

7. The method of claim 1, wherein said electromagnetic pulse is provided by a flashlamp.

8. The method of claim 1, wherein said electromagnetic pulse is provided by a directed plasma arc.

9. The method of claim 1, wherein said two absorbing traces are not in direct contact with each other.

10. A method for fabricating a thin film transistor, said method comprising:

patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of ceramic, wherein said thin film is located on top of a substrate;

irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, and allowing heat from said two absorbing traces to thermally process said thin film;

depositing a dielectric layer on said two absorbing trace and said thin film; and

forming a gate by depositing a conductive trace on top of said dielectric layer.

11. The method of claim 10, wherein said substrate has a maximum working temperature of less than 450° C.

12. The method of claim 11, wherein said two absorbing traces are not in direct contact with each other.

13. The method of claim 10, wherein said two absorbing traces are made of materials more absorptive of said electromagnetic pulse than said thin film.

14. The method of claim 10, wherein said two absorbing traces are made of metal.

15. The method of claim 10, wherein said method further includes providing a heat spreading layer adjacent to said thin film.

16. The method of claim 15, wherein said method further includes providing a high-temperature, low-thermal conductivity film between said heat spreading layer and said substrate.

17. The method of claim 10, wherein said electromagnetic pulse is provided by a flashlamp.

18. The method of claim 10, wherein said electromagnetic pulse is provided by a directed plasma arc.

19. A method for thermally processing a thin film, said method comprising:

patterning two absorbing traces adjacent to the thin film, wherein said two absorbing traces are made of metal, wherein said thin film is located on top of a substrate;

irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, wherein a pulse length of said at least one electromagnetic pulse is shorter than a thermal equilibration time of said substrate; and

allowing heat from said two absorbing traces to thermally process said thin film.

20. The method of claim 19, wherein said substrate has a maximum working temperature of less than 450° C.

21. The method of claim 19, wherein said two absorbing traces are made of materials more absorptive of said electromagnetic pulse than said thin film.

22. The method of claim 19, wherein said method further includes providing a heat spreading layer adjacent to said thin film.

23. The method of claim 22, wherein said method further includes providing a high temperature, low-thermal conductivity film between said heat spreading layer and said substrate.

24. The method of claim 19, wherein said electromagnetic pulse is provided by a flashlamp.

25. The method of claim 19, wherein said electromagnetic pulse is provided by a directed plasma arc.

26. A method for fabricating a thin film transistor, said method comprising:

patterning two absorbing traces adjacent to a thin film, wherein said two absorbing traces are made of metal, wherein said thin film is located on top of a substrate;

irradiating said two absorbing traces with at least one electromagnetic pulse to heat up said two absorbing traces, wherein a pulse length of said at least one electromagnetic pulse is shorter than a thermal equilibration time of said substrate, and allowing heat from said two absorbing traces to thermally process said thin film;

depositing a dielectric layer on said two absorbing trace and said thin film; and

forming a gate by depositing a conductive trace on top of said dielectric layer.

27. The method of claim 26, wherein said substrate has a maximum working temperature of less than 450° C.

28. The method of claim 26, wherein said two absorbing traces are made of materials more absorptive of said electromagnetic pulse than said thin film.

29. The method of claim 26, wherein said method further includes providing a heat spreading layer adjacent to said thin film.

30. The method of claim 29, wherein said method further includes providing a high-temperature, low-thermal conductivity film between said heat spreading layer and said substrate.

31. The method of claim 26, wherein said electromagnetic pulse is provided by a flashlamp.

32. The method of claim 26, wherein said electromagnetic pulse is provided by a directed plasma arc.

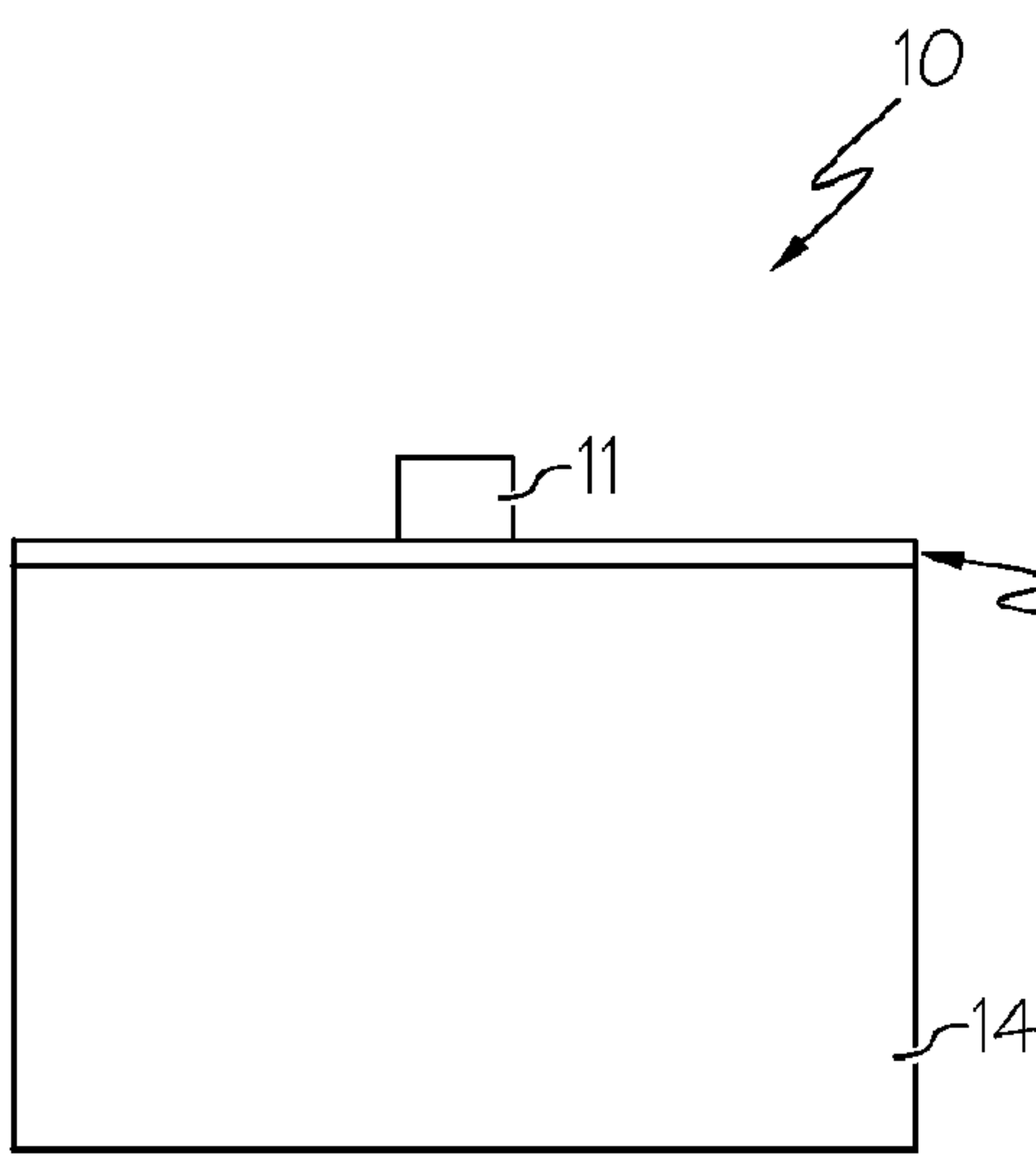


FIG. 1A

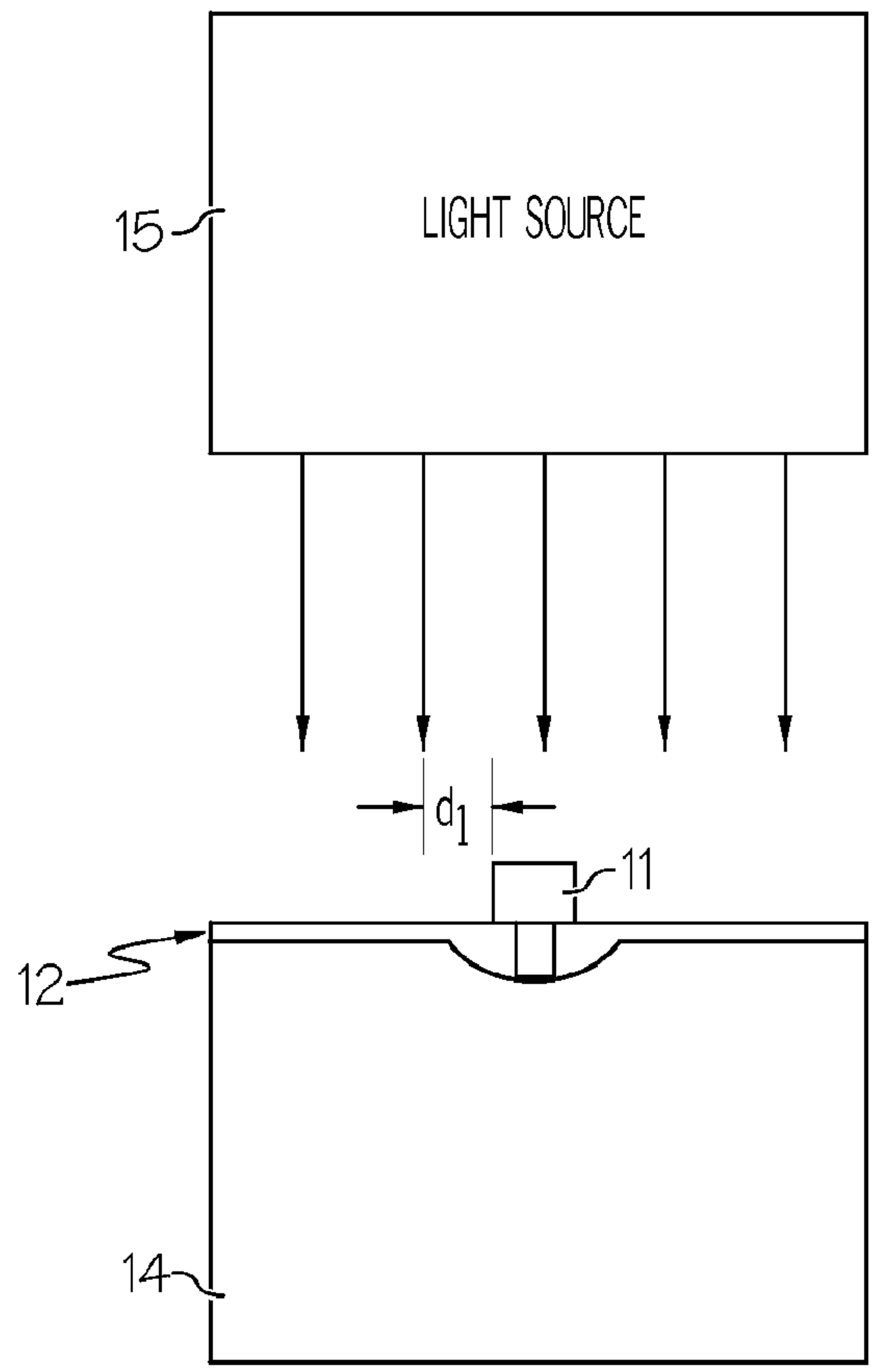


FIG. 1B

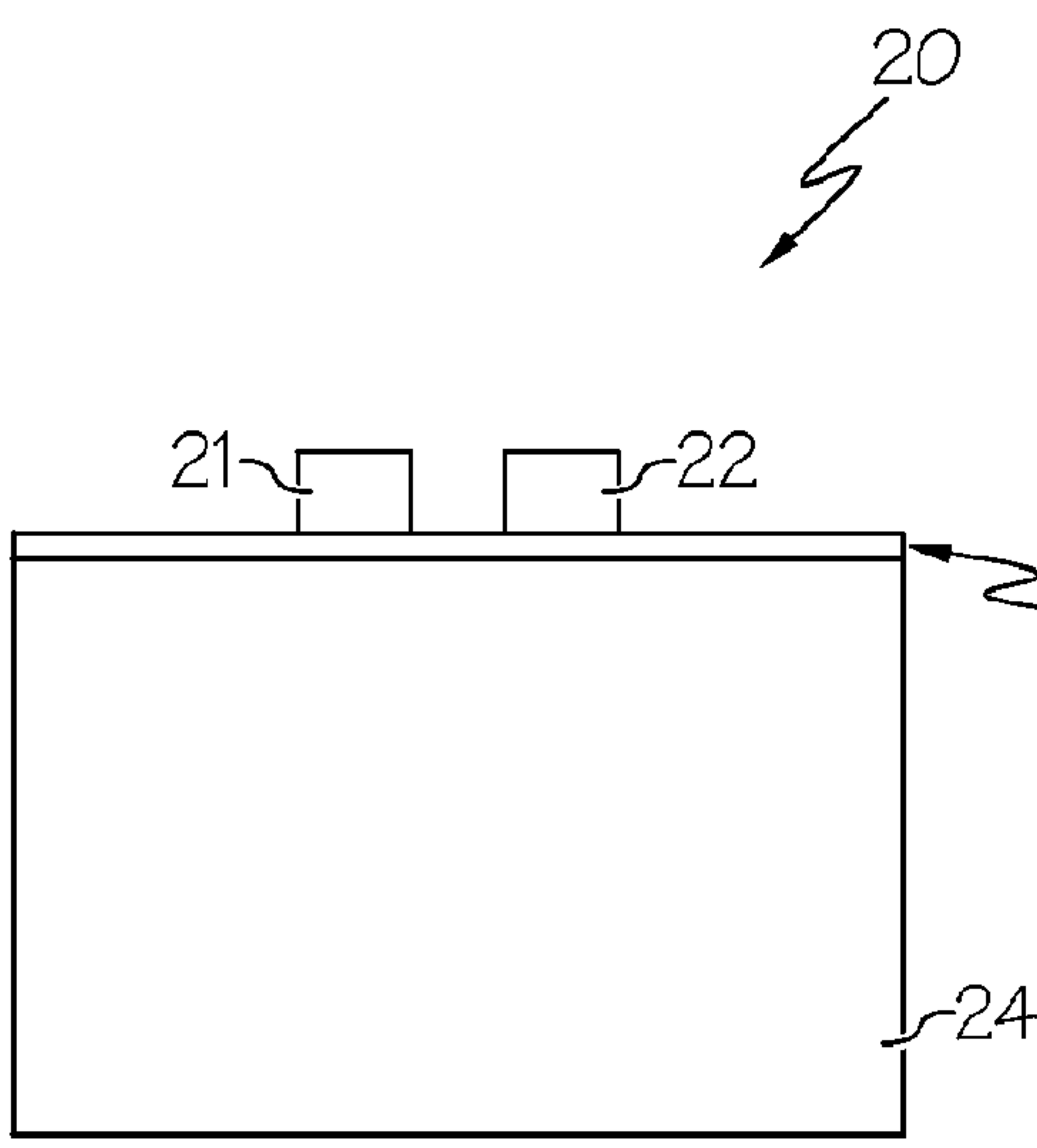


FIG. 2A

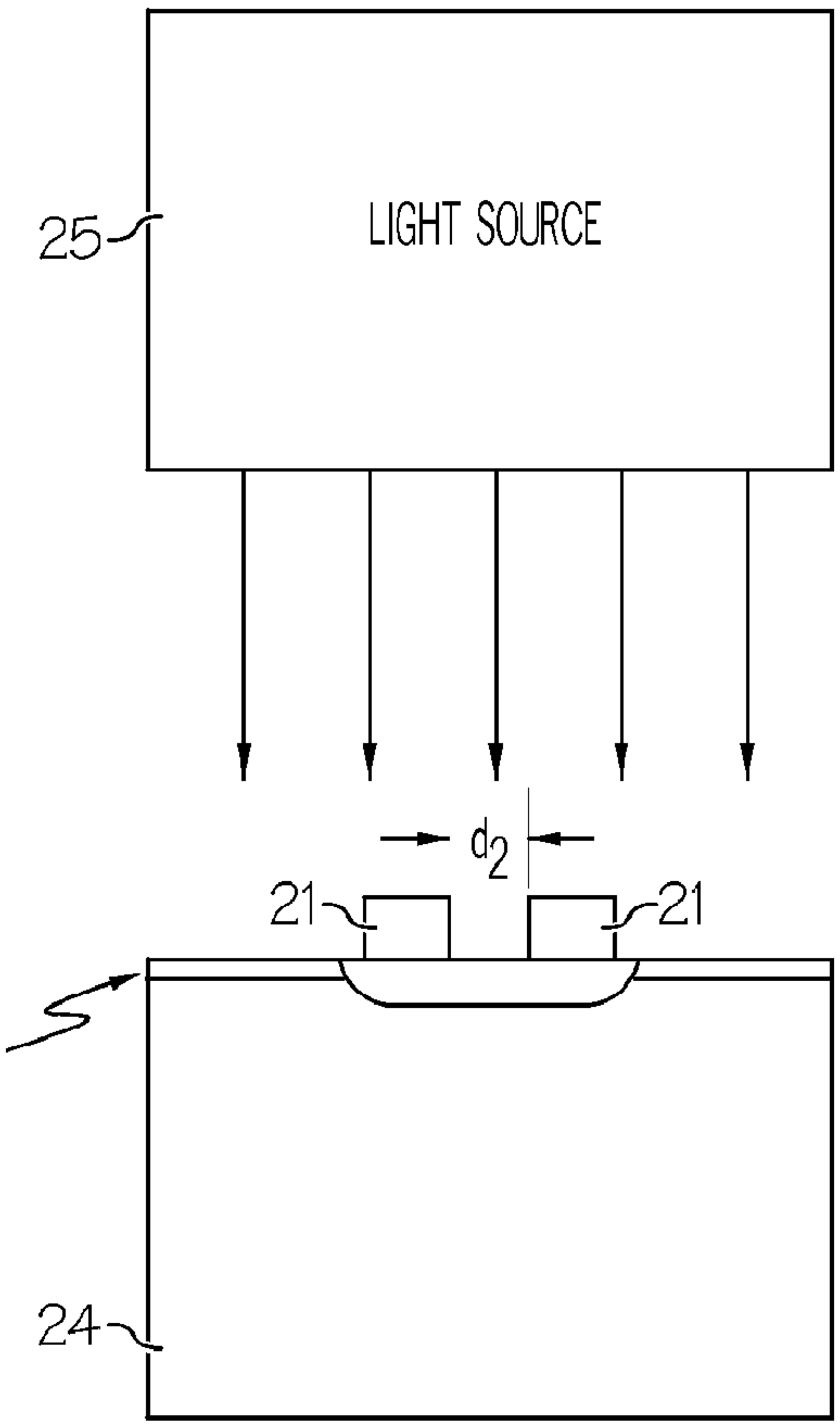


FIG. 2B

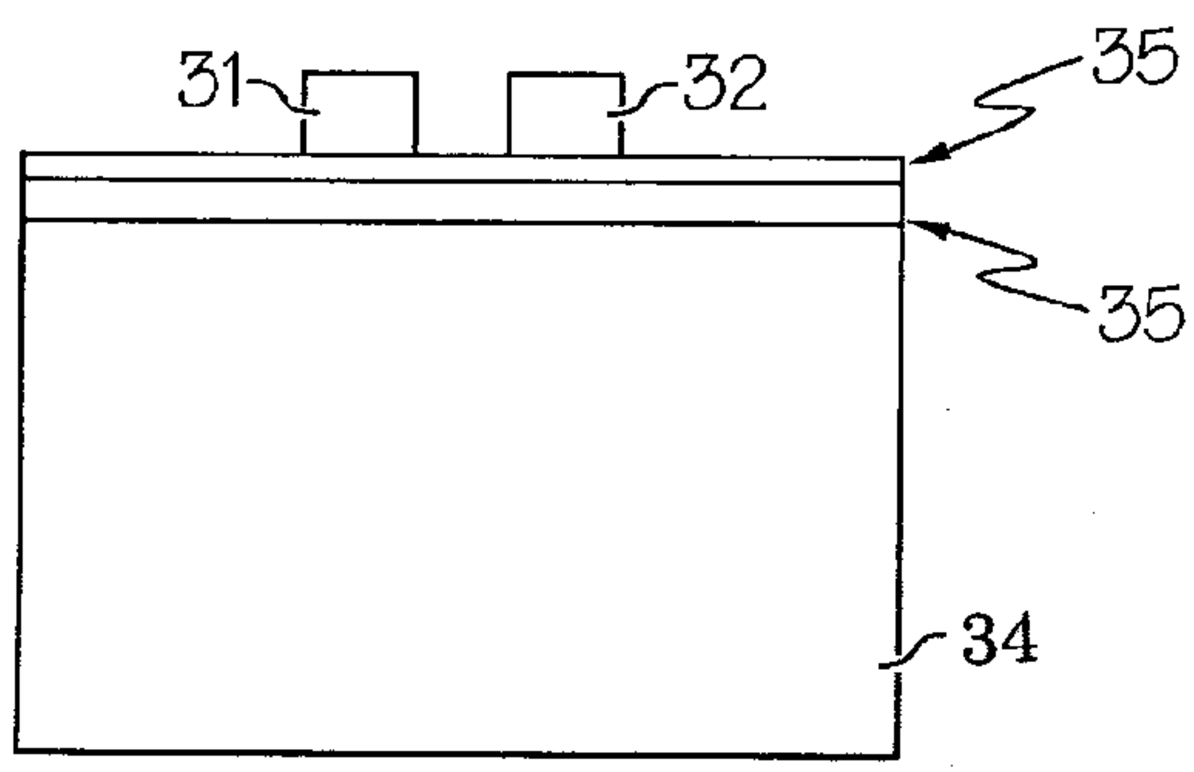


FIG. 3A

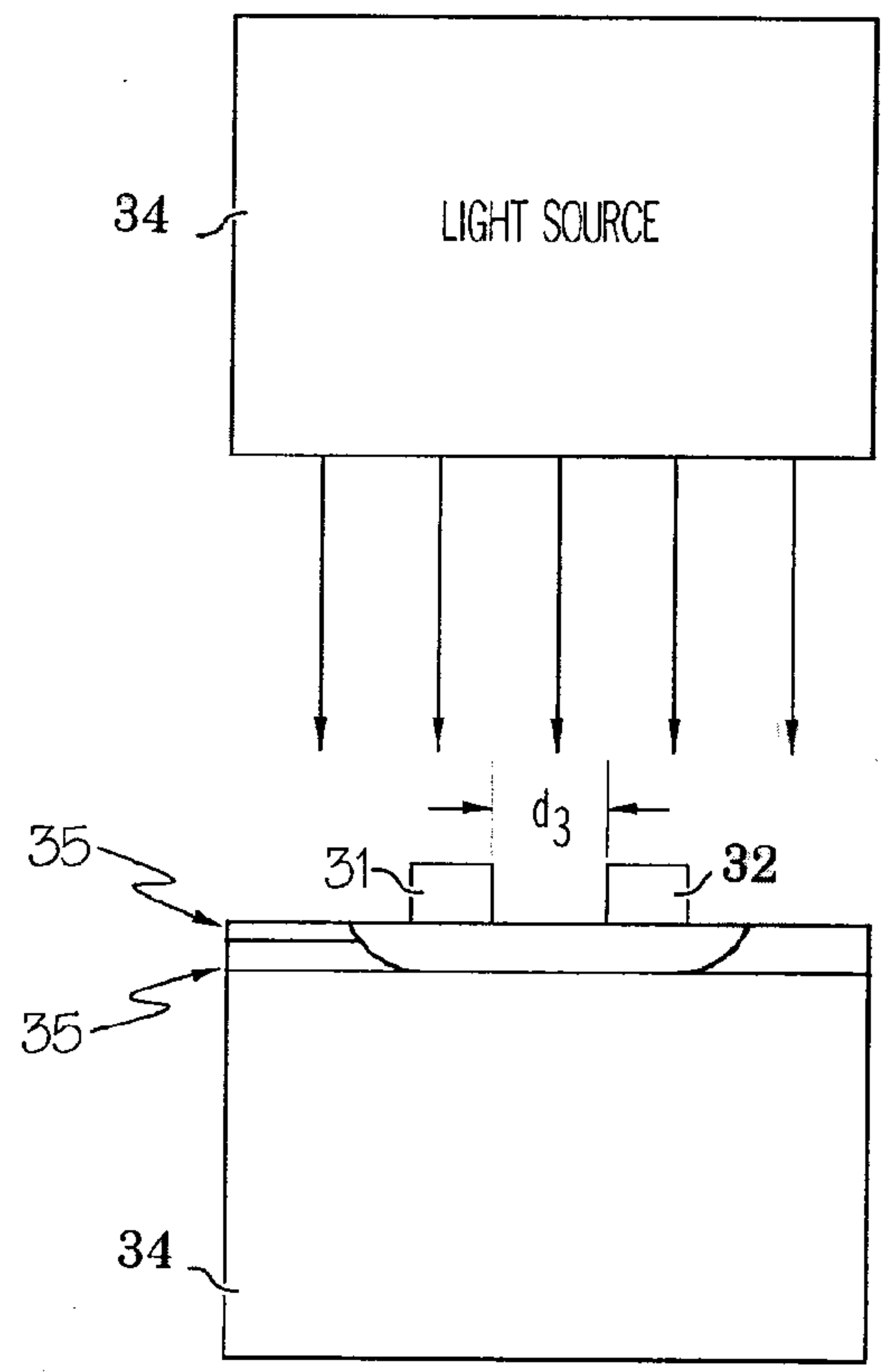


FIG. 3B

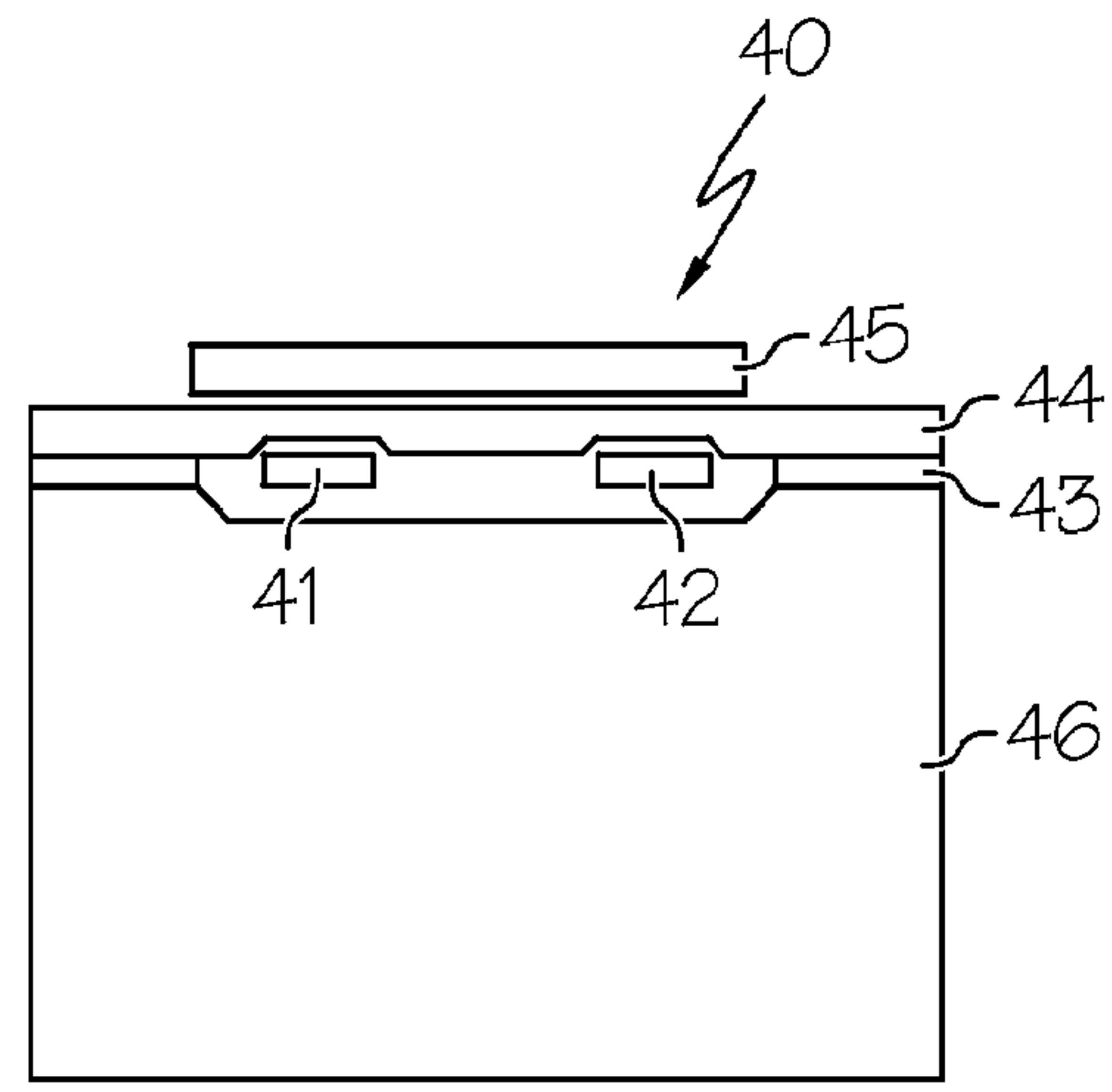

40
45
44
43
41
42
46

FIG. 4

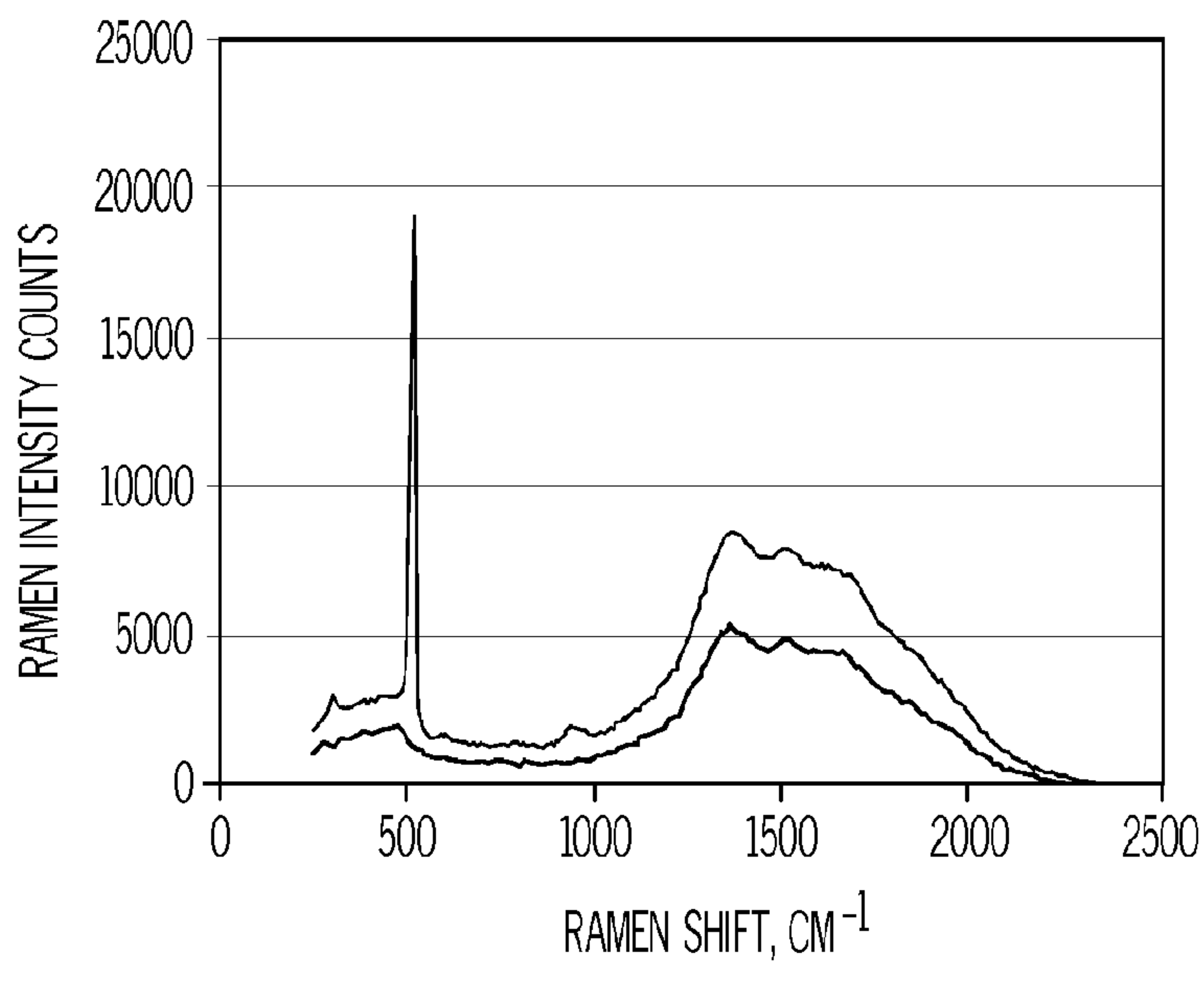

25000
20000
15000
10000
5000
0
RAMEN INTENSITY COUNTS
0
500
1000
1500
2000
2500
RAMEN SHIFT, CM-1

FIG. 5

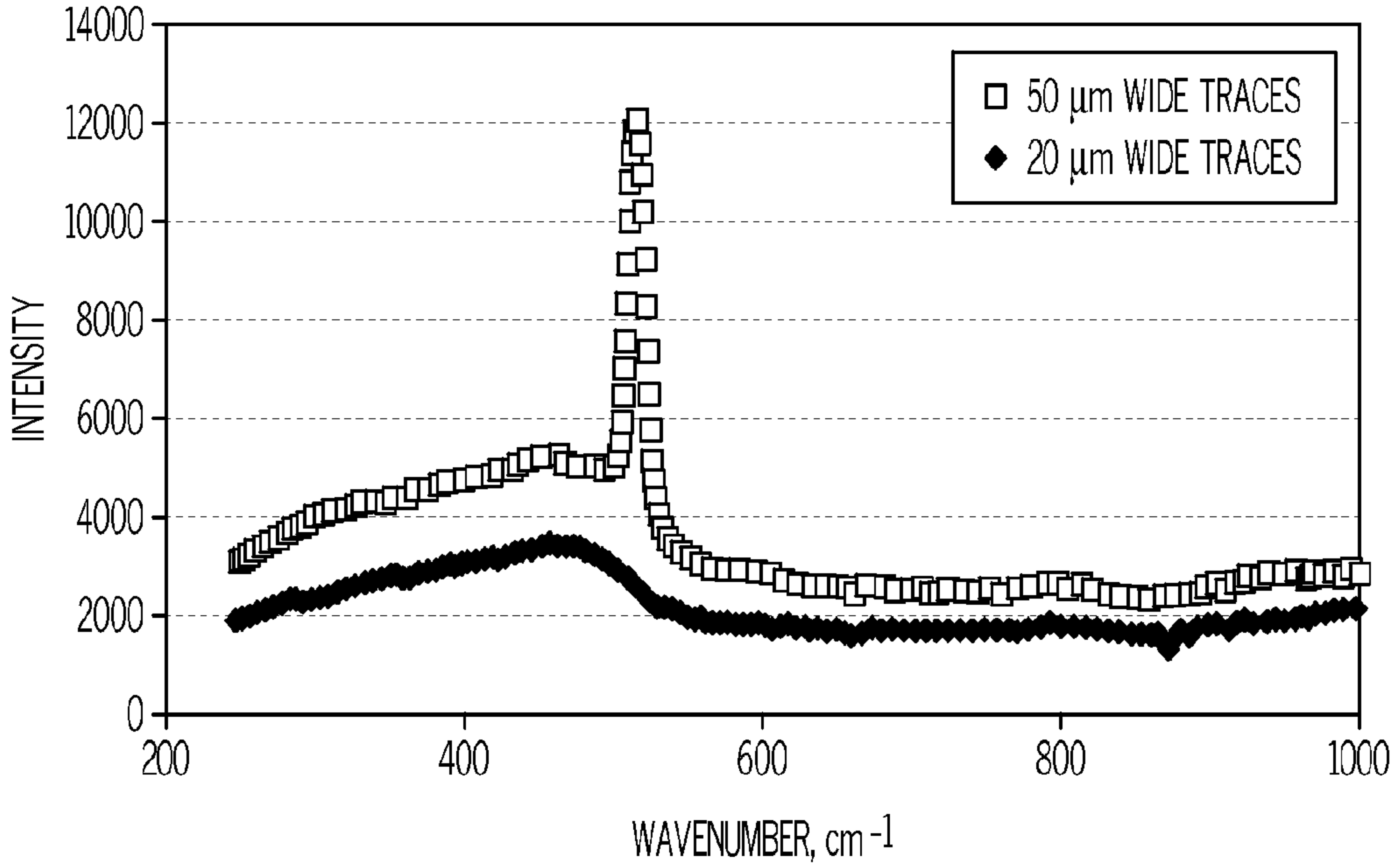

14000
12000
10000
8000
6000
4000
2000
0
INTENSITY
50 µm WIDE TRACES
20 µm WIDE TRACES
200
400
600
800
1000
WAVENUMBER, cm-1

FIG. 6

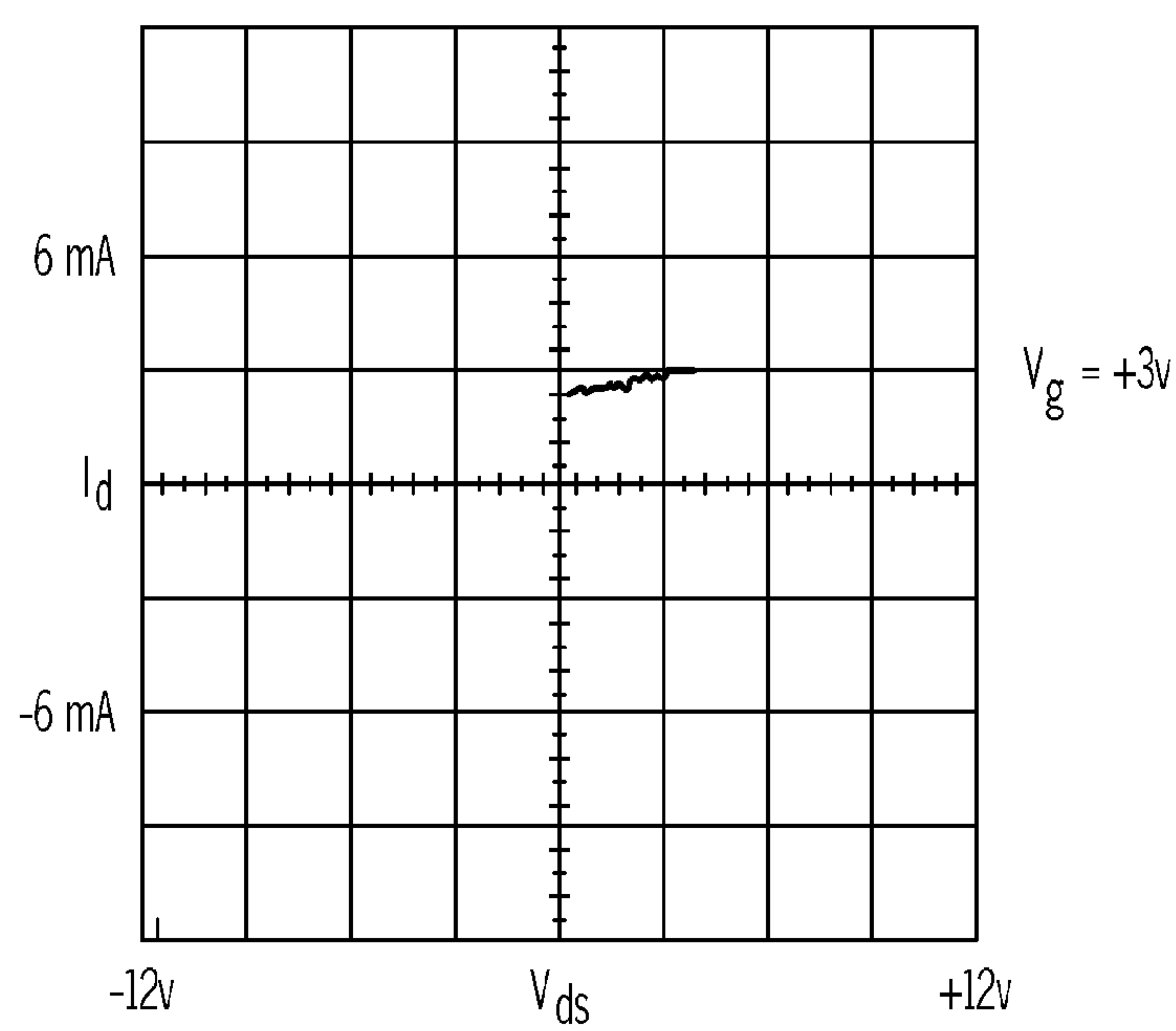
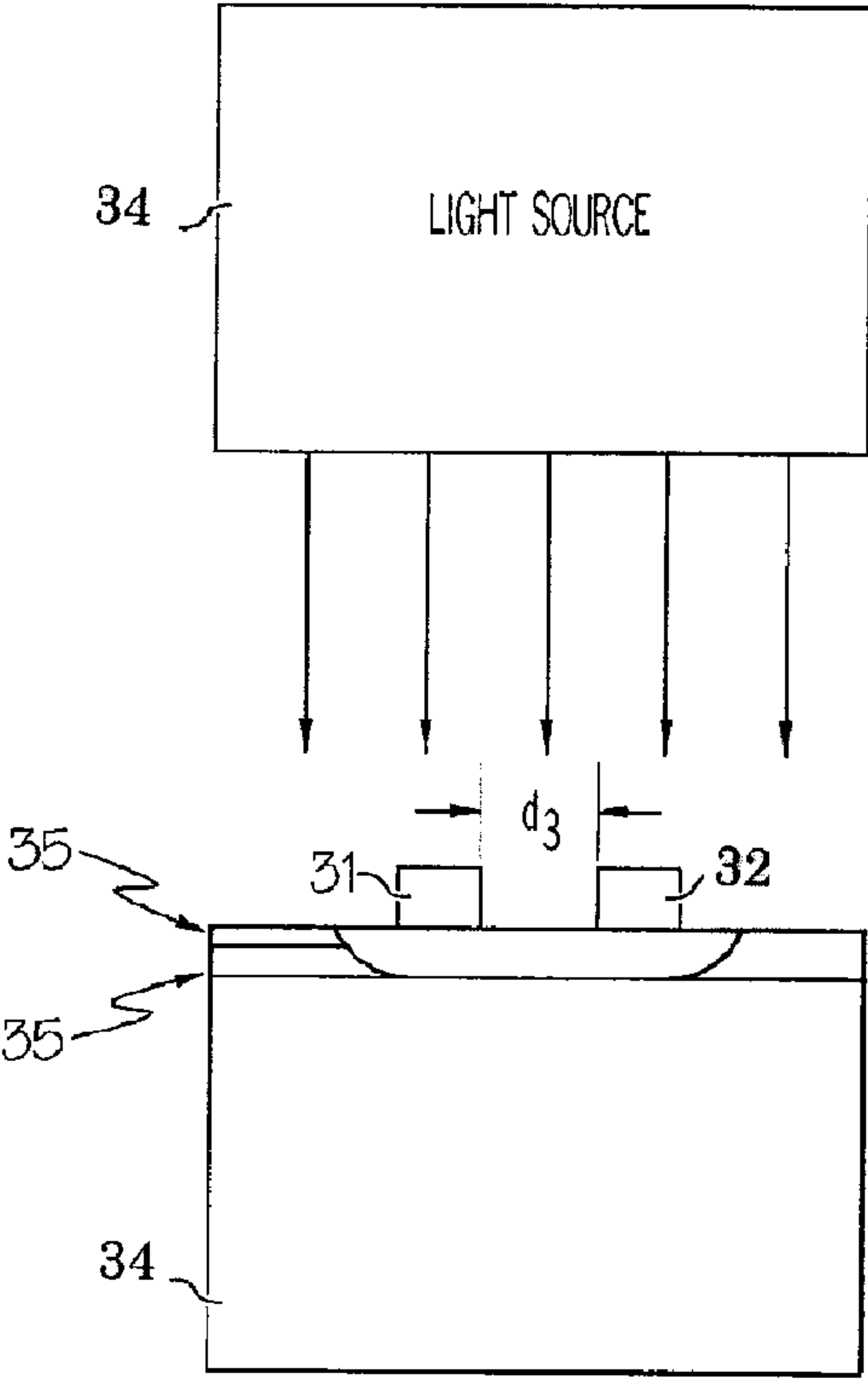

6 mA
I_d
-6 mA
V_g = +3v
-12v
V_{ds}
+12v

FIG. 7



34
LIGHT SOURCE
d_3
35
31
32
35
34