

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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SONY GROUP CORPORATION,  
Petitioner,

v.

GREENTHREAD LLC  
Patent Owner.

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IPR2023-00324 (Patent No. 11,121,222 B2)  
IPR2023-00325 (Patent No. 11,316,014 B2)  
IPR2023-00375 (Patent No. 10,734,481 B2)  
IPR2023-00376 (Patent No. 10,510,842 B2)<sup>1</sup>

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Before GRACE KARAFFA OBERMANN, CHRISTOPHER L.  
CRUMBLEY, and CHRISTOPHER M. KAISER, *Administrative Patent*  
*Judges.*

*Per Curiam.*

DECISION  
Settlement Prior to Institution of Trial  
*37 C.F.R. § 42.74*

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<sup>1</sup> This Order addresses issues that are the same in the above-captioned proceedings. The parties are not authorized to use a multi-case caption.

IPR2023-00324 (Patent No. 11,121,222 B2)  
IPR2023-00325 (Patent No. 11,316,014 B2)  
IPR2023-00375 (Patent No. 10,734,481 B2)  
IPR2023-00376 (Patent No. 10,510,842 B2)

## I. INTRODUCTION

On May 3, 2023, after email authorization by the Board, Petitioner and Patent Owner (collectively “the Parties”) filed a Joint Motion to Terminate *Inter Partes* Review in the above-identified proceeding. Paper 8 (“Joint Motion”).<sup>2</sup> In support of the Joint Motion, the Parties filed copies of Confidential Settlement-Related Agreements (Exs. 2001, 2002 (“Settlement Agreements”)), as well as a Joint Request that Agreements be Treated as Business Confidential Information and be Kept Separate Pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74 (Paper 9 (“Joint Request”)).

## II. DISCUSSION

In the Joint Motion, “[t]he Parties jointly request that the Board terminate this *inter partes* review in its entirety.” Paper 8, 2. The Parties represent that the filed Settlement Agreements are true copies and “together form the complete agreement resolving the disputes in the *inter partes* review between the Parties” and that “[t]here are no other collateral agreements between the Parties made in connection with, or in contemplation of, the termination sought.” *Id.* at 1. The Parties further represent that the District Court proceedings between the Parties involving the above-identified patent at issue was dismissed on April 27, 2023. *Id.* at 2.

The Parties also filed a Joint Request that the Settlement Agreements be treated as business confidential information and be kept separate from the

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<sup>2</sup> For purposes of expediency, we cite to papers and exhibits filed in IPR2023-00324, unless otherwise noted. The Parties filed similar papers and exhibits in each of the above-identified proceedings.

IPR2023-00324 (Patent No. 11,121,222 B2)  
IPR2023-00325 (Patent No. 11,316,014 B2)  
IPR2023-00375 (Patent No. 10,734,481 B2)  
IPR2023-00376 (Patent No. 10,510,842 B2)

file of the patent involved in this *inter partes* proceeding. Paper 9, 1. As the filing party for confidential Exhibit 2001, Patent Owner represents that it “is not permitted to share certain portions . . . with any party other than the Board and its staff.” Paper 8, 1. Patent Owner further represents that “Exhibit 2001, to which Sony is not a party, is to be filed such that it is available to the Board and Patent Owner only” and that “the Parties are in agreement with this procedure.” *Id.*

This proceeding is in its preliminary phase. Petitioner filed its Petition on December 12, 2022, and Patent Owner has not filed a Preliminary Response, which was due May 12, 2023. Paper 5, 1; Ex. 3002, 1. Accordingly, we have not yet entered a decision on institution. In view of the early stage of the proceeding and the settlement between the Parties, we determine that good cause exists to terminate the proceeding with respect to the Parties.

After reviewing each of the Settlement Agreements, we find that the Settlement Agreements contain confidential business information regarding the terms of settlement. We determine that good cause exists to treat the Settlement Agreements as business confidential information pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74(c) and kept separate from the files of the challenged patent.

The Parties further request that “the Board inform them if anyone seeks production of the agreements and afford them an opportunity to address whether such request is supported by good cause.” Paper 9, 1. We have no such procedure to serve upon the Parties a request for access to the Settlement Agreements, and, further, our regulations do not require us to do

IPR2023-00324 (Patent No. 11,121,222 B2)  
IPR2023-00325 (Patent No. 11,316,014 B2)  
IPR2023-00375 (Patent No. 10,734,481 B2)  
IPR2023-00376 (Patent No. 10,510,842 B2)

so. Therefore, we decline to issue an order regarding any request for access to the Settlement Agreements.

This Order does not constitute a final written decision pursuant to 35 U.S.C. § 318(a).

Accordingly, for the reasons discussed above, it is:

### III. ORDER

ORDERED that the Joint Motion to Terminate is *granted*;

FURTHER ORDERED that the Joint Request that Agreements be Treated as Business Confidential Information and be Kept Separate Pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74 is *granted*,

FURTHER ORDERED that Exhibits 2001 and 2002 shall remain business confidential information, and

FURTHER ORDERED that the Petition is *dismissed*.

IPR2023-00324 (Patent No. 11,121,222 B2)  
IPR2023-00325 (Patent No. 11,316,014 B2)  
IPR2023-00375 (Patent No. 10,734,481 B2)  
IPR2023-00376 (Patent No. 10,510,842 B2)

For PETITIONER:

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For PATENT OWNER:

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Stuart McCommas  
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ajairam@mckoolsmith.com  
smccommas@mckoolsmith.com  
nozarkar@mckoolsmith.com

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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DELL TECHNOLOGIES INC. AND DELL INC.,  
Petitioner,

v.

GREENTHREAD LLC,  
Patent Owner.

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IPR2023-00506 (Patent No. 10,510,842 B2)  
IPR2023-00507 (Patent No. 10,734,481 B2)  
IPR2023-00509 (Patent No. 11,121,222 B2)  
IPR2023-00510 (Patent No. 11,316,014 B2)<sup>1</sup>

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Before CHRISTOPHER L. CRUMBLEY, CHRISTOPHER M. KAISER,  
and KRISTI L. R. SAWERT, *Administrative Patent Judges*.

*Per Curiam.*

DECISION  
Settlement Prior to Institution of Trial  
*37 C.F.R. § 42.74*

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<sup>1</sup> This Order addresses issues that are the same in the above-captioned proceedings. The parties are not authorized to use a multi-case caption.

IPR2023-00506 (Patent No. 10,510,842 B2)  
IPR2023-00507 (Patent No. 10,734,481 B2)  
IPR2023-00509 (Patent No. 11,121,222 B2)  
IPR2023-00510 (Patent No. 11,316,014 B2)

## I. INTRODUCTION

On May 2, 2023, after email authorization by the Board, Petitioner and Patent Owner (collectively “the Parties”) filed a Joint Motion to Terminate *Inter Partes* Review in the above-identified proceeding. Paper 9 (“Joint Motion”).<sup>2</sup> In support of the Joint Motion, the Parties filed copies of Confidential Settlement-Related Agreements (Exs. 2001, 2002 (“Settlement Agreements”)), as well as a Joint Request to Keep Separate Pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74(c) (Paper 10 (“Joint Request”)).

## II. DISCUSSION

In the Joint Motion, “[t]he Parties jointly request that the Board terminate this *inter partes* review of the Patent-in-Suit, Case No. IPR2023-00506, in its entirety.” Paper 9, 2. The Parties represent that the filed Settlement Agreements are true copies and “together form the complete agreement resolving the disputes in the *inter partes* review between the Parties” and that “[t]here are no other collateral agreements between the Parties made in connection with, or in contemplation of, the termination sought.” *Id.* at 1. The Parties further represent that a “joint motion to dismiss the lawsuit between” the Parties “involving the Patent-in-Suit was filed on April 24, 2023.” *Id.* at 2.

The Parties also filed a Joint Request that the Settlement Agreements be treated as business confidential information and be kept separate from the file of the patent involved in this *inter partes* proceeding and the files of this

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<sup>2</sup> For purposes of expediency, we cite to papers and exhibits filed in IPR2023-00506, unless otherwise noted. The Parties filed similar papers and exhibits in each of the above-identified proceedings.

IPR2023-00506 (Patent No. 10,510,842 B2)  
IPR2023-00507 (Patent No. 10,734,481 B2)  
IPR2023-00509 (Patent No. 11,121,222 B2)  
IPR2023-00510 (Patent No. 11,316,014 B2)

proceeding. Paper 10, 1. As the filing party for confidential Exhibit 2001, Patent Owner represents that it “is not permitted to share certain portions . . . with any party other than the Board and its staff.” Paper 9, 1. Patent Owner further represents that “Exhibit 2001, to which Dell is not a party, is to be filed such that it is available to the Board and Patent Owner only” and that “the Parties are in agreement with this procedure.” *Id.*

This proceeding is in its preliminary phase. Petitioner filed its Petition on January 27, 2022, and Patent Owner has not filed a Preliminary Response. Paper 9, 2. Accordingly, we have not yet entered a decision on institution. In view of the early stage of the proceeding and the settlement between the Parties, we determine that good cause exists to terminate the proceeding with respect to the Parties.

After reviewing each of the Settlement Agreements, we find that the Settlement Agreements contain confidential business information regarding the terms of settlement. We determine that good cause exists to treat the Settlement Agreements as business confidential information pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74(c) and kept separate from the files of the challenged patent. On the other hand, as to the Parties’ request that the Board keep the Settlement Agreements “separate from the files of this proceeding,” Paper 10, 1, our regulations do not require us to do so. Therefore, we decline to issue an order to keep the Settlement Agreements separate from the file of this *inter partes* proceeding.

The Parties further request that “the Board inform them if anyone seeks production of the agreements and afford them an opportunity to address whether such request is supported by good cause.” Paper 10, 1. We

IPR2023-00506 (Patent No. 10,510,842 B2)  
IPR2023-00507 (Patent No. 10,734,481 B2)  
IPR2023-00509 (Patent No. 11,121,222 B2)  
IPR2023-00510 (Patent No. 11,316,014 B2)

have no such procedure to serve upon the Parties a request for access to the Settlement Agreements, and, further, our regulations do not require us to do so. Therefore, we decline to issue an order regarding any request for access to the Settlement Agreements.

This Order does not constitute a final written decision pursuant to 35 U.S.C. § 318(a).

Accordingly, for the reasons discussed above, it is:

### III. ORDER

ORDERED that the Joint Motion to Terminate is *granted*;

FURTHER ORDERED that the Joint Request to Keep Separate Pursuant to 35 U.S.C. § 317(b) and 37 C.F.R. § 42.74(c) is *granted-in-part* and *denied-in-part*,

FURTHER ORDERED that Exhibits 2001 and 2002 shall remain business confidential information, and

FURTHER ORDERED that the Petition is *dismissed*.

IPR2023-00506 (Patent No. 10,510,842 B2)  
IPR2023-00507 (Patent No. 10,734,481 B2)  
IPR2023-00509 (Patent No. 11,121,222 B2)  
IPR2023-00510 (Patent No. 11,316,014 B2)

FOR PETITIONER:

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nozarkar@mckoolsmith.com  
nmatich@mckoolsmith.com  
smccommas@mckoolsmith.com

AO 120 (Rev. 08/10)

|                                                                                                                                               |                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| <b>TO: Mail Stop 8</b><br><b>Director of the U.S. Patent and Trademark Office</b><br><b>P.O. Box 1450</b><br><b>Alexandria, VA 22313-1450</b> | <b>REPORT ON THE</b><br><b>FILING OR DETERMINATION OF AN</b><br><b>ACTION REGARDING A PATENT OR</b><br><b>TRADEMARK</b> |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas, Waco Division on the following

☐ Trademarks or ☒ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

|                               |                             |                                                                        |
|-------------------------------|-----------------------------|------------------------------------------------------------------------|
| DOCKET NO.<br>6:22-cv-00105   | DATE FILED<br>1/27/2022     | U.S. DISTRICT COURT<br>Western District of Texas, Waco Division        |
| PLAINTIFF<br>GREENTHREAD, LLC |                             | DEFENDANT<br>INTEL CORPORATION, DELL INC., AND DELL TECHNOLOGIES INC., |
| PATENT OR TRADEMARK NO.       | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK                                          |
| 1 8,421,195                   | 4/16/2013                   | GREENTHREAD, LLC                                                       |
| 2 9,190,502                   | 11/17/2015                  | GREENTHREAD, LLC                                                       |
| 3 10,510,842                  | 12/17/2019                  | GREENTHREAD, LLC                                                       |
| 4 10,734,481                  | 8/4/2020                    | GREENTHREAD, LLC                                                       |
| 5 11,121,222                  | 9/14/2021                   | GREENTHREAD, LLC                                                       |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

|                         |                                                                                                                                                                          |                               |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| DATE INCLUDED           | INCLUDED BY<br><input checked="" type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading |                               |
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK                                                                                                                                              | HOLDER OF PATENT OR TRADEMARK |
| 1 11,316,014            | 4/26/2022                                                                                                                                                                | GREENTHREAD, LLC              |
| 2                       |                                                                                                                                                                          |                               |
| 3                       |                                                                                                                                                                          |                               |
| 4                       |                                                                                                                                                                          |                               |
| 5                       |                                                                                                                                                                          |                               |

In the above—entitled case, the following decision has been rendered or judgement issued:

|                    |
|--------------------|
| DECISION/JUDGEMENT |
|--------------------|

|       |                   |      |
|-------|-------------------|------|
| CLERK | (BY) DEPUTY CLERK | DATE |
|-------|-------------------|------|

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director  
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

|                                                                                                                                                         |                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| <b>TO:</b><br><b>Mail Stop 8</b><br><b>Director of the U.S. Patent and Trademark Office</b><br><b>P.O. Box 1450</b><br><b>Alexandria, VA 22313-1450</b> | <b>REPORT ON THE</b><br><b>FILING OR DETERMINATION OF AN</b><br><b>ACTION REGARDING A PATENT OR</b><br><b>TRADEMARK</b> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Western District of Texas, Waco Division on the following

☐ Trademarks or ☒ Patents. ( ☐ the patent action involves 35 U.S.C. § 292.):

|                                   |                             |                                                                            |
|-----------------------------------|-----------------------------|----------------------------------------------------------------------------|
| DOCKET NO.<br>6:22-cv-00105       | DATE FILED<br>1/27/2022     | U.S. DISTRICT COURT<br>Western District of Texas, Waco Division            |
| PLAINTIFF<br><br>GREENTHREAD, LLC |                             | DEFENDANT<br><br>INTEL CORPORATION, DELL INC., AND DELL TECHNOLOGIES INC., |
| PATENT OR TRADEMARK NO.           | DATE OF PATENT OR TRADEMARK | HOLDER OF PATENT OR TRADEMARK                                              |
| 1 8,421,195                       | 4/16/2013                   | GREENTHREAD, LLC                                                           |
| 2 9,190,502                       | 11/17/2015                  | GREENTHREAD, LLC                                                           |
| 3 10,510,842                      | 12/17/2019                  | GREENTHREAD, LLC                                                           |
| 4 10,734,481                      | 8/4/2020                    | GREENTHREAD, LLC                                                           |
| 5 11,121,222                      | 9/14/2021                   | GREENTHREAD, LLC                                                           |

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

|                         |                                                                                                                                                               |                               |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| DATE INCLUDED           | INCLUDED BY<br><input type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading |                               |
| PATENT OR TRADEMARK NO. | DATE OF PATENT OR TRADEMARK                                                                                                                                   | HOLDER OF PATENT OR TRADEMARK |
| 1                       |                                                                                                                                                               |                               |
| 2                       |                                                                                                                                                               |                               |
| 3                       |                                                                                                                                                               |                               |
| 4                       |                                                                                                                                                               |                               |
| 5                       |                                                                                                                                                               |                               |

In the above—entitled case, the following decision has been rendered or judgement issued:

|                    |
|--------------------|
| DECISION/JUDGEMENT |
|--------------------|

|       |                   |      |
|-------|-------------------|------|
| CLERK | (BY) DEPUTY CLERK | DATE |
|-------|-------------------|------|

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 Copy 2—Upon filing document adding patent(s), mail this copy to Director    Copy 4—Case file copy



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 16/717,950         | 12/17/2019            | G.R. Mohan Rao        | GRTD.01.01.DV6         |

**CONFIRMATION NO. 5519**

**POWER OF ATTORNEY NOTICE**

40672  
LAW OFFICE OF BILL NAIFEH  
PO BOX 803423  
DALLAS, TX 75380



Date Mailed: 10/15/2021

**NOTICE REGARDING CHANGE OF POWER OF ATTORNEY**

This is in response to the Power of Attorney filed 10/07/2021.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/atesfai/



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 16/717,950         | 12/17/2019            | G.R. Mohan Rao        | GRTD60-35377           |

25883  
MUNCK WILSON MANDALA L.L.P.  
P.O. Drawer 800889  
DALLAS, TX 75380

**CONFIRMATION NO. 5519**  
**POA ACCEPTANCE LETTER**



Date Mailed: 10/15/2021

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 10/07/2021.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/atesfai/

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**PATENT - POWER OF ATTORNEY  
OR  
REVOCATION OF POWER OF ATTORNEY  
WITH A NEW POWER OF ATTORNEY  
AND  
CHANGE OF CORRESPONDENCE ADDRESS**

|                      |                                                        |
|----------------------|--------------------------------------------------------|
| Patent Number        | 10,734,481                                             |
| Issue Date           | 08-04-2020                                             |
| First Named Inventor | G.R. Mohan RAO                                         |
| Title                | SEMICONDUCTOR<br>DEVICES WITH GRADED<br>DOPANT REGIONS |
| Attorney Docket No.  | GRTD60-35377                                           |

I hereby revoke all previous powers of attorney given in the above-identified patent.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint Practitioner(s) associated with the Customer Number identified in the box at right as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

25883

OR

☐ I hereby appoint Practitioner(s) named below as my/our attorney(s) or agent(s) with respect to the patent identified above, and to transact all business in the United States Patent and Trademark Office connected therewith:

| Practitioner(s) Name | Registration Number |
|----------------------|---------------------|
|                      |                     |
|                      |                     |
|                      |                     |
|                      |                     |

Please recognize or change the correspondence address for the above-identified patent to:

☐ The address associated with the above-identified Customer Number.

OR

☒ The address associated with the Customer Number identified in the box at right:

25883

OR

☐ Firm or  
Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the:

☐ Applicant.

OR

☒ Patent owner.

Statement under 37 CFR 3.73(c) (Form PTO/AIA/96) submitted herewith or filed on \_\_\_\_\_.

**SIGNATURE of Applicant or Patent Owner**

|                   |                     |           |                  |
|-------------------|---------------------|-----------|------------------|
| Signature         | <i>Phillip John</i> | Date      | 9/30/2021        |
| Name              | Phillip John        | Telephone | 219-728-8244     |
| Title and Company | Manager             |           | Greenthread, LLC |

**NOTE:** Signatures of all the applicants or patent owners of the entire interest or their representative(s) are required. If more than one signature is required, submit multiple forms, check the box below, and identify the total number of forms submitted in the blank below.☐ A total of \_\_\_\_\_ forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public, which is to update (and by the USPTO to process) the file of a patent or reexamination proceeding. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**STATEMENT UNDER 37 CFR 3.73(c)**Applicant/Patent Owner: Greenthread, LLCApplication No./Patent No.: 10,734,481 Filed/Issue Date: 08-04-2020Titled: SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONSGreenthread, LLC, a Limited Liability Company

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☒ The assignee of the entire right, title, and interest.
2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):
- ☐ The extent (by percentage) of its ownership interest is \_\_\_\_\_%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

- A. ☒ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel 051843, Frame 0078, or for which a copy thereof is attached.
- B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:
1. From: \_\_\_\_\_ To: \_\_\_\_\_
- The document was recorded in the United States Patent and Trademark Office at
- Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.
2. From: \_\_\_\_\_ To: \_\_\_\_\_
- The document was recorded in the United States Patent and Trademark Office at
- Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Greenthread Ex. 2070, p. 16 of 140

Cirrus Logic, et al. v. Greenthread

IPR2024-00018

**STATEMENT UNDER 37 CFR 3.73(c)**

3. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at  
 Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

4. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at  
 Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

5. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at  
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6. From: \_\_\_\_\_ To: \_\_\_\_\_

The document was recorded in the United States Patent and Trademark Office at  
 Reel \_\_\_\_\_, Frame \_\_\_\_\_, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☒ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Gregory M. Howison, Reg. #30646/

October 5, 2021

Signature

Date

Gregory M. Howison

30,646

Printed or Typed Name

Title or Registration Number

## Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| Electronic Acknowledgement Receipt   |                                                  |
|--------------------------------------|--------------------------------------------------|
| EFS ID:                              | 43954987                                         |
| Application Number:                  | 16717950                                         |
| International Application Number:    |                                                  |
| Confirmation Number:                 | 5519                                             |
| Title of Invention:                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| First Named Inventor/Applicant Name: | G.R. Mohan Rao                                   |
| Customer Number:                     | 40672                                            |
| Filer:                               | Gregory Michael Howison                          |
| Filer Authorized By:                 |                                                  |
| Attorney Docket Number:              | GRTD.01.01.DV6                                   |
| Receipt Date:                        | 07-OCT-2021                                      |
| Filing Date:                         | 17-DEC-2019                                      |
| Time Stamp:                          | 11:45:31                                         |
| Application Type:                    | Utility under 35 USC 111(a)                      |

| Payment information:   |                      |                                      |                                          |                  |                  |
|------------------------|----------------------|--------------------------------------|------------------------------------------|------------------|------------------|
| Submitted with Payment |                      |                                      | no                                       |                  |                  |
| File Listing:          |                      |                                      |                                          |                  |                  |
| Document Number        | Document Description | File Name                            | File Size(Bytes)/ Message Digest         | Multi Part /.zip | Pages (if appl.) |
| 1                      | Power of Attorney    | GRT35377POACHANGEADDRESS<br>SEXE.pdf | 1029309                                  | no               | 1                |
|                        |                      |                                      | 3acfbed46ef481052c4e2a13c086408631a9b159 |                  |                  |
| Warnings:              |                      |                                      |                                          |                  |                  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                               |                     |                                          |         |   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|---------------------|------------------------------------------|---------|---|
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                               |                     |                                          |         |   |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Assignee showing of ownership per 37 CFR 3.73 | GRT35377373STMT.pdf | 120456                                   | no      | 3 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                               |                     | 2cfd5990a1bfac2c5318d20fd7dee2abab650b07 |         |   |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                               |                     |                                          |         |   |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                               |                     |                                          |         |   |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                               |                     |                                          | 1149765 |   |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> <b>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</b></p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> <b>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</b></p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> <b>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</b></p> |                                               |                     |                                          |         |   |



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY.DOCKET NO./TITLE | REQUEST ID |
|--------------------|-----------------------|-----------------------|-----------------------|------------|
| 16/717,950         | 12/17/2019            | GREENTHREAD, LLC      | GRTD.01.01.DV6        | 121973     |

## Acknowledgement of Loss of Entitlement to Entity Status Discount

The entity status change request below filed through Private PAIR on 09/28/2020 has been accepted.

### CERTIFICATIONS:

#### Change of Entity Status:

✕ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

|                      |                                  |
|----------------------|----------------------------------|
| Signature:           | /Bill R. Naifeh, Reg. No. 44962/ |
| Name:                | Bill R. Naifeh                   |
| Registration Number: | 44962                            |



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Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
[www.uspto.gov](http://www.uspto.gov)

| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|------------|------------|---------------------|------------------|
| 16/717,950      | 08/04/2020 | 10734481   | GRTD.01.01.DV6      | 5519             |

40672 7590 07/15/2020  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

## ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

### **Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)** (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

GREENTHREAD, LLC, Dallas, TX;  
G.R. Mohan Rao, Allen, TX;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit [SelectUSA.gov](http://SelectUSA.gov).

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

40672 7590 04/07/2020  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

## Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

|                         |
|-------------------------|
| (Typed or printed name) |
| (Signature)             |
| (Date)                  |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 16/717,950      | 12/17/2019  | G.R. Mohan Rao       | GRTD.01.01.DV6      | 5519             |

TITLE OF INVENTION: SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

| APPLN. TYPE    | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE   |
|----------------|---------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | SMALL         | \$500         | \$0.00              | \$0.00               | \$500            | 07/07/2020 |

| EXAMINER    | ART UNIT | CLASS-SUBCLASS |
|-------------|----------|----------------|
| ARORA, AJAY | 2892     | 257-025000     |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

1 Bill R. Naifeh

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2

3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

Greenthread, LLC

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Dallas, Texas

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. \_\_\_\_\_

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29☐ Applicant asserting small entity status. See 37 CFR 1.27☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Bill R. Naifeh, Reg No. 44962/

Date 2020-06-19

Typed or printed name Bill R. Naifeh

Registration No. 44,962

| Electronic Patent Application Fee Transmittal |          |                                                  |        |                      |
|-----------------------------------------------|----------|--------------------------------------------------|--------|----------------------|
| Application Number:                           |          | 16717950                                         |        |                      |
| Filing Date:                                  |          | 17-Dec-2019                                      |        |                      |
| Title of Invention:                           |          | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |        |                      |
| First Named Inventor/Applicant Name:          |          | G.R. Mohan Rao                                   |        |                      |
| Filer:                                        |          | Bill Naifeh/April Reasoner                       |        |                      |
| Attorney Docket Number:                       |          | GRTD.01.01.DV6                                   |        |                      |
| Filed as Small Entity                         |          |                                                  |        |                      |
| Filing Fees for   Utility under 35 USC 111(a) |          |                                                  |        |                      |
| Description                                   | Fee Code | Quantity                                         | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                                  |        |                      |
| Pages:                                        |          |                                                  |        |                      |
| Claims:                                       |          |                                                  |        |                      |
| Miscellaneous-Filing:                         |          |                                                  |        |                      |
| Petition:                                     |          |                                                  |        |                      |
| Patent-Appeals-and-Interference:              |          |                                                  |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                                  |        |                      |
| UTILITY APPL ISSUE FEE                        | 2501     | 1                                                | 500    | 500                  |

| Description        | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|--------------------|----------|----------|--------|----------------------|
| Extension-of-Time: |          |          |        |                      |
| Miscellaneous:     |          |          |        |                      |
| Total in USD (\$)  |          |          |        | 500                  |

## Electronic Acknowledgement Receipt

|                                             |                                                  |
|---------------------------------------------|--------------------------------------------------|
| <b>EFS ID:</b>                              | 39774893                                         |
| <b>Application Number:</b>                  | 16717950                                         |
| <b>International Application Number:</b>    |                                                  |
| <b>Confirmation Number:</b>                 | 5519                                             |
| <b>Title of Invention:</b>                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| <b>First Named Inventor/Applicant Name:</b> | G.R. Mohan Rao                                   |
| <b>Customer Number:</b>                     | 40672                                            |
| <b>Filer:</b>                               | Bill Naifeh/April Reasoner                       |
| <b>Filer Authorized By:</b>                 | Bill Naifeh                                      |
| <b>Attorney Docket Number:</b>              | GRTD.01.01.DV6                                   |
| <b>Receipt Date:</b>                        | 19-JUN-2020                                      |
| <b>Filing Date:</b>                         | 17-DEC-2019                                      |
| <b>Time Stamp:</b>                          | 15:00:05                                         |
| <b>Application Type:</b>                    | Utility under 35 USC 111(a)                      |

### Payment information:

|                                          |                  |
|------------------------------------------|------------------|
| Submitted with Payment                   | yes              |
| Payment Type                             | CARD             |
| Payment was successfully received in RAM | \$ 500           |
| RAM confirmation Number                  | E20206IF00323136 |
| Deposit Account                          |                  |
| Authorized User                          |                  |

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

| <b>File Listing:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                             |                           |                                          |                  |                  |
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| Document Number                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Document Description        | File Name                 | File Size(Bytes)/<br>Message Digest      | Multi Part /.zip | Pages (if appl.) |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Issue Fee Payment (PTO-85B) | GRTDDV6_IssueFeeTrans.pdf | 80366                                    | no               | 1                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                             |                           | 2daa2ccb217ed4d7f410ccf6a13da505fd54b255 |                  |                  |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                             |                           |                                          |                  |                  |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                             |                           |                                          |                  |                  |
| 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Fee Worksheet (SB06)        | fee-info.pdf              | 30214                                    | no               | 2                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                             |                           | 8a27da1d75a283a5d5fa506b4f8cc17f24169c55 |                  |                  |
| <b>Warnings:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                             |                           |                                          |                  |                  |
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                             |                           |                                          |                  |                  |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                             |                           | 110580                                   |                  |                  |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p> |                             |                           |                                          |                  |                  |



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| APPLICATION NO.  | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|------------------|-------------|----------------------|---------------------|------------------|
| 16/717,950       | 12/17/2019  | G.R. Mohan Rao       | GRTD.01.01.DV6      | 5519             |
| 40672            | 7590        | 06/19/2020           | EXAMINER            |                  |
| BILL R. NAIFEH   |             |                      | ARORA, AJAY         |                  |
| PO BOX 803423    |             |                      |                     |                  |
| DALLAS, TX 75380 |             |                      |                     |                  |
|                  |             |                      | ART UNIT            | PAPER NUMBER     |
|                  |             |                      | 2892                |                  |
|                  |             |                      | NOTIFICATION DATE   | DELIVERY MODE    |
|                  |             |                      | 06/19/2020          | ELECTRONIC       |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

patents@naifeh.com

|                                                   |                                      |                                        |                                |
|---------------------------------------------------|--------------------------------------|----------------------------------------|--------------------------------|
| <b>Corrected</b><br><b>Notice of Allowability</b> | <b>Application No.</b><br>16/717,950 | <b>Applicant(s)</b><br>Rao, G.R. Mohan |                                |
|                                                   | <b>Examiner</b><br>AJAY ARORA        | <b>Art Unit</b><br>2892                | <b>AIA (FITF) Status</b><br>No |

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 4/6/2020.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on \_\_\_\_\_.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_\_; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 17-52. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to [PPHfeedback@uspto.gov](mailto:PPHfeedback@uspto.gov).

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a) ☐ All      b) ☐ Some      \*c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.

☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

**Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

|                                                                                                                                |                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 1. <input type="checkbox"/> Notice of References Cited (PTO-892)                                                               | 5. <input type="checkbox"/> Examiner's Amendment/Comment                  |
| 2. <input checked="" type="checkbox"/> Information Disclosure Statements (PTO/SB/08),<br>Paper No./Mail Date <u>4/6/2020</u> . | 6. <input type="checkbox"/> Examiner's Statement of Reasons for Allowance |
| 3. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit<br>of Biological Material _____.              | 7. <input type="checkbox"/> Other _____.                                  |
| 4. <input type="checkbox"/> Interview Summary (PTO-413),<br>Paper No./Mail Date. _____.                                        |                                                                           |

|                                                 |  |
|-------------------------------------------------|--|
| /AJAY ARORA/<br>Primary Examiner, Art Unit 2892 |  |
|-------------------------------------------------|--|

Doc code: IDS

PTO/SB/08a (02-18)

Doc description: Information Disclosure Statement (IDS) Filed

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|                        |                |
|------------------------|----------------|
| Application Number     | 16717950       |
| Filing Date            | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |
| Art Unit               | 2892           |
| Examiner Name          | Arora, Ajay    |
| Attorney Docket Number | GRTD.01.01.DV6 |

## **U.S.PATENTS**

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| Examiner Initial* | Cite No | Patent Number | Kind Code <sup>1</sup> | Issue Date | Name of Patentee or Applicant of cited Document | Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear |
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| Attorney Docket Number |                | GRTD.01.01.DV6 |

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| Examiner Name          | Arora, Ajay    |
| Attorney Docket Number | GRTD.01.01.DV6 |

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| Attorney Docket Number | GRTD.01.01.DV6 |

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| Attorney Docket Number | GRTD.01.01.DV6 |

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**EXAMINER SIGNATURE**

|                    |              |                 |            |
|--------------------|--------------|-----------------|------------|
| Examiner Signature | /AJAY ARORA/ | Date Considered | 06/16/2020 |
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<sup>1</sup> See Kind Codes of USPTO Patent Documents at [www.USPTO.GOV](http://www.USPTO.GOV) or MPEP 901.04. <sup>2</sup> Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). <sup>3</sup> For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. <sup>4</sup> Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. <sup>5</sup> Applicant is to place a check mark here if English language translation is attached.

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| Attorney Docket Number | GRTD.01.01.DV6 |

## **CERTIFICATION STATEMENT**

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

**OR**

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

### **SIGNATURE**

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

|            |                                  |                     |            |
|------------|----------------------------------|---------------------|------------|
| Signature  | /Bill R. Naifeh, Reg. No. 44962/ | Date (YYYY-MM-DD)   | 2020-04-06 |
| Name/Print | Bill R. Naifeh                   | Registration Number | 44962      |

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

## Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|--------------------|-----------------------|-----------------------|------------------------|
| 16/717,950         | 12/17/2019            | G.R. Mohan Rao        | GRTD.01.01.DV6         |

**CONFIRMATION NO. 5519**

## PUBLICATION NOTICE



\*OC000000116475555\*

40672  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

**Title:** SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

**Publication No.** US-2020-0127095-A1

**Publication Date:** 04/23/2020

## NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at [www.uspto.gov](http://www.uspto.gov). The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at [www.uspto.gov](http://www.uspto.gov) using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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DALLAS, TX 75380



**Courtesy Reminder for  
Application Serial No: 16/717,950**

Attorney Docket No: GRTD.01.01.DV6  
Customer Number: 40672  
Date of Electronic Notification: 04/07/2020

This is a courtesy reminder that new correspondence is available for this application. If you have not done so already, please review the correspondence. The official date of notification of the outgoing correspondence will be indicated on the form PTOL-90 accompanying the correspondence.

An email notification regarding the correspondence was sent to the following email address(es) associated with your customer number:  
patents@naifeh.com

To view your correspondence online or update your email addresses, please visit us anytime at **<https://ppair-my.uspto.gov/pair/PrivatePair>**.  
If you have any questions, please email the Electronic Business Center (EBC) at [EBC@uspto.gov](mailto:EBC@uspto.gov) or call 1-866-217-9197.



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## NOTICE OF ALLOWANCE AND FEE(S) DUE

40672 7590 04/07/2020  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

EXAMINER

ARORA, AJAY

ART UNIT

PAPER NUMBER

2892

DATE MAILED: 04/07/2020

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 16/717,950      | 12/17/2019  | G.R. Mohan Rao       | GRTD.01.01.DV6      | 5519             |

TITLE OF INVENTION: SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

| APPLN. TYPE    | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE   |
|----------------|---------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | SMALL         | \$500         | \$0.00              | \$0.00               | \$500            | 07/07/2020 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

### HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at [www.uspto.gov/PatentMaintenanceFees](http://www.uspto.gov/PatentMaintenanceFees).**

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

40672 7590 04/07/2020  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

## Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

|                         |
|-------------------------|
| (Typed or printed name) |
| (Signature)             |
| (Date)                  |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
| 16/717,950      | 12/17/2019  | G.R. Mohan Rao       | GRTD.01.01.DV6      | 5519             |

TITLE OF INVENTION: SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

| APPLN. TYPE    | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE   |
|----------------|---------------|---------------|---------------------|----------------------|------------------|------------|
| nonprovisional | SMALL         | \$500         | \$0.00              | \$0.00               | \$500            | 07/07/2020 |

| EXAMINER    | ART UNIT | CLASS-SUBCLASS |
|-------------|----------|----------------|
| ARORA, AJAY | 2892     | 257-025000     |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

1 \_\_\_\_\_

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2 \_\_\_\_\_

3 \_\_\_\_\_

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies \_\_\_\_\_

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. \_\_\_\_\_

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29☐ Applicant asserting small entity status. See 37 CFR 1.27☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature \_\_\_\_\_

Date \_\_\_\_\_

Typed or printed name \_\_\_\_\_

Registration No. \_\_\_\_\_



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www.uspto.gov

| APPLICATION NO.                                     | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------------------------------------------|-------------|----------------------|---------------------|------------------|
| 16/717,950                                          | 12/17/2019  | G.R. Mohan Rao       | GRTD.01.01.DV6      | 5519             |
| 40672                                               | 7590        | 04/07/2020           | EXAMINER            |                  |
| BILL R. NAIFEH<br>PO BOX 803423<br>DALLAS, TX 75380 |             |                      | ARORA, AJAY         |                  |
|                                                     |             |                      | ART UNIT            | PAPER NUMBER     |
|                                                     |             |                      | 2892                |                  |
| DATE MAILED: 04/07/2020                             |             |                      |                     |                  |

## Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

## OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

### Privacy Act Statement

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The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

|                               |                                      |                                        |                                |
|-------------------------------|--------------------------------------|----------------------------------------|--------------------------------|
| <b>Notice of Allowability</b> | <b>Application No.</b><br>16/717,950 | <b>Applicant(s)</b><br>Rao, G.R. Mohan |                                |
|                               | <b>Examiner</b><br>AJAY ARORA        | <b>Art Unit</b><br>2892                | <b>AIA (FITF) Status</b><br>No |

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 3/20/2020.  
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on \_\_\_\_.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on \_\_\_\_; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 17-52. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see [http://www.uspto.gov/patents/init\\_events/pph/index.jsp](http://www.uspto.gov/patents/init_events/pph/index.jsp) or send an inquiry to [PPHfeedback@uspto.gov](mailto:PPHfeedback@uspto.gov).

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a) ☐ All      b) ☐ Some      \*c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.  
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_.

**Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

|                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)<br>2. <input type="checkbox"/> Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date ____.<br>3. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material ____.<br>4. <input type="checkbox"/> Interview Summary (PTO-413), Paper No./Mail Date _____. | 5. <input type="checkbox"/> Examiner's Amendment/Comment<br>6. <input checked="" type="checkbox"/> Examiner's Statement of Reasons for Allowance<br>7. <input type="checkbox"/> Other _____. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

/AJAY ARORA/  
Primary Examiner, Art Unit 2892

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

1. The present application is being examined under the pre-AIA first to invent provisions.

### Reasons for Allowance

2. Claims 17-52 are allowed. The following is an examiner's statement of reasons for allowance:

3. Claims 17-35 are allowed because the prior art of record does not teach or suggest, singularly or in combination, at least the limitations of the base claim 17 that requires "a first active region" within which "transistors can be formed" (see lines 4-6) and "a second active region separate from the first active region" within which "transistors can be formed" (see lines 7-8) in conjunction with "at least one graded dopant region, the graded dopant region to aid carrier movement from the first surface to the second surface of the substrate" (see last 2 lines).

The closest reference is Hong (US 2007/0045682), hereinafter Hong. More specifically, regarding claim 17, Hong (refer to Figures 4A-4D and 5A-5C) teaches a semiconductor device, comprising:

a substrate (312 – see para 29) of a first doping type (i.e. parts 312 and 21 of the substrate have n-type doping, see para 29) at a first doping level having first and second surfaces;

a first region (311, which includes wells such as 21, 22, 5, 2) disposed adjacent the first surface,

a second region (such as source/drain region 2, see para 40; or 2 or 5 or 22 of pixel cell formed in an adjacent region separated by shallow trench isolation 37 – see para 30) separate from the first region disposed adjacent to the first active region;

at least a portion of at least one of the first and second regions having at least one graded dopant concentration (350 – see para 24, last 3 sentences; also see Figure 5C and para 29) to aid carrier movement (para 26).

Although Hong does not specifically state that the aiding of carrier movement is “from the first surface to the second surface of the substrate”, such directional movement by doping gradient is known in the art. However, the “first region” and “second region” described above are not “active” regions and hence transistor cannot be formed in any of these regions (only parts of a transistor such as source or drain are shown formed, not a transistor). Further, it is not obvious to modify Hong as changing first region and second region as above would change the intended function of the device.

4. Similarly, claims 36-52 are allowed because the prior art of record does not teach or suggest, singularly or in combination, at least the limitations of the base claim 36 that similarly requires “a first active region” within which “transistors can be formed in the surface thereof” (see lines 4-6) and “a second active region separate from the first active region” within which “transistors can be formed in the surface thereof” (see lines 7-9) in

conjunction with “at least one graded dopant region, the graded dopant region to aid carrier movement from the first surface to the second surface of the substrate” (see last 2 lines). In this case also, the closest reference is Hong.

5. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

### ***Conclusion***

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to AJAY ARORA whose telephone number is (571)272-8347. The examiner can normally be reached on 9 AM - 5 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Thao X. Le can be reached on 5712721708. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only.

For more information about the PAIR system, see <https://ppair-my.uspto.gov/pair/PrivatePair>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/AJAY ARORA/  
Primary Examiner, Art Unit 2892

|                                   |                                       |  |                                                               |             |
|-----------------------------------|---------------------------------------|--|---------------------------------------------------------------|-------------|
| <b>Notice of References Cited</b> | Application/Control No.<br>16/717,950 |  | Applicant(s)/Patent Under<br>Reexamination<br>Rao, G.R. Mohan |             |
|                                   | Examiner<br>AJAY ARORA                |  | Art Unit<br>2892                                              | Page 1 of 1 |

U.S. PATENT DOCUMENTS

| * |   | Document Number<br>Country Code-Number-Kind Code | Date<br>MM-YYYY | Name                   | CPC Classification | US Classification |
|---|---|--------------------------------------------------|-----------------|------------------------|--------------------|-------------------|
| * | A | US-20070045682-A1                                | 03-2007         | Hong; Sungkwon C.      | H01L27/14601       | 257/292           |
| * | B | US-20030030488-A1                                | 02-2003         | Huetting, Raymond J.E. | H01L29/0821        | 330/57            |
|   | C |                                                  |                 |                        |                    |                   |
|   | D |                                                  |                 |                        |                    |                   |
|   | E |                                                  |                 |                        |                    |                   |
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|   | L |                                                  |                 |                        |                    |                   |
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FOREIGN PATENT DOCUMENTS

| * |   | Document Number<br>Country Code-Number-Kind Code | Date<br>MM-YYYY | Country | Name | CPC Classification |
|---|---|--------------------------------------------------|-----------------|---------|------|--------------------|
|   | N |                                                  |                 |         |      |                    |
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NON-PATENT DOCUMENTS

| * |   | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|-------------------------------------------------------------------------------------------|
|   | U |                                                                                           |
|   | V |                                                                                           |
|   | W |                                                                                           |
|   | X |                                                                                           |

\*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)  
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

|                                                                                                                    |                                              |                                                                   |
|--------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <b><i>Index of Claims</i></b><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                    | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

|   |                 |   |                   |   |                     |   |                 |
|---|-----------------|---|-------------------|---|---------------------|---|-----------------|
| ✓ | <b>Rejected</b> | - | <b>Cancelled</b>  | N | <b>Non-Elected</b>  | A | <b>Appeal</b>   |
| = | <b>Allowed</b>  | ÷ | <b>Restricted</b> | I | <b>Interference</b> | O | <b>Objected</b> |

| CLAIMS                                                                                                                                                                                       |          |      |  |  |  |  |  |  |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|--|--|--|--|--|--|--|--|
| <input checked="" type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47 |          |      |  |  |  |  |  |  |  |  |
| CLAIM                                                                                                                                                                                        |          | DATE |  |  |  |  |  |  |  |  |
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| -                                                                                                                                                                                            | 2        |      |  |  |  |  |  |  |  |  |
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| -                                                                                                                                                                                            | 4        |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 5        |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 6        |      |  |  |  |  |  |  |  |  |
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|                                                                                                                                                                                              | 9        |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 10       |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 11       |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 12       |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 13       |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 14       |      |  |  |  |  |  |  |  |  |
| -                                                                                                                                                                                            | 15       |      |  |  |  |  |  |  |  |  |
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| 2                                                                                                                                                                                            | 18       |      |  |  |  |  |  |  |  |  |
| 3                                                                                                                                                                                            | 19       |      |  |  |  |  |  |  |  |  |
| 4                                                                                                                                                                                            | 20       |      |  |  |  |  |  |  |  |  |
| 5                                                                                                                                                                                            | 21       |      |  |  |  |  |  |  |  |  |
| 6                                                                                                                                                                                            | 22       |      |  |  |  |  |  |  |  |  |
| 7                                                                                                                                                                                            | 23       |      |  |  |  |  |  |  |  |  |
| 8                                                                                                                                                                                            | 24       |      |  |  |  |  |  |  |  |  |
| 9                                                                                                                                                                                            | 25       |      |  |  |  |  |  |  |  |  |
| 10                                                                                                                                                                                           | 26       |      |  |  |  |  |  |  |  |  |
| 11                                                                                                                                                                                           | 27       |      |  |  |  |  |  |  |  |  |
| 12                                                                                                                                                                                           | 28       |      |  |  |  |  |  |  |  |  |
| 13                                                                                                                                                                                           | 29       |      |  |  |  |  |  |  |  |  |
| 14                                                                                                                                                                                           | 30       |      |  |  |  |  |  |  |  |  |
| 15                                                                                                                                                                                           | 31       |      |  |  |  |  |  |  |  |  |
| 16                                                                                                                                                                                           | 32       |      |  |  |  |  |  |  |  |  |
| 17                                                                                                                                                                                           | 33       |      |  |  |  |  |  |  |  |  |
| 18                                                                                                                                                                                           | 34       |      |  |  |  |  |  |  |  |  |
| 19                                                                                                                                                                                           | 35       |      |  |  |  |  |  |  |  |  |
| 20                                                                                                                                                                                           | 36       |      |  |  |  |  |  |  |  |  |
| 21                                                                                                                                                                                           | 37       |      |  |  |  |  |  |  |  |  |
| 22                                                                                                                                                                                           | 38       |      |  |  |  |  |  |  |  |  |
| 23                                                                                                                                                                                           | 39       |      |  |  |  |  |  |  |  |  |
| 24                                                                                                                                                                                           | 40       |      |  |  |  |  |  |  |  |  |
| 25                                                                                                                                                                                           | 41       |      |  |  |  |  |  |  |  |  |
| 26                                                                                                                                                                                           | 42       |      |  |  |  |  |  |  |  |  |

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|--------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <i><b>Index of Claims</b></i><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                    | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

| CLAIM |          | DATE |  |  |  |  |  |  |  |  |
|-------|----------|------|--|--|--|--|--|--|--|--|
| Final | Original |      |  |  |  |  |  |  |  |  |
| 27    | 43       |      |  |  |  |  |  |  |  |  |
| 28    | 44       |      |  |  |  |  |  |  |  |  |
| 29    | 45       |      |  |  |  |  |  |  |  |  |
| 30    | 46       |      |  |  |  |  |  |  |  |  |
| 31    | 47       |      |  |  |  |  |  |  |  |  |
| 32    | 48       |      |  |  |  |  |  |  |  |  |
| 33    | 49       |      |  |  |  |  |  |  |  |  |
| 34    | 50       |      |  |  |  |  |  |  |  |  |
| 35    | 51       |      |  |  |  |  |  |  |  |  |
| 36    | 52       |      |  |  |  |  |  |  |  |  |

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|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <b><i>Search Notes</i></b><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                 | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

| CPC - Searched* |            |          |
|-----------------|------------|----------|
| Symbol          | Date       | Examiner |
| H01L 29/1095    | 03/28/2020 | AKA      |

| CPC Combination Sets - Searched* |      |          |
|----------------------------------|------|----------|
| Symbol                           | Date | Examiner |
|                                  |      |          |

| US Classification - Searched* |          |      |          |
|-------------------------------|----------|------|----------|
| Class                         | Subclass | Date | Examiner |
| 257                           | 25       |      | AKA      |

\* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes                                     |            |          |
|--------------------------------------------------|------------|----------|
| Search Notes                                     | Date       | Examiner |
| All references of parent applications considered | 03/30/2020 | AKA      |
| Inventor search                                  | 03/28/2020 | AKA      |
| Assignee search                                  | 03/28/2020 | AKA      |
| .clm. interference search                        | 03/28/2020 | AKA      |
| EAST search history report                       | 03/30/2020 | AKA      |

| Interference Search |                       |            |          |
|---------------------|-----------------------|------------|----------|
| US Class/CPC Symbol | US Subclass/CPC Group | Date       | Examiner |
| H01L                | 29/1095               | 03/28/2020 | AKA      |
| 257                 | 25                    | 03/28/2020 | AKA      |

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|------------------------------------------|--|
| /A.A/<br>Primary Examiner, Art Unit 2892 |  |
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|                                                                                                                  |                                              |                                                                   |
|------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <b>Issue Classification</b><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                  | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

| CPC    |   |    |   |       |      |            |
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| Symbol |   |    |   |       | Type | Version    |
| H01L   | / | 29 | / | 1095  | F    | 2013-01-01 |
| H01L   | / | 29 | / | 36    | I    | 2013-01-01 |
| H01L   | / | 29 | / | 7395  | I    | 2013-01-01 |
| H01L   | / | 27 | / | 14643 | I    | 2013-01-01 |
| H01L   | / | 27 | / | 11524 | I    | 2013-01-01 |
| H01L   | / | 27 | / | 11521 | I    | 2013-01-01 |
| H01L   | / | 27 | / | 0214  | A    | 2013-01-01 |
| H01L   | / | 27 | / | 10844 | A    | 2013-01-01 |

| CPC Combination Sets |   |      |     |         |
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| Symbol               |   | Type | Set | Ranking |
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| NONE                                            | <b>Total Claims Allowed:</b> |                     |
| (Assistant Examiner)                            | (Date)                       | 36                  |
| /AJAY ARORA/<br>Primary Examiner, Art Unit 2892 | 30 March 2020                | O.G. Print Claim(s) |
| (Primary Examiner)                              | (Date)                       | 1                   |
|                                                 |                              | O.G. Print Figure   |
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|------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <b>Issue Classification</b><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                  | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

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| <b>INTERNATIONAL CLASSIFICATION</b> |   |    |      |
| <b>CLAIMED</b>                      |   |    |      |
| H01L                                | / | 29 | / 06 |
| <b>NON-CLAIMED</b>                  |   |    |      |
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| <b>US ORIGINAL CLASSIFICATION</b> |                 |
| <b>CLASS</b>                      | <b>SUBCLASS</b> |
| 257                               | 25              |

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| <b>CROSS REFERENCES(S)</b> |                                          |  |  |  |  |  |
| <b>CLASS</b>               | <b>SUBCLASS (ONE SUBCLASS PER BLOCK)</b> |  |  |  |  |  |
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| NONE                                                                  |                         | <b>Total Claims Allowed:</b> |                         |
| (Assistant Examiner)                                                  | (Date)                  | 36                           |                         |
| /AJAY ARORA/<br>Primary Examiner, Art Unit 2892<br>(Primary Examiner) | 30 March 2020<br>(Date) | O.G. Print Claim(s)<br>1     | O.G. Print Figure<br>5B |

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|------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------|
| <b>Issue Classification</b><br> | <b>Application/Control No.</b><br>16/717,950 | <b>Applicant(s)/Patent Under Reexamination</b><br>Rao, G.R. Mohan |
|                                                                                                                  | <b>Examiner</b><br>AJAY ARORA                | <b>Art Unit</b><br>2892                                           |

|                                                                                                                                                                                              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |
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| <input checked="" type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47 |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |
| <b>CLAIMS</b>                                                                                                                                                                                |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |              |                 |
| <b>Final</b>                                                                                                                                                                                 | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> | <b>Final</b> | <b>Original</b> |
| 1                                                                                                                                                                                            | 17              | 10           | 26              | 19           | 35              | 28           | 44              |              |                 |              |                 |              |                 |              |                 |
| 2                                                                                                                                                                                            | 18              | 11           | 27              | 20           | 36              | 29           | 45              |              |                 |              |                 |              |                 |              |                 |
| 3                                                                                                                                                                                            | 19              | 12           | 28              | 21           | 37              | 30           | 46              |              |                 |              |                 |              |                 |              |                 |
| 4                                                                                                                                                                                            | 20              | 13           | 29              | 22           | 38              | 31           | 47              |              |                 |              |                 |              |                 |              |                 |
| 5                                                                                                                                                                                            | 21              | 14           | 30              | 23           | 39              | 32           | 48              |              |                 |              |                 |              |                 |              |                 |
| 6                                                                                                                                                                                            | 22              | 15           | 31              | 24           | 40              | 33           | 49              |              |                 |              |                 |              |                 |              |                 |
| 7                                                                                                                                                                                            | 23              | 16           | 32              | 25           | 41              | 34           | 50              |              |                 |              |                 |              |                 |              |                 |
| 8                                                                                                                                                                                            | 24              | 17           | 33              | 26           | 42              | 35           | 51              |              |                 |              |                 |              |                 |              |                 |
| 9                                                                                                                                                                                            | 25              | 18           | 34              | 27           | 43              | 36           | 52              |              |                 |              |                 |              |                 |              |                 |

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|-------------------------------------------------|------------------------------|---------------------|
| NONE                                            | <b>Total Claims Allowed:</b> |                     |
| (Assistant Examiner)                            | (Date)                       | 36                  |
| /AJAY ARORA/<br>Primary Examiner, Art Unit 2892 | 30 March 2020                | O.G. Print Claim(s) |
| (Primary Examiner)                              | (Date)                       | 1                   |
|                                                 |                              | O.G. Print Figure   |
|                                                 |                              | 5B                  |

EAST Search History

EAST Search History (Prior Art)

| Ref # | Hits | Search Query                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | DBs                                                                        | Default Operator | Plurals | Time Stamp          |
|-------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------|---------|---------------------|
| L1    | 10   | ("20010040622"   "20030030488"   "4160985").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR               | OFF     | 2020/03/30<br>19:48 |
| L2    | 193  | ("20030030488"   "20020102783"   "20030026126"   "20030030488"   "6211028"   "6310366"   "6753202"   "7115925"   "8164124"   "20020056883"   "20020093281"   "20150200314"   "4347654"   "5496746"   "6452086"   "6737722"   "6747883"   "20030042511"   "5029277"   "5888857"   "6670544"   "6706550"   "6713813"   "6921943"   "20040027753"   "4160985"   "5448087"   "6472715"   "6683343"   "6831292"   "7307327"   "5569612"   "5575862"   "5637898"   "6720622"   "6744117"   "20020134419"   "20060113592"   "20130001661"   "4481522"   "5262345"   "6756616"   "20010040622"   "20020074585"   "5130262"   "5213988"   "5329144"   "6465862"   "6696314"   "RE37441"   "20020084430"   "4001864"   "4866000"   "5480816"   "5517052"   "5797999"   "5973575"   "6754093").PN. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR               | OFF     | 2020/03/30<br>19:50 |
| L3    | 27   | ("5448087"   "5888857"   "20030030488"   "6720622"   "20030026126"   "5973575"   "5262345"   "20040027753").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR               | OFF     | 2020/03/30<br>19:51 |
| L4    | 44   | ("20020056883"   "20020084430"   "20020102783"   "20030042511"   "4160985"   "5637898"   "5517052"   "4481522"   "6831292"   "20020093281"   "5029277"   "20060113592"   "20020134419").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR               | OFF     | 2020/03/30<br>19:51 |
| L5    | 96   | ("20020074585"   "5496746"   "6683343"   "6696314"   "6452086"   "6472715"   "6747883"   "5797999"   "6670544"   "20040063288"   "4347654"   "4866000"   "6744117"   "6754093"   "5213988"   "5569612"   "RE37441"   "4001864"   "6756616"   "5130262"   "5329144"   "6706550"   "6753202"   "5480816"   "6713813"   "6737722"                                                                                                                                                                                                                                                                                                                                                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR               | OFF     | 2020/03/30<br>19:51 |

|     |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                            |    |     |                     |
|-----|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----|-----|---------------------|
|     |        | "5575862"   "6211028").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                            |    |     |                     |
| L6  | 220    | ("20020102783"   "20030026126"   "20030030488"   "6211028"   "6310366"   "6753202"   "7115925"   "8164124"   "6878603"   "20020056883"   "20020093281"   "20150200314"   "4347654"   "5496746"   "6452086"   "6737722"   "6747883"   "6780713"   "20030042511"   "5029277"   "5888857"   "6670544"   "6706550"   "6713813"   "6921943"   "7504692"   "20040027753"   "4160985"   "5448087"   "6472715"   "6683343"   "6831292"   "7307327"   "5569612"   "5575862"   "5637898"   "6720622"   "6744117"   "20070045682"   "20020134419"   "20060113592"   "20130001661"   "4481522"   "5262345"   "6756616"   "6933215"   "7233044"   "20010040622"   "20020074585"   "5130262"   "5213988"   "5329144"   "6465862"   "6696314"   "RE37441"   "20020084430"   "4001864"   "4866000"   "5480816"   "5517052"   "5797999"   "5973575"   "6754093"   "7064385"   "20120048462").PN. | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L7  | 222    | L3 L4 L5 L6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L8  | 222    | I1 I2 L7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L9  | 202035 | (source drain source/drain) and drift ((gradient graded) near2 concentration near2 dop\$3) and well                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L10 | 33     | L9 and I8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L11 | 18     | L7 and (((gradient graded) near2 concentration near2 dop\$3) and well)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/30<br>19:51 |
| L12 | 18     | L11 and I8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US-PGPUB;<br>USPAT;                                                        | OR | OFF | 2020/03/30<br>19:51 |

|    |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                            |    |     |                     |
|----|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----|-----|---------------------|
|    |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB                        |    |     |                     |
| S1 | 0   | "16717950"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:09 |
| S2 | 6   | 14/515,584                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:09 |
| S3 | 27  | ("5448087"   "5888857"  <br>"20030030488"   "6720622"  <br>"20030026126"   "5973575"   "5262345"<br>  "20040027753").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:10 |
| S4 | 44  | ("20020056883"   "20020084430"  <br>"20020102783"   "20030042511"  <br>"4160985"   "5637898"   "5517052"  <br>"4481522"   "6831292"   "20020093281"<br>  "5029277"   "20060113592"  <br>"20020134419").PN.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:10 |
| S5 | 96  | ("20020074585"   "5496746"  <br>"6683343"   "6696314"   "6452086"  <br>"6472715"   "6747883"   "5797999"  <br>"6670544"   "20040063288"   "4347654"<br>  "4866000"   "6744117"   "6754093"  <br>"5213988"   "5569612"   "RE37441"  <br>"4001864"   "6756616"   "5130262"  <br>"5329144"   "6706550"   "6753202"  <br>"5480816"   "6713813"   "6737722"  <br>"5575862"   "6211028").PN.                                                                                                                                                                                                                                                                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:10 |
| S6 | 220 | ("20020102783"   "20030026126"  <br>"20030030488"   "6211028"   "6310366"<br>  "6753202"   "7115925"   "8164124"  <br>"6878603"   "20020056883"  <br>"20020093281"   "20150200314"  <br>"4347654"   "5496746"   "6452086"  <br>"6737722"   "6747883"   "6780713"  <br>"20030042511"   "5029277"   "5888857"<br>  "6670544"   "6706550"   "6713813"  <br>"6921943"   "7504692"   "20040027753"<br>  "4160985"   "5448087"   "6472715"  <br>"6683343"   "6831292"   "7307327"  <br>"5569612"   "5575862"   "5637898"  <br>"6720622"   "6744117"   "20070045682"<br>  "20020134419"   "20060113592"  <br>"20130001661"   "4481522"   "5262345"<br>  "6756616"   "6933215"   "7233044"  <br>"20010040622"   "20020074585"  <br>"5130262"   "5213988"   "5329144" | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:11 |

|     |        |                                                                                                                                                                        |                                                                            |    |     |                     |
|-----|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----|-----|---------------------|
|     |        | "6465862"   "6696314"   "RE37441"   "20020084430"   "4001864"   "4866000"   "5480816"   "5517052"   "5797999"   "5973575"   "6754093"   "7064385"   "20120048462").PN. |                                                                            |    |     |                     |
| S7  | 222    | S3 S4 S5 S6                                                                                                                                                            | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:12 |
| S8  | 1003   | ((Mohan) near2 (Rao)).INV.                                                                                                                                             | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:13 |
| S9  | 8      | S8 and drift                                                                                                                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:13 |
| S10 | 202035 | (source drain source/drain) and drift ((gradient graded) near2 concentration near2 dop\$3) and well                                                                    | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:13 |
| S11 | 25808  | H01L29/1095.cpc.                                                                                                                                                       | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:14 |
| S12 | 662    | (257/25).CCLS.                                                                                                                                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:14 |
| S13 | 24026  | H01L27/11521.cpc.                                                                                                                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | ON  | 2020/03/28<br>18:15 |
| S14 | 11555  | H01L27/11524.cpc.                                                                                                                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | ON  | 2020/03/28<br>18:15 |

|     |       |                                                                                                                                                                          |                                                                            |    |     |                     |
|-----|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----|-----|---------------------|
| S15 | 25088 | H01L27/14643.cpc.                                                                                                                                                        | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | ON  | 2020/03/28<br>18:15 |
| S16 | 9892  | H01L29/36.cpc.                                                                                                                                                           | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | ON  | 2020/03/28<br>18:16 |
| S17 | 11614 | H01L29/7395.cpc.                                                                                                                                                         | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | ON  | 2020/03/28<br>18:16 |
| S18 | 0     | ((source drain "source/drain") and drift and ((gradient graded) near2 concentration near2 dop\$3) and well and unidirectional).clm.                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:18 |
| S19 | 2     | ((source drain "source/drain") and drift and (((gradient graded) near2 concentration near2 dop\$3) SAME well)).clm.                                                      | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:19 |
| S20 | 6     | S8 and (((gradient graded) near2 concentration near2 dop\$3) and well)                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:19 |
| S21 | 18    | S7 and (((gradient graded) near2 concentration near2 dop\$3) and well)                                                                                                   | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:19 |
| S22 | 1150  | (257/655).CCLS.                                                                                                                                                          | US-PGPUB;<br>USPAT;<br>USOCR;<br>FPRS;<br>EPO; JPO;<br>DERWENT;<br>IBM_TDB | OR | OFF | 2020/03/28<br>18:19 |
| S23 | 12    | (US-20030030488-\$ or US-20040027753-\$ or US-20030026126-\$ or US-20140034997-\$ or US-20060049464-\$ or US-20130234201-\$ or US-20070181927-\$).did. or (US-5448087-\$ | US-PGPUB;<br>USPAT                                                         | OR | ON  | 2020/03/28<br>18:20 |

|  |  |                                                                             |  |  |  |  |
|--|--|-----------------------------------------------------------------------------|--|--|--|--|
|  |  | or US-5262345-\$ or US-5973575-\$ or<br>US-6720622-\$ or US-5888857-\$.did. |  |  |  |  |
|--|--|-----------------------------------------------------------------------------|--|--|--|--|

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**C:\Users\aarora\Documents\EAST\Workspaces\16717950.wsp**

Bibliographic Data

Application No: 16/717,950

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged: 

/AJAY ARORA/

Examiner's Signature

Initials

Title: 

SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

| FILING or 371(c) DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|-----------------------|-------|----------------|---------------------|
| 12/17/2019            | 257   | 2892           | GRTD.01.01.DV6      |
| RULE                  |       |                |                     |

APPLICANTS

GREENTHREAD, LLC, Dallas, TX, UNITED STATES

INVENTORS

G.R. Mohan Rao Allen, TX, UNITED STATES

CONTINUING DATA

This application is a CON of 15590282 05/09/2017 PAT 10510842  
15590282 is a CON of 14931636 11/03/2015 PAT 9647070  
14931636 is a CON of 14515584 10/16/2014 PAT 9190502  
14515584 is a CON of 13854319 04/01/2013ABN  
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11622496 is a DIV of 10934915 09/03/2004ABN

FOREIGN APPLICATIONS

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|-----------------------------------------------------------------------------------------------------|------------------------|----------------|------------|
| <b>INFORMATION DISCLOSURE<br/>STATEMENT BY APPLICANT</b><br>( Not for submission under 37 CFR 1.99) | Application Number     |                | 16717950   |
|                                                                                                     | Filing Date            |                | 2019-12-17 |
|                                                                                                     | First Named Inventor   | G.R. Mohan Rao |            |
|                                                                                                     | Art Unit               | 2892           |            |
|                                                                                                     | Examiner Name          | Arora, Ajay    |            |
|                                                                                                     | Attorney Docket Number | GRTD.01.01.DV6 |            |

| U.S.PATENTS       |         |               |                        |            |                                                 | <a href="#">Remove</a>                                                 |
|-------------------|---------|---------------|------------------------|------------|-------------------------------------------------|------------------------------------------------------------------------|
| Examiner Initial* | Cite No | Patent Number | Kind Code <sup>1</sup> | Issue Date | Name of Patentee or Applicant of cited Document | Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear |
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STATEMENT BY APPLICANT**  
( Not for submission under 37 CFR 1.99)

|                        |                |                |
|------------------------|----------------|----------------|
| Application Number     |                | 16717950       |
| Filing Date            |                | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |                |
| Art Unit               |                | 2892           |
| Examiner Name          | Arora, Ajay    |                |
| Attorney Docket Number |                | GRTD.01.01.DV6 |

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STATEMENT BY APPLICANT**  
( Not for submission under 37 CFR 1.99)

|                        |                |                |
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| Application Number     |                | 16717950       |
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| First Named Inventor   | G.R. Mohan Rao |                |
| Art Unit               |                | 2892           |
| Examiner Name          | Arora, Ajay    |                |
| Attorney Docket Number |                | GRTD.01.01.DV6 |

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STATEMENT BY APPLICANT**  
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| Filing Date            |                | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |                |
| Art Unit               |                | 2892           |
| Examiner Name          | Arora, Ajay    |                |
| Attorney Docket Number |                | GRTD.01.01.DV6 |

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STATEMENT BY APPLICANT**  
( Not for submission under 37 CFR 1.99)

|                        |                |                |
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| Application Number     |                | 16717950       |
| Filing Date            |                | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |                |
| Art Unit               |                | 2892           |
| Examiner Name          | Arora, Ajay    |                |
| Attorney Docket Number |                | GRTD.01.01.DV6 |

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| 50 | 8421195 | B2 | 2013-04-16 | Rao               |  |
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**INFORMATION DISCLOSURE  
STATEMENT BY APPLICANT**  
( Not for submission under 37 CFR 1.99)

|                        |                |
|------------------------|----------------|
| Application Number     | 16717950       |
| Filing Date            | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |
| Art Unit               | 2892           |
| Examiner Name          | Arora, Ajay    |
| Attorney Docket Number | GRTD.01.01.DV6 |

|    |          |    |            |     |
|----|----------|----|------------|-----|
| 53 | 10510842 | B2 | 2019-12-17 | Rao |
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|                   | 8       | 20030026126        | A1                     | 2003-02-06       | Uemura                                          |                                                                          |

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|                                                                                                     | Filing Date            |                | 2019-12-17 |
|                                                                                                     | First Named Inventor   | G.R. Mohan Rao |            |
|                                                                                                     | Art Unit               | 2892           |            |
|                                                                                                     | Examiner Name          | Arora, Ajay    |            |
|                                                                                                     | Attorney Docket Number | GRTD.01.01.DV6 |            |

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|                                                                                                     | Examiner Name          | Arora, Ajay    |                |
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| Filing Date            | 2019-12-17     |
| First Named Inventor   | G.R. Mohan Rao |
| Art Unit               | 2892           |
| Examiner Name          | Arora, Ajay    |
| Attorney Docket Number | GRTD.01.01.DV6 |

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Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

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See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

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| Signature  | /Bill R. Naifeh, Reg. No. 44962/ | Date (YYYY-MM-DD)   | 2020-04-06 |
| Name/Print | Bill R. Naifeh                   | Registration Number | 44962      |

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| Confirmation Number:                 | 5519                                             |
| Title of Invention:                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| First Named Inventor/Applicant Name: | G.R. Mohan Rao                                   |
| Customer Number:                     | 40672                                            |
| Filer:                               | Bill Naifeh/April Reasoner                       |
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| Attorney Docket Number:              | GRTD.01.01.DV6                                   |
| Receipt Date:                        | 06-APR-2020                                      |
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| 16/717,950         | 12/17/2019            | G.R. Mohan Rao        | GRTD.01.01.DV6         |

40672  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

**CONFIRMATION NO. 5519**  
**POA ACCEPTANCE LETTER**



Date Mailed: 03/27/2020

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| Electronic Acknowledgement Receipt   |                                                  |
| EFS ID:                              | 38951349                                         |
| Application Number:                  | 16717950                                         |
| International Application Number:    |                                                  |
| Confirmation Number:                 | 5519                                             |
| Title of Invention:                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| First Named Inventor/Applicant Name: | G.R. Mohan Rao                                   |
| Customer Number:                     | 40672                                            |
| Filer:                               | Bill Naifeh/April Reasoner                       |
| Filer Authorized By:                 | Bill Naifeh                                      |
| Attorney Docket Number:              | GRTD.01.01.DV6                                   |
| Receipt Date:                        | 24-MAR-2020                                      |
| Filing Date:                         | 17-DEC-2019                                      |
| Time Stamp:                          | 13:03:28                                         |
| Application Type:                    | Utility under 35 USC 111(a)                      |

|                        |                      |                     |                                          |                  |                  |
|------------------------|----------------------|---------------------|------------------------------------------|------------------|------------------|
| Payment information:   |                      |                     |                                          |                  |                  |
| Submitted with Payment |                      |                     | no                                       |                  |                  |
| File Listing:          |                      |                     |                                          |                  |                  |
| Document Number        | Document Description | File Name           | File Size(Bytes)/ Message Digest         | Multi Part /.zip | Pages (if appl.) |
| 1                      | Power of Attorney    | POA-Greenthread.pdf | 2989622                                  | no               | 1                |
|                        |                      |                     | cc0a7855f517b7200d9e1467395b0ebd3ec396b7 |                  |                  |
| Warnings:              |                      |                     |                                          |                  |                  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| <b>Information:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |
| <b>Total Files Size (in bytes):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2989622 |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p> |         |

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

|                                                                                                                                 |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------------------------------------|---------------|---------------------------|--|---------------------------------------|--|
| <b>PATENT APPLICATION FEE DETERMINATION RECORD</b><br>Substitute for Form PTO-875                                               |                                                                                          |                                                                                                                                                                                                                               |                            | Application or Docket Number<br>16/717,950 |               | Filing Date<br>12/17/2019 |  | <input type="checkbox"/> To be Mailed |  |
| ENTITY: <input type="checkbox"/> LARGE <input checked="" type="checkbox"/> SMALL <input type="checkbox"/> MICRO                 |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
| <b>APPLICATION AS FILED - PART I</b>                                                                                            |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
| FOR                                                                                                                             |                                                                                          | (Column 1)<br>NUMBER FILED                                                                                                                                                                                                    | (Column 2)<br>NUMBER EXTRA | RATE (\$)                                  |               | FEE (\$)                  |  |                                       |  |
| <input type="checkbox"/> BASIC FEE<br>(37 CFR 1.16(a), (b), or (c))                                                             |                                                                                          | N/A                                                                                                                                                                                                                           | N/A                        | N/A                                        |               |                           |  |                                       |  |
| <input type="checkbox"/> SEARCH FEE<br>(37 CFR 1.16(k), (l), or (m))                                                            |                                                                                          | N/A                                                                                                                                                                                                                           | N/A                        | N/A                                        |               |                           |  |                                       |  |
| <input type="checkbox"/> EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q))                                                       |                                                                                          | N/A                                                                                                                                                                                                                           | N/A                        | N/A                                        |               |                           |  |                                       |  |
| TOTAL CLAIMS<br>(37 CFR 1.16(i))                                                                                                |                                                                                          | minus 20 =                                                                                                                                                                                                                    | *                          | x \$50 =                                   |               |                           |  |                                       |  |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h))                                                                                          |                                                                                          | minus 3 =                                                                                                                                                                                                                     | *                          | x \$230 =                                  |               |                           |  |                                       |  |
| <input type="checkbox"/> APPLICATION SIZE FEE (37 CFR 1.16(s))                                                                  |                                                                                          | If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). |                            |                                            |               |                           |  |                                       |  |
| <input type="checkbox"/> MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))                                                      |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
| * If the difference in column 1 is less than zero, enter "0" in column 2.                                                       |                                                                                          |                                                                                                                                                                                                                               |                            | TOTAL                                      |               |                           |  |                                       |  |
| <b>APPLICATION AS AMENDED - PART II</b>                                                                                         |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
| AMENDMENT                                                                                                                       | 03/20/2020                                                                               | CLAIMS REMAINING AFTER AMENDMENT                                                                                                                                                                                              |                            | HIGHEST NUMBER PREVIOUSLY PAID FOR         | PRESENT EXTRA | RATE (\$)                 |  | ADDITIONAL FEE (\$)                   |  |
|                                                                                                                                 | Total<br>(37 CFR 1.16(i))                                                                | * 36                                                                                                                                                                                                                          | Minus                      | ** 20                                      | = 16          | x \$50 =                  |  | 800                                   |  |
|                                                                                                                                 | Independent<br>(37 CFR 1.16(h))                                                          | * 2                                                                                                                                                                                                                           | Minus                      | *** 3                                      | = 0           | x \$230 =                 |  | 0                                     |  |
|                                                                                                                                 | <input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))                           |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
|                                                                                                                                 | <input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
|                                                                                                                                 |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               | TOTAL ADD'L FEE           |  | 800                                   |  |
| AMENDMENT                                                                                                                       |                                                                                          | CLAIMS REMAINING AFTER AMENDMENT                                                                                                                                                                                              |                            | HIGHEST NUMBER PREVIOUSLY PAID FOR         | PRESENT EXTRA | RATE (\$)                 |  | ADDITIONAL FEE (\$)                   |  |
|                                                                                                                                 | Total<br>(37 CFR 1.16(i))                                                                | *                                                                                                                                                                                                                             | Minus                      | **                                         | =             | x \$0 =                   |  |                                       |  |
|                                                                                                                                 | Independent<br>(37 CFR 1.16(h))                                                          | *                                                                                                                                                                                                                             | Minus                      | ***                                        | =             | x \$0 =                   |  |                                       |  |
|                                                                                                                                 | <input type="checkbox"/> Application Size Fee (37 CFR 1.16(s))                           |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
|                                                                                                                                 | <input type="checkbox"/> FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
|                                                                                                                                 |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               | TOTAL ADD'L FEE           |  |                                       |  |
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3.                                           |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               | LIE                       |  |                                       |  |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".                                       |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               | /VINCENT S BUTLER/        |  |                                       |  |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".                                        |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. |                                                                                          |                                                                                                                                                                                                                               |                            |                                            |               |                           |  |                                       |  |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

|            |                   |   |                 |             |
|------------|-------------------|---|-----------------|-------------|
| Applicant: | G.R. Mohan Roa    | § | Conf. No.:      | 5519        |
|            |                   | § |                 |             |
| Serial No: | 16/717,950        | § | Group Art Unit: | 2892        |
|            |                   | § |                 |             |
| Filed:     | December 17, 2019 | § | Examiner:       | Arora, Ajay |
|            |                   | § |                 |             |

For: SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

Via EFS

Mail Stop NON-FEE AMENDMENT  
Commissioner for Patents  
P. O. Box 1450  
Alexandria, VA 22313.1450

**PRELIMINARY AMENDMENT**

Please amend the application as follows prior to the substantive examination thereof:

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this paper.

**Remarks** begin on page 7 of this paper.

## **AMENDMENTS TO THE CLAIMS**

The listing of claims will replace all prior versions, and listings, of claims in the application:

### **Listing of Claims**

#### **1-16. (Canceled)**

#### **17. (New)** A semiconductor device, comprising:

- a substrate of a first doping type at a first doping level having first and second surfaces;

- a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity to the first doping type and within which transistors can be formed;

- a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed;

- transistors formed in at least one of the first active region or second active region;

- at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate; and

- at least one well region adjacent to the first or second active region containing at least one graded dopant region, the graded dopant region to aid carrier movement from the first surface to the second surface of the substrate.

#### **18. (New)** The semiconductor device of Claim 17, wherein the substrate is a p-type substrate.

#### **19. (New)** The semiconductor device of Claim 17, wherein the substrate has epitaxial silicon on top of a nonepitaxial substrate.

20. **(New)** The semiconductor device of Claim 17, wherein the first active region and second active region contain one of either p-channel and n-channel devices.
21. **(New)** The semiconductor device of Claim 17, wherein the first active region and second active region contain either p-channel or n-channel devices in n-wells or p-wells, respectively, and each well has at least one graded dopant.
22. **(New)** The semiconductor device of Claim 17, wherein the first active region and second active region are each separated by at least one isolation region.
23. **(New)** The semiconductor device of Claim 17, wherein the graded dopant is fabricated with an ion implantation process.
24. **(New)** The semiconductor device of Claim 17, wherein the first and second active regions are formed adjacent the first surface of the substrate.
25. **(New)** The semiconductor device of Claim 17, wherein dopants of the graded dopant concentration in the first active region or the second active region are either p-type or n-type.
26. **(New)** The semiconductor device of Claim 17, wherein dopants of the graded dopant concentration in the first active region are both p-type and n-type.
27. **(New)** The semiconductor device of Claim 17, wherein dopants of the graded dopant concentration in the second active region are both p-type and n-type.
28. **(New)** The semiconductor device of Claim 17, wherein dopants of the graded dopant region in the well region are both p-type and n-type.
29. **(New)** The semiconductor device of claim 17, wherein the transistors which can be formed in the first and second active regions are CMOS transistors requiring at least a source, a drain, a gate and a channel.

30. **(New)** The semiconductor device of Claim 17, wherein the device is a dynamic random access memory (DRAM).
31. **(New)** The semiconductor device of Claim 17, wherein the device is a complementary metal oxide semiconductor (CMOS) with a nonepitaxial substrate.
32. **(New)** The semiconductor device of Claim 17, wherein the device is a flash memory.
33. **(New)** The semiconductor device of Claim 17, wherein the device is a logic device.
34. **(New)** The semiconductor device of Claim 33, wherein the device is central processing unit.
35. **(New)** The semiconductor device of claim 17, wherein the device is an image sensor.
36. **(New)** A semiconductor device, comprising:  
a substrate of a first doping type at a first doping level having first and second surfaces;  
a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity to the first doping type and within which transistors can be formed in the surface thereof;  
a second active region separate from the first active region disposed adjacent to the first active region and within which transistors can be formed in the surface thereof;  
transistors formed in at least one of the first active region or second active region;  
at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the surface to the substrate; and

at least one well region adjacent to the first or second active region containing at least one graded dopant region, the graded dopant region to aid carrier movement from the first surface to the second surface of the substrate.

37. **(New)** The semiconductor device of Claim 36, wherein the substrate is an n-type substrate.

38. **(New)** The semiconductor device of Claim 36, wherein the substrate is a p-type substrate.

39. **(New)** The semiconductor device of Claim 36, wherein the substrate has epitaxial silicon on top of a nonepitaxial substrate.

40. **(New)** The semiconductor device of Claim 36, wherein the first active region and second active region contain at least one of either p-channel and n-channel devices.

41. **(New)** The semiconductor device of Claim 36, wherein the first active region and second active region contain either p-channel or n-channel devices in n-wells or p-wells, respectively, and each well has at least one graded dopant.

42. **(New)** The semiconductor device of Claim 36, wherein the first active region and second active region are each separated by at least one isolation region.

43. **(New)** The semiconductor device of Claim 36, wherein dopants of the graded dopant concentration in the first active region or the second active region are either p-type or n-type.

44. **(New)** The semiconductor device of Claim 36, wherein dopants of the graded dopant concentration in the first active region are both p-type and n-type.

45. **(New)** The semiconductor device of Claim 36, wherein dopants of the graded dopant concentration in the second active region are both p-type and n-type.

46. **(New)** The semiconductor device of Claim 36, wherein dopants of the graded dopant region in the well region are both p-type and n-type.
47. **(New)** The semiconductor device of Claim 36, wherein the graded dopant is fabricated with an ion implantation process.
48. **(New)** The semiconductor device of Claim 36, wherein the substrate is a complementary metal oxide semiconductor (CMOS) device.
49. **(New)** The semiconductor device of Claim 36, wherein the device is a flash memory.
50. **(New)** The semiconductor device of Claim 36, wherein the device is a logic device.
51. **(New)** The semiconductor device of Claim 50, wherein the device is central processing unit.
52. **(New)** The semiconductor device of claim 36, wherein the device is an image sensor.

**REMARKS**

The Applicant has canceled original claims 1-16 and added new claims 17-52. Accordingly, claims 17-52 are pending in the application.

The new claims are not made for any reason related to any statutory requirements of patentability. The new claims have been made to more completely claim that to which the Applicant is entitled and to conform to the personal preferences of the current patent attorney. Therefore no amendments have been made to narrow the scope of the claims or to create any sort of estoppel. Favorable consideration of the pending claims is respectfully requested.

Respectfully submitted,

/Bill R. Naifeh, Reg. No. 44,962/

Registration No. 44,962

**Bill R. Naifeh**  
**Law Office of Bill Naifeh**  
15303 Dallas Parkway  
Suite 700  
Addison, TX 7540  
972-726-9500  
214-550-2542 (fax)

| Electronic Patent Application Fee Transmittal |          |                                                  |        |                      |
|-----------------------------------------------|----------|--------------------------------------------------|--------|----------------------|
| Application Number:                           |          | 16717950                                         |        |                      |
| Filing Date:                                  |          | 17-Dec-2019                                      |        |                      |
| Title of Invention:                           |          | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |        |                      |
| First Named Inventor/Applicant Name:          |          | G.R. Mohan Rao                                   |        |                      |
| Filer:                                        |          | Bill Naifeh/April Reasoner                       |        |                      |
| Attorney Docket Number:                       |          | GRTD.01.01.DV6                                   |        |                      |
| Filed as Small Entity                         |          |                                                  |        |                      |
| Filing Fees for   Utility under 35 USC 111(a) |          |                                                  |        |                      |
| Description                                   | Fee Code | Quantity                                         | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                                  |        |                      |
| Pages:                                        |          |                                                  |        |                      |
| Claims:                                       |          |                                                  |        |                      |
| CLAIMS IN EXCESS OF 20                        | 2202     | 16                                               | 50     | 800                  |
| Miscellaneous-Filing:                         |          |                                                  |        |                      |
| Petition:                                     |          |                                                  |        |                      |
| Patent-Appeals-and-Interference:              |          |                                                  |        |                      |
| Post-Allowance-and-Post-Issuance:             |          |                                                  |        |                      |

| Description        | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|--------------------|----------|----------|--------|----------------------|
| Extension-of-Time: |          |          |        |                      |
| Miscellaneous:     |          |          |        |                      |
| Total in USD (\$)  |          |          |        | 800                  |

| Electronic Acknowledgement Receipt   |                                                  |
|--------------------------------------|--------------------------------------------------|
| EFS ID:                              | 38925122                                         |
| Application Number:                  | 16717950                                         |
| International Application Number:    |                                                  |
| Confirmation Number:                 | 5519                                             |
| Title of Invention:                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| First Named Inventor/Applicant Name: | G.R. Mohan Rao                                   |
| Customer Number:                     | 40672                                            |
| Filer:                               | Bill Naifeh/April Reasoner                       |
| Filer Authorized By:                 | Bill Naifeh                                      |
| Attorney Docket Number:              | GRTD.01.01.DV6                                   |
| Receipt Date:                        | 20-MAR-2020                                      |
| Filing Date:                         | 17-DEC-2019                                      |
| Time Stamp:                          | 13:45:52                                         |
| Application Type:                    | Utility under 35 USC 111(a)                      |

| Payment information:                                                                                           |                  |
|----------------------------------------------------------------------------------------------------------------|------------------|
| Submitted with Payment                                                                                         | yes              |
| Payment Type                                                                                                   | CARD             |
| Payment was successfully received in RAM                                                                       | \$800            |
| RAM confirmation Number                                                                                        | E20203JD46246547 |
| Deposit Account                                                                                                |                  |
| Authorized User                                                                                                |                  |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: |                  |

|                              |                                                     |                        |                                          |                  |                  |
|------------------------------|-----------------------------------------------------|------------------------|------------------------------------------|------------------|------------------|
|                              |                                                     |                        |                                          |                  |                  |
| File Listing:                |                                                     |                        |                                          |                  |                  |
| Document Number              | Document Description                                | File Name              | File Size(Bytes)/ Message Digest         | Multi Part /.zip | Pages (if appl.) |
| 1                            |                                                     | GRTD-DV6_PrelimAmd.pdf | 40282                                    | yes              | 7                |
|                              |                                                     |                        | 3dbe2328ec5f519f4cf436fc3db131fa9485d8e4 |                  |                  |
|                              | Multipart Description/PDF files in .zip description |                        |                                          |                  |                  |
|                              | Document Description                                |                        | Start                                    | End              |                  |
|                              | Preliminary Amendment                               |                        | 1                                        | 1                |                  |
|                              | Claims                                              |                        | 2                                        | 6                |                  |
|                              | Applicant Arguments/Remarks Made in an Amendment    |                        | 7                                        | 7                |                  |
| Warnings:                    |                                                     |                        |                                          |                  |                  |
| Information:                 |                                                     |                        |                                          |                  |                  |
| 2                            | Fee Worksheet (SB06)                                | fee-info.pdf           | 30514                                    | no               | 2                |
|                              |                                                     |                        | e57276a87bb93a743099dd4085bbc6480435b73c |                  |                  |
| Warnings:                    |                                                     |                        |                                          |                  |                  |
| Information:                 |                                                     |                        |                                          |                  |                  |
| Total Files Size (in bytes): |                                                     |                        | 70796                                    |                  |                  |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

| <b>PATENT APPLICATION FEE DETERMINATION RECORD</b><br>Substitute for Form PTO-875                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                    |                    |              |                    | Application or Docket Number<br>16/717,950 |          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------|--------------|--------------------|--------------------------------------------|----------|
| <b>APPLICATION AS FILED - PART I</b>                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                               |                                    |                    |              |                    |                                            |          |
| (Column 1)                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                               | (Column 2)                         |                    | SMALL ENTITY |                    | OTHER THAN SMALL ENTITY                    |          |
| FOR                                                                                                                                                                                                                                                                                                                                                                                                        | NUMBER FILED                                                                                                                                                                                                                  | NUMBER EXTRA                       | RATE(\$)           | FEE(\$)      |                    | RATE(\$)                                   | FEE(\$)  |
| BASIC FEE<br>(37 CFR 1.16(a), (b), or (c))                                                                                                                                                                                                                                                                                                                                                                 | N/A                                                                                                                                                                                                                           | N/A                                | N/A                | 75           |                    | N/A                                        |          |
| SEARCH FEE<br>(37 CFR 1.16(k), (l), or (m))                                                                                                                                                                                                                                                                                                                                                                | N/A                                                                                                                                                                                                                           | N/A                                | N/A                | 330          |                    | N/A                                        |          |
| EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q))                                                                                                                                                                                                                                                                                                                                                           | N/A                                                                                                                                                                                                                           | N/A                                | N/A                | 380          |                    | N/A                                        |          |
| TOTAL CLAIMS<br>(37 CFR 1.16(j))                                                                                                                                                                                                                                                                                                                                                                           | 16                                                                                                                                                                                                                            | minus 20 = *                       | x 50 =             | 0.00         | OR                 |                                            |          |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h))                                                                                                                                                                                                                                                                                                                                                                     | 2                                                                                                                                                                                                                             | minus 3 = *                        | x 230 =            | 0.00         |                    |                                            |          |
| APPLICATION SIZE FEE<br>(37 CFR 1.16(s))                                                                                                                                                                                                                                                                                                                                                                   | If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). |                                    |                    | 0.00         |                    |                                            |          |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                               |                                    |                    | 0.00         |                    |                                            |          |
| * If the difference in column 1 is less than zero, enter "0" in column 2.                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                               |                                    | TOTAL              | 785          |                    | TOTAL                                      |          |
| <b>APPLICATION AS AMENDED - PART II</b>                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                               |                                    |                    |              |                    |                                            |          |
| (Column 1)                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                               | (Column 2)                         |                    | (Column 3)   |                    | SMALL ENTITY                               |          |
| AMENDMENT A                                                                                                                                                                                                                                                                                                                                                                                                | CLAIMS REMAINING AFTER AMENDMENT                                                                                                                                                                                              | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA      | RATE(\$)     | ADDITIONAL FEE(\$) |                                            | RATE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                  | Minus **           | =            | x =                | OR                                         | x =      |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                  | Minus ***          | =            | x =                | OR                                         | x =      |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                    |                    |              |                    | OR                                         |          |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                    |                    |              |                    | OR                                         |          |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                    | TOTAL<br>ADD'L FEE |              | OR                 | TOTAL<br>ADD'L FEE                         |          |
| (Column 1)                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                               | (Column 2)                         |                    | (Column 3)   |                    | SMALL ENTITY                               |          |
| AMENDMENT B                                                                                                                                                                                                                                                                                                                                                                                                | CLAIMS REMAINING AFTER AMENDMENT                                                                                                                                                                                              | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA      | RATE(\$)     | ADDITIONAL FEE(\$) |                                            | RATE(\$) |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Total<br>(37 CFR 1.16(i))                                                                                                                                                                                                     | *                                  | Minus **           | =            | x =                | OR                                         | x =      |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Independent<br>(37 CFR 1.16(h))                                                                                                                                                                                               | *                                  | Minus ***          | =            | x =                | OR                                         | x =      |
|                                                                                                                                                                                                                                                                                                                                                                                                            | Application Size Fee (37 CFR 1.16(s))                                                                                                                                                                                         |                                    |                    |              |                    | OR                                         |          |
|                                                                                                                                                                                                                                                                                                                                                                                                            | FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))                                                                                                                                                               |                                    |                    |              |                    | OR                                         |          |
|                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                               |                                    | TOTAL<br>ADD'L FEE |              | OR                 | TOTAL<br>ADD'L FEE                         |          |
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3.<br>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".<br>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".<br>The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1. |                                                                                                                                                                                                                               |                                    |                    |              |                    |                                            |          |



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| APPLICATION<br>NUMBER | FILING or<br>371(c) DATE | GRP ART<br>UNIT | FIL FEE REC'D | ATTY. DOCKET NO | TOT CLAIMS | IND CLAIMS |
|-----------------------|--------------------------|-----------------|---------------|-----------------|------------|------------|
| 16/717,950            | 12/17/2019               | 2811            | 785           | GRTD.01.01.DV6  | 16         | 2          |

CONFIRMATION NO. 5519

## FILING RECEIPT



0000000113853577

40672  
BILL R. NAIFEH  
PO BOX 803423  
DALLAS, TX 75380

Date Mailed: 01/14/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

**Please verify the accuracy of the data presented on this receipt.** If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

### Inventor(s)

G.R. Mohan Rao, Allen, TX;

### Applicant(s)

GREENTHREAD, LLC, Dallas, TX;

**Power of Attorney:** None

### Domestic Priority data as claimed by applicant

This application is a CON of 15/590,282 05/09/2017 PAT 10510842  
which is a CON of 14/931,636 11/03/2015 PAT 9647070  
which is a CON of 14/515,584 10/16/2014 PAT 9190502  
which is a CON of 13/854,319 04/01/2013 ABN  
which is a CON of 11/622,496 01/12/2007 PAT 8421195  
which is a DIV of 10/934,915 09/03/2004 ABN

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 01/09/2020

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/717,950**

**Projected Publication Date:** 04/23/2020

**Non-Publication Request:** No

**Early Publication Request:** No

**\*\* SMALL ENTITY \*\***

**Title**

SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS

**Preliminary Class**

257

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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Application Number: 16717950

Document Date: 12/17/2019

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Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

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- External customers may access SCORE content via PAIR using the Supplemental Content tab.

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VIA THE INTERNET AND EMAIL**

Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application by video conferencing or electronic mail. I understand that a copy of these communications will be made of record in the application file.

Respectfully submitted,

/Bill R. Naifeh, Reg. No. 44,962/

Bill R. Naifeh  
Registration No. 44,962

**Bill R. Naifeh**  
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972-726-9500  
214-550-2542 (fax)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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New claims in this Application may be broader than the claims previously allowed in parent or related applications.

Respectfully submitted,

/Bill R. Naifeh, Reg. No. 44,962/

Bill R. Naifeh  
Registration No. 44,962

**Bill R. Naifeh**  
**Law Office of Bill Naifeh**  
P.O. Box 803423  
Dallas, TX 75380  
972-726-9500  
214-550-2542 (fax)

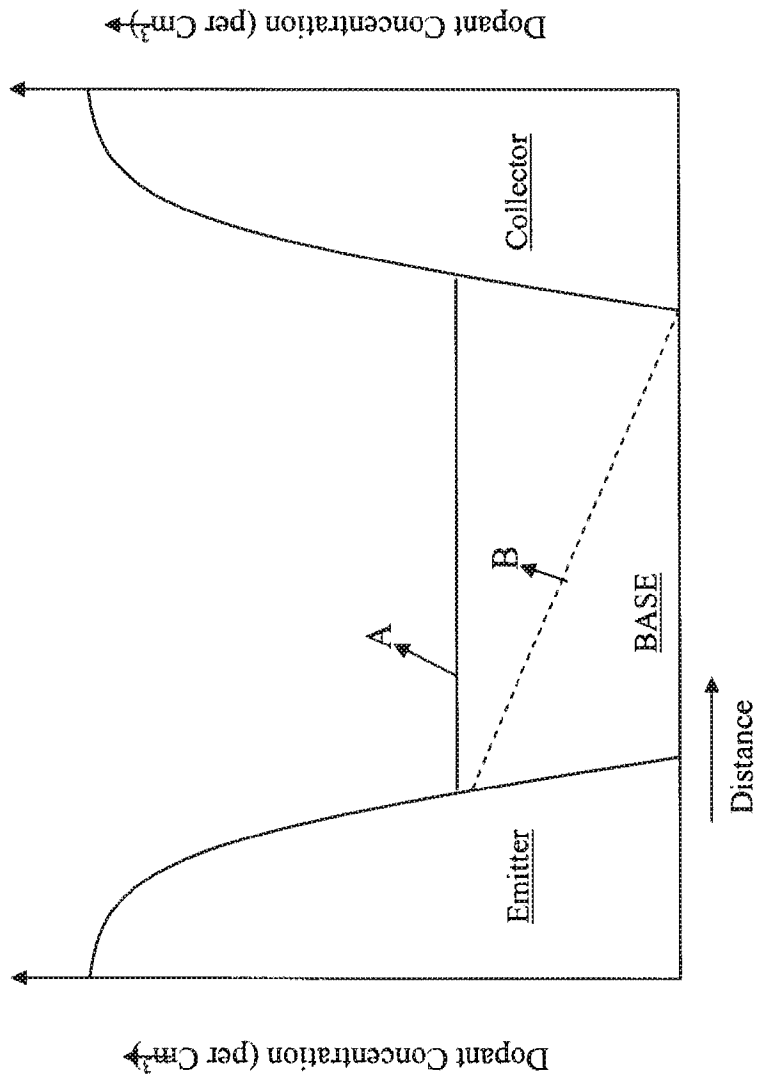


Figure 1 Prior Art

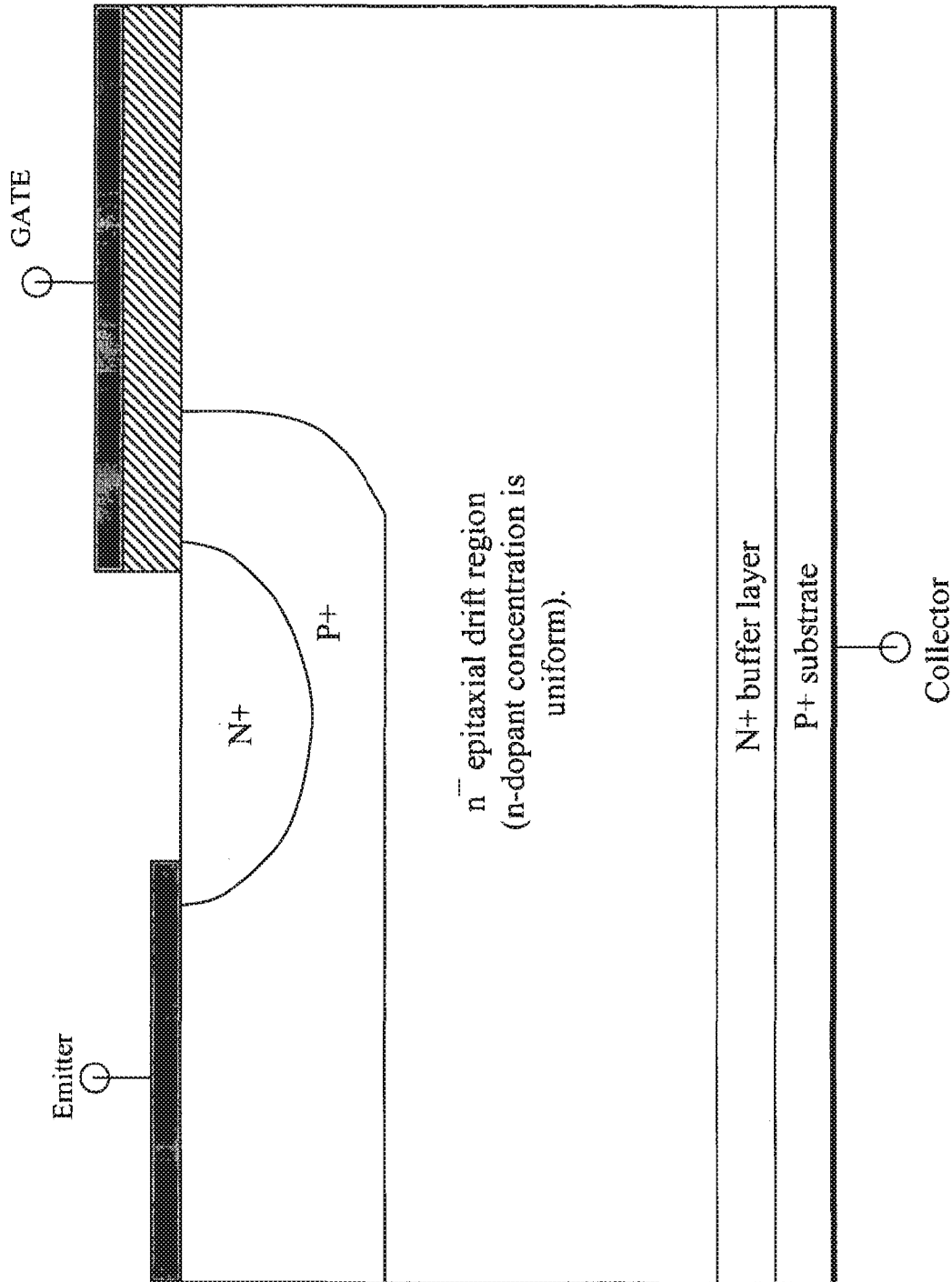


**FIGURE 2 Prior art**

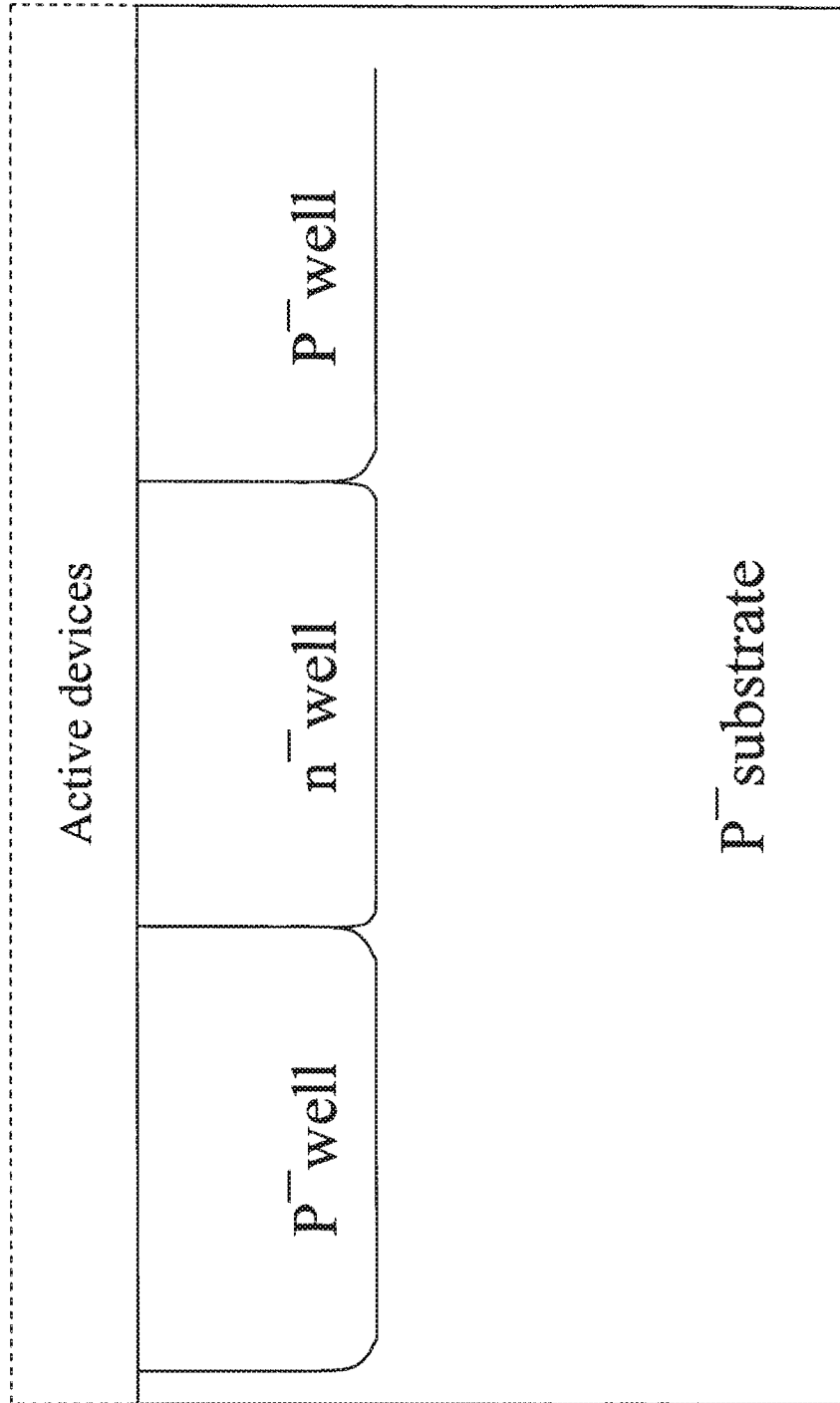


FIGURE 3A Prior art (Twin well CMOS) for a CMOS integrated circuit

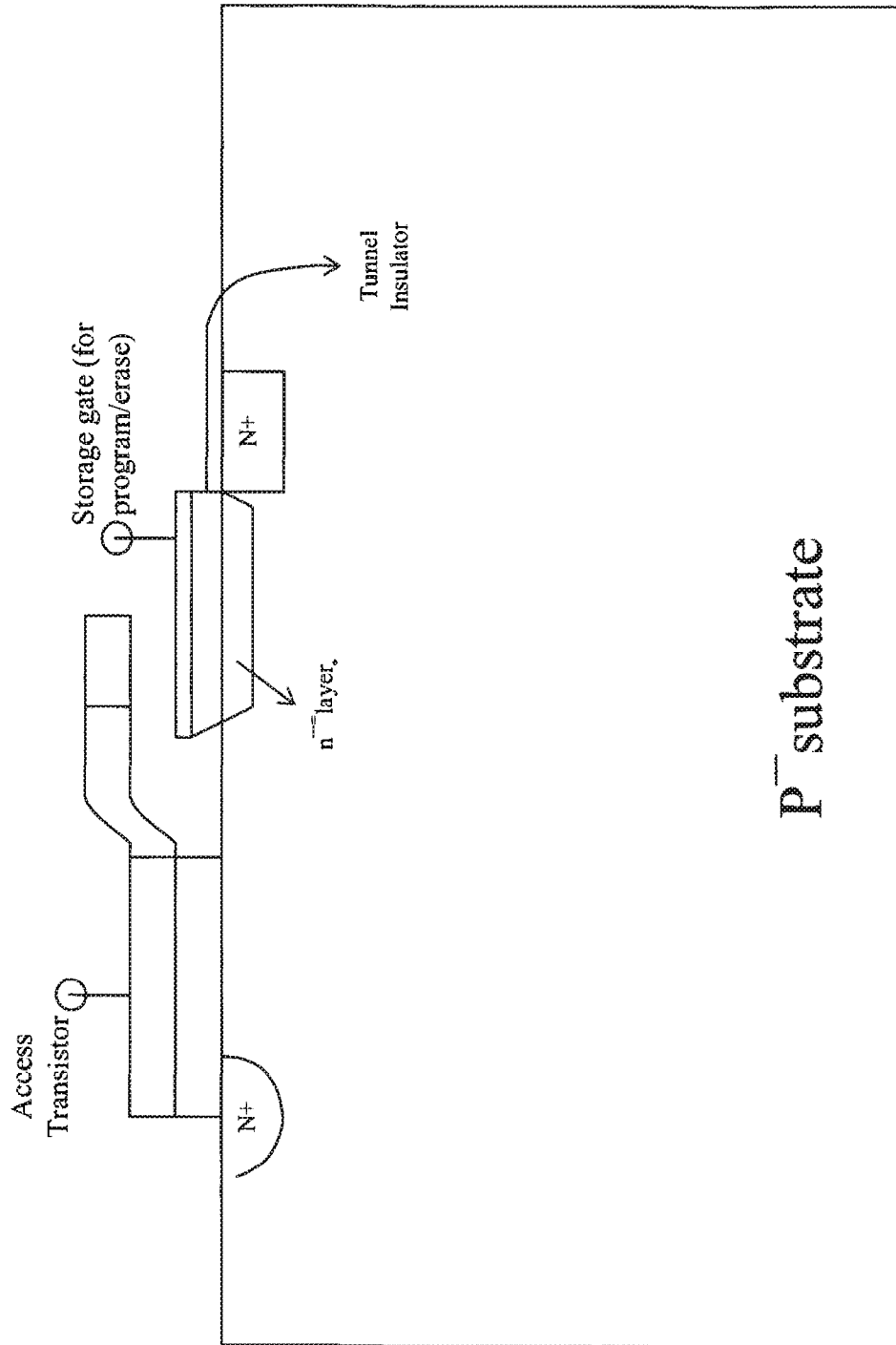


**FIGURE 3B** Prior art for a two-device EEPROM memory cell

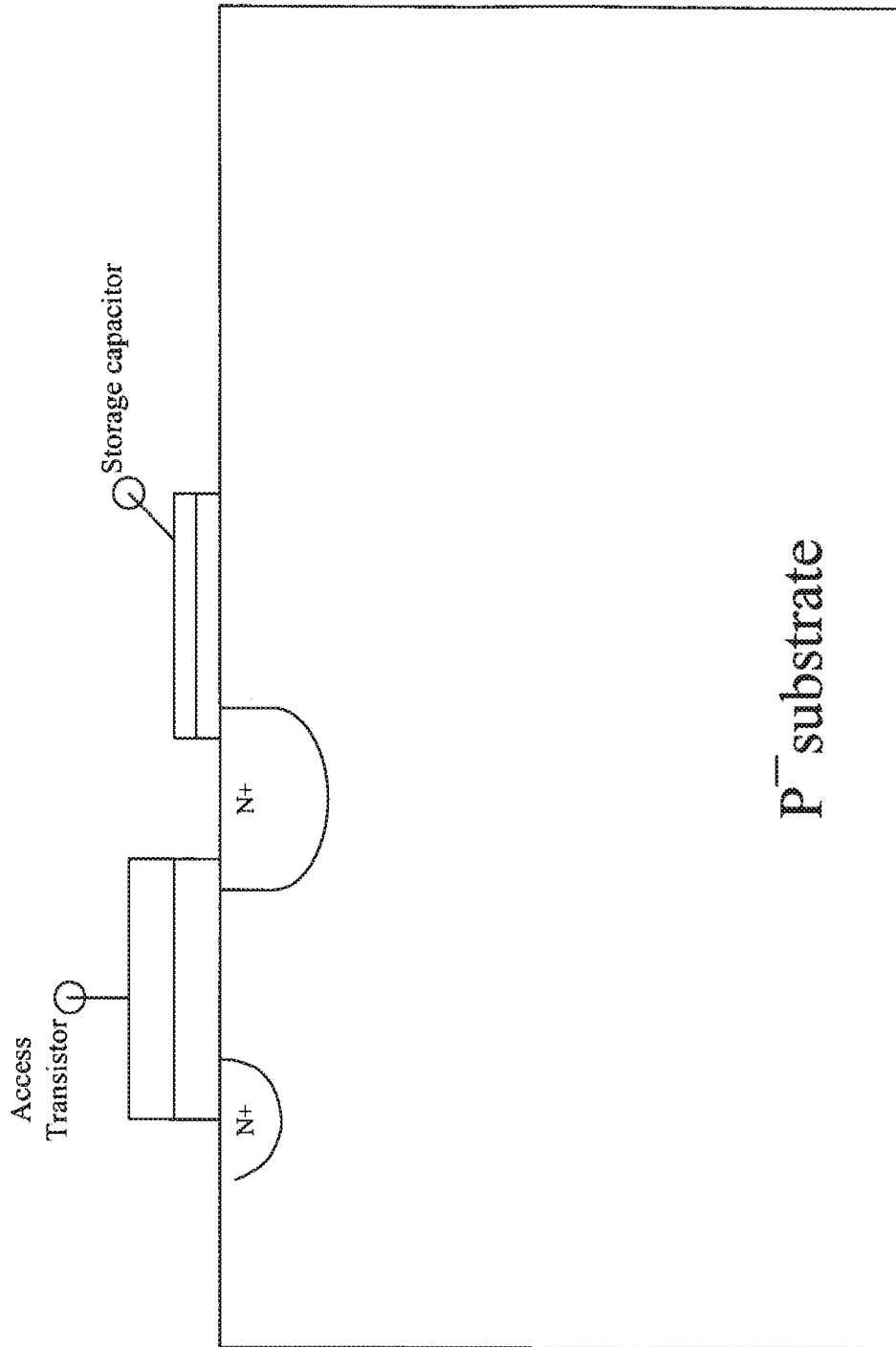


**FIGURE 3C** Prior art for a 1T-1C DRAM memory cell

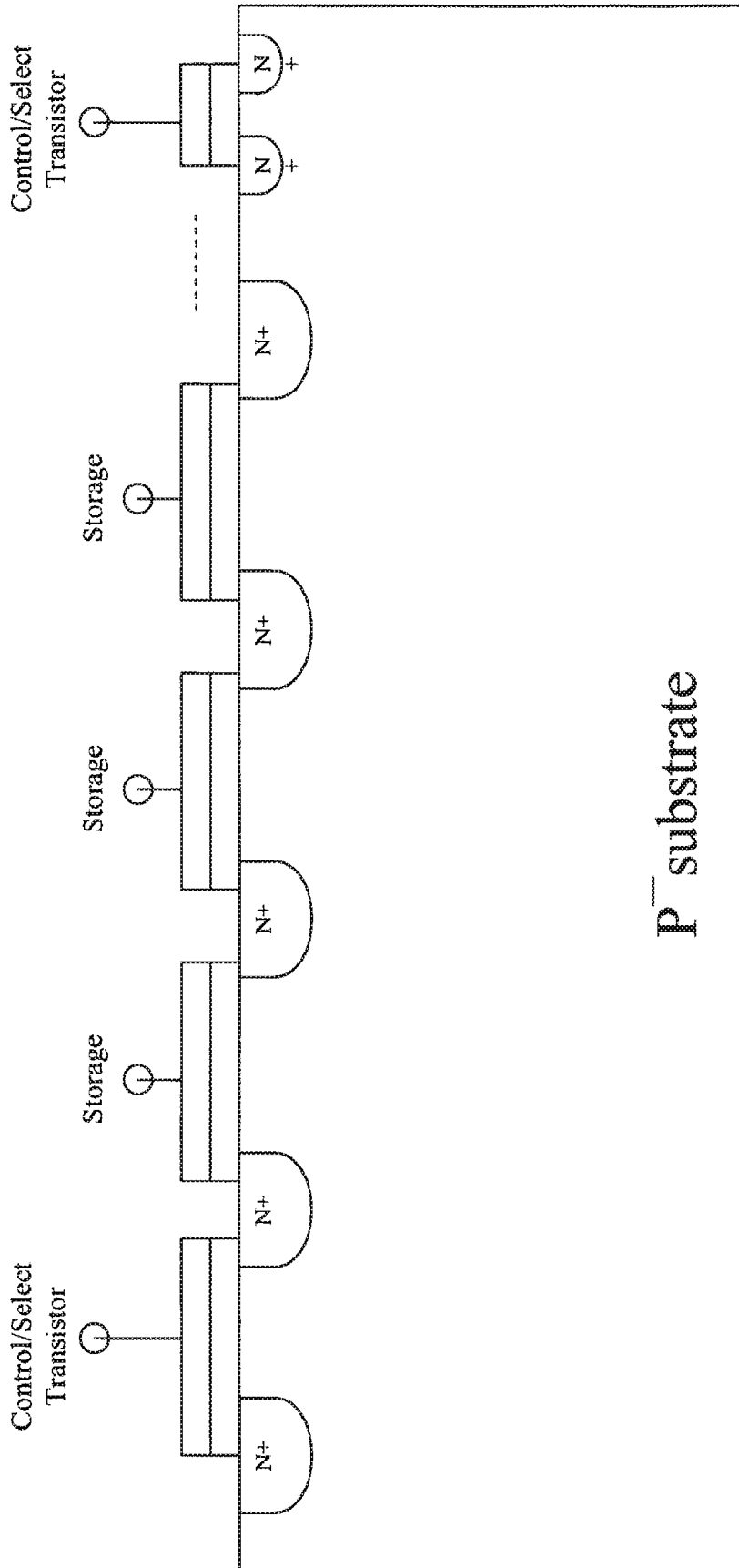


**FIGURE 3D Prior art for a NAND flash memory cell**

Note: Control/ Sect transistors have a single insulator - traditional MOS transistor.

Storage nodes have a stacked gate structure, typically with a floating gate and control gate comprising the stack.

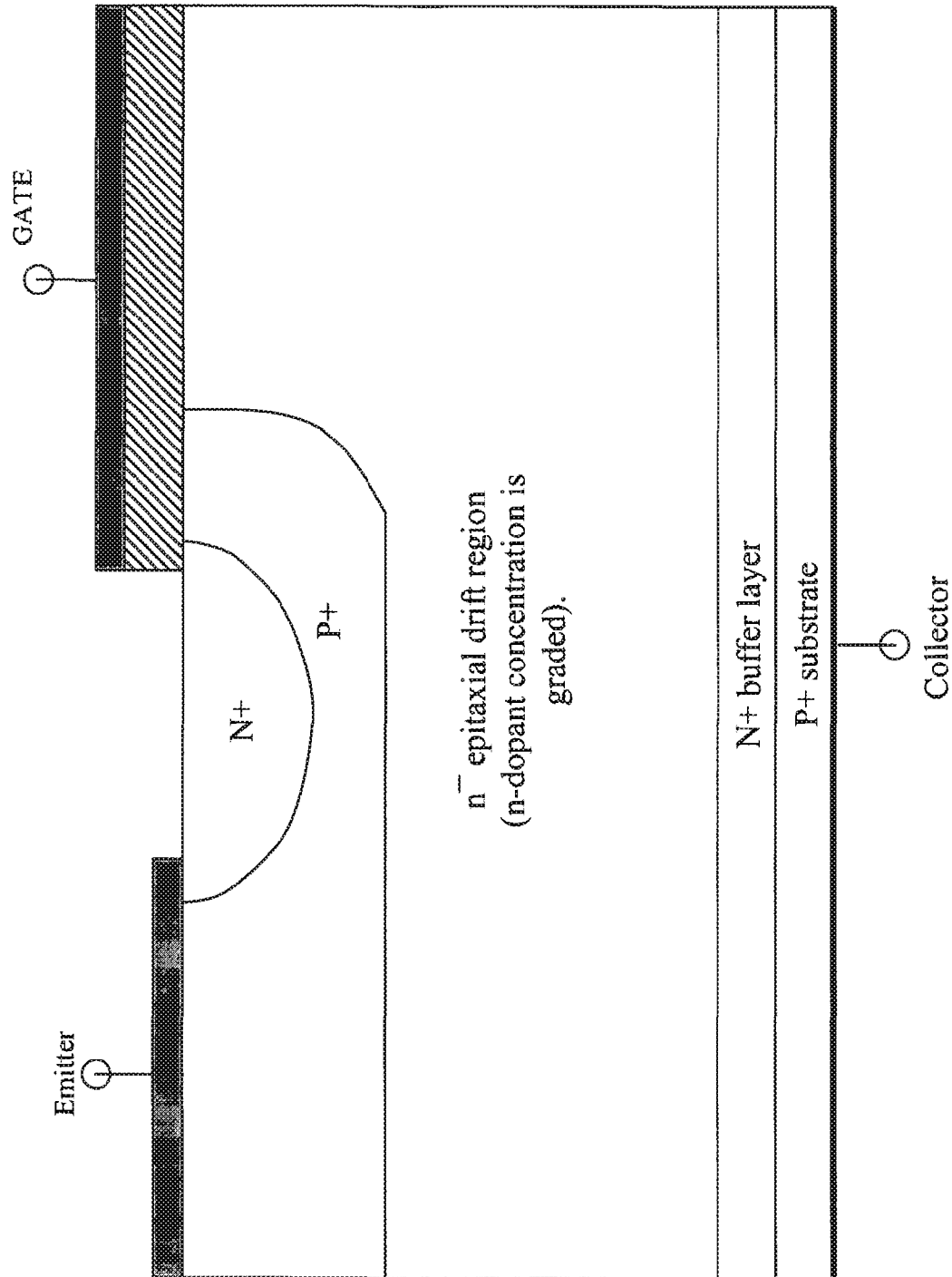


**FIGURE 4 A dopant - concentration graded drift region in a IGBT**

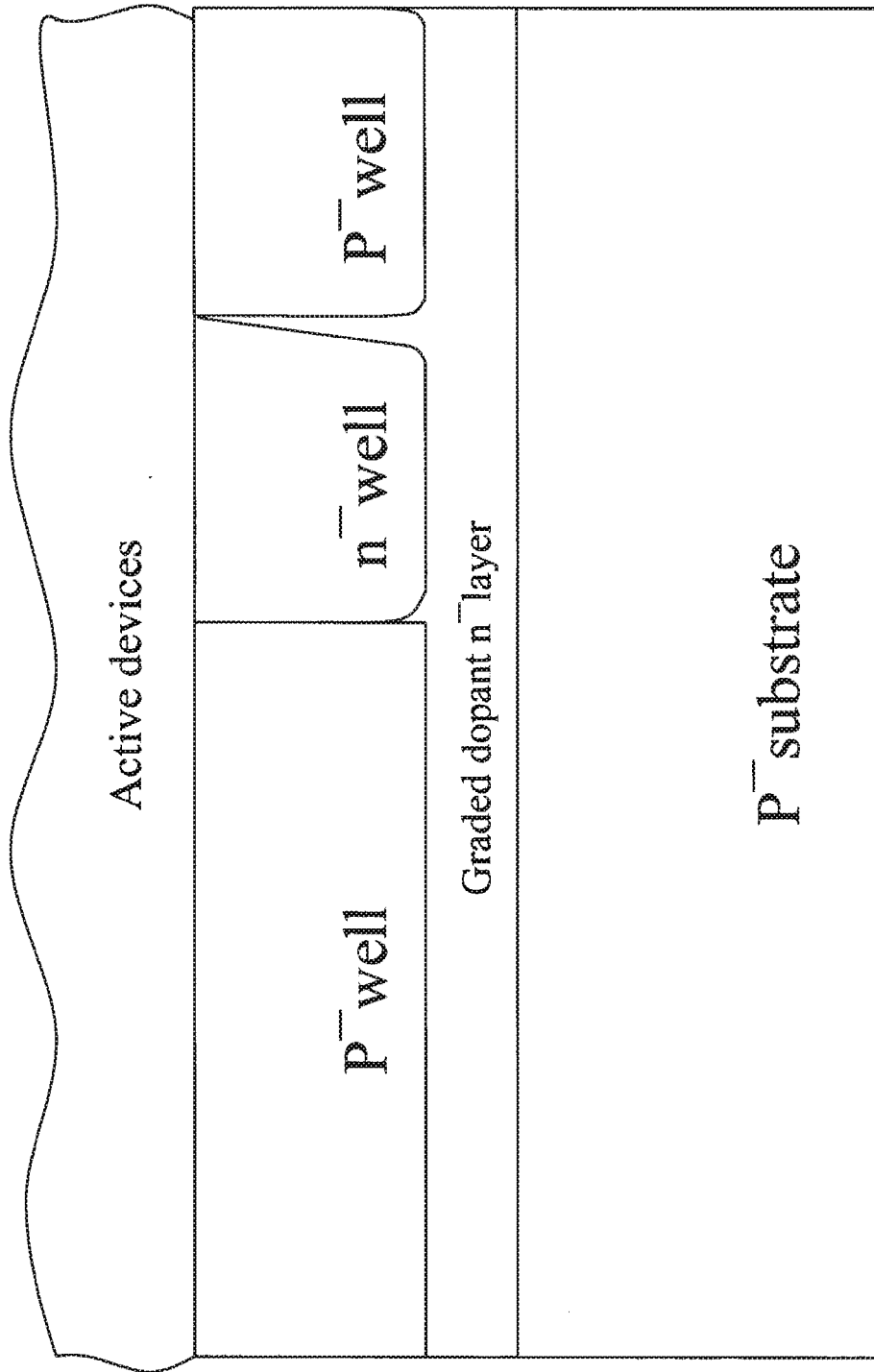


**FIGURE 5A A CMOS Substrate for digital, mixed, signal, and sensors IC's**

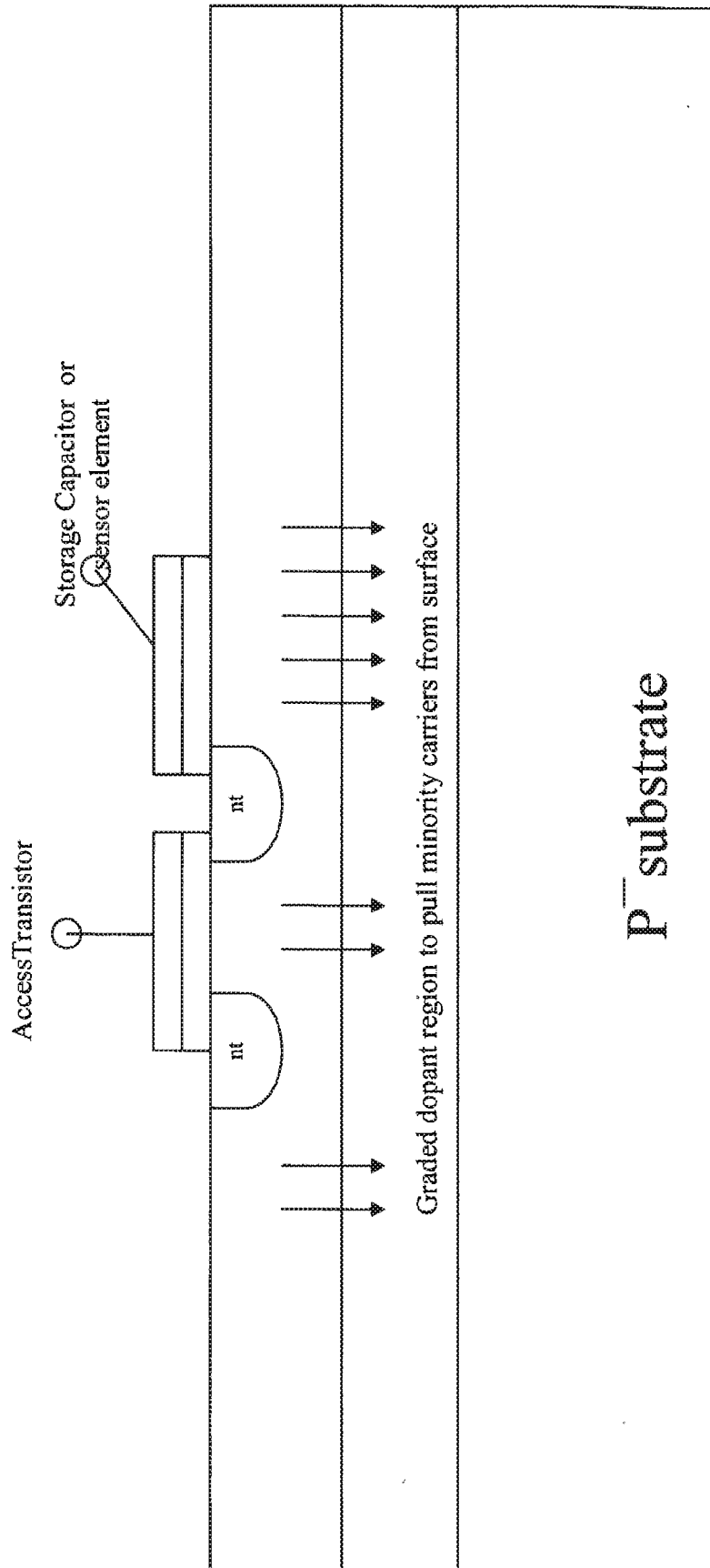


**FIGURE 5B CMOS Substrate for a DRAM or image sensor, with one embodiment of the invention**

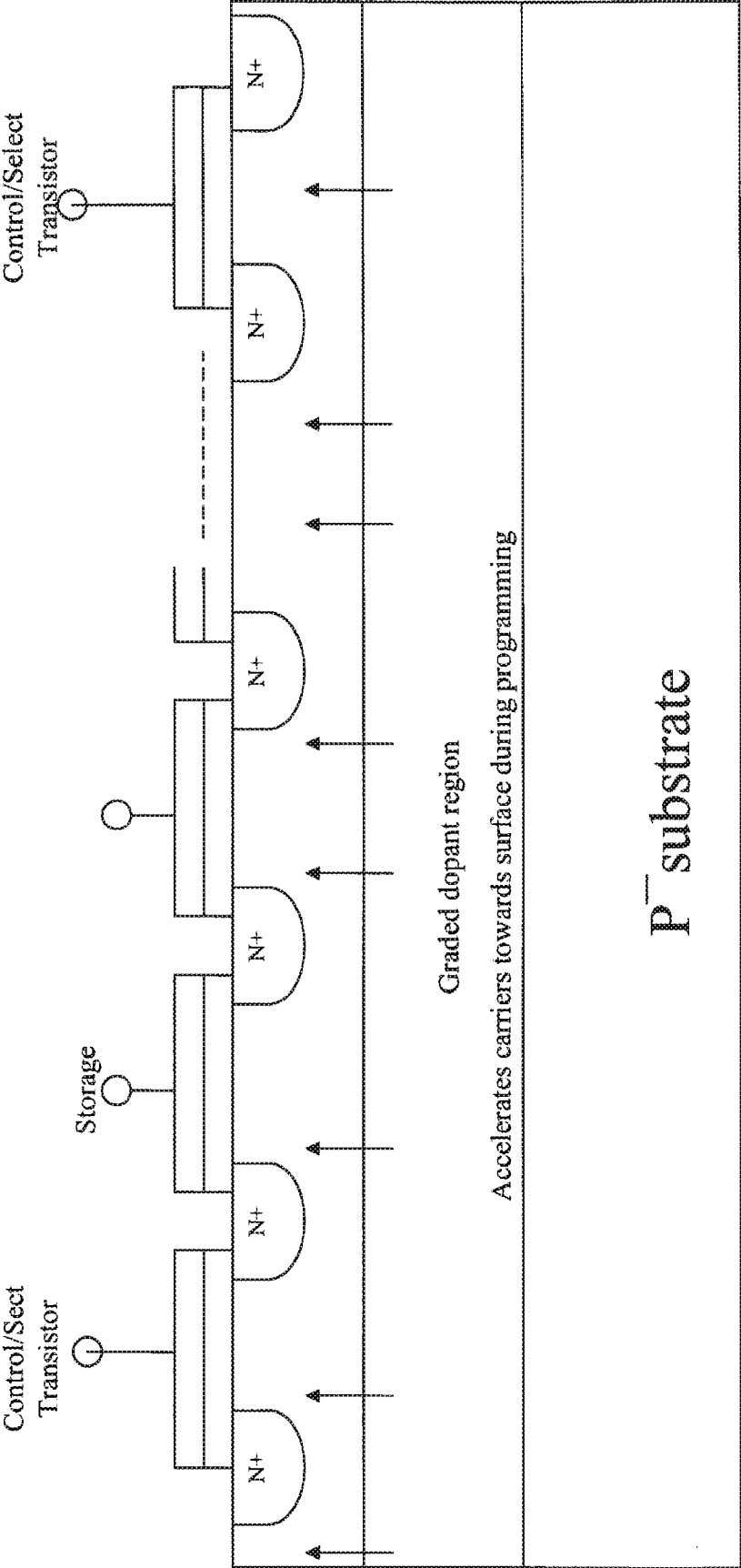


**FIGURE 5C CMOS Substrate for a NAND flash device to improve programming times**

| Electronic Patent Application Fee Transmittal |          |                                                  |        |                      |
|-----------------------------------------------|----------|--------------------------------------------------|--------|----------------------|
| Application Number:                           |          |                                                  |        |                      |
| Filing Date:                                  |          |                                                  |        |                      |
| Title of Invention:                           |          | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |        |                      |
| First Named Inventor/Applicant Name:          |          | G.R. Mohan Rao                                   |        |                      |
| Filer:                                        |          | Bill Naifeh/April Reasoner                       |        |                      |
| Attorney Docket Number:                       |          | GRTD.01.01.DV6                                   |        |                      |
| Filed as Small Entity                         |          |                                                  |        |                      |
| Filing Fees for   Utility under 35 USC 111(a) |          |                                                  |        |                      |
| Description                                   | Fee Code | Quantity                                         | Amount | Sub-Total in USD(\$) |
| Basic Filing:                                 |          |                                                  |        |                      |
| UTILITY FILING FEE (ELECTRONIC FILING)        | 4011     | 1                                                | 75     | 75                   |
| UTILITY SEARCH FEE                            | 2111     | 1                                                | 330    | 330                  |
| UTILITY EXAMINATION FEE                       | 2311     | 1                                                | 380    | 380                  |
| Pages:                                        |          |                                                  |        |                      |
| Claims:                                       |          |                                                  |        |                      |
| Miscellaneous-Filing:                         |          |                                                  |        |                      |
| Petition:                                     |          |                                                  |        |                      |
| Patent-Appeals-and-Interference:              |          |                                                  |        |                      |

| Description                       | Fee Code | Quantity | Amount | Sub-Total in USD(\$) |
|-----------------------------------|----------|----------|--------|----------------------|
| Post-Allowance-and-Post-Issuance: |          |          |        |                      |
| Extension-of-Time:                |          |          |        |                      |
| Miscellaneous:                    |          |          |        |                      |
| Total in USD (\$)                 |          |          |        | 785                  |

| Electronic Acknowledgement Receipt   |                                                  |
|--------------------------------------|--------------------------------------------------|
| EFS ID:                              | 38062583                                         |
| Application Number:                  | 16717950                                         |
| International Application Number:    |                                                  |
| Confirmation Number:                 | 5519                                             |
| Title of Invention:                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |
| First Named Inventor/Applicant Name: | G.R. Mohan Rao                                   |
| Customer Number:                     | 40672                                            |
| Filer:                               | Bill Naifeh/April Reasoner                       |
| Filer Authorized By:                 | Bill Naifeh                                      |
| Attorney Docket Number:              | GRTD.01.01.DV6                                   |
| Receipt Date:                        | 17-DEC-2019                                      |
| Filing Date:                         |                                                  |
| Time Stamp:                          | 18:54:09                                         |
| Application Type:                    | Utility under 35 USC 111(a)                      |

| Payment information:                                                                                           |                  |
|----------------------------------------------------------------------------------------------------------------|------------------|
| Submitted with Payment                                                                                         | yes              |
| Payment Type                                                                                                   | CARD             |
| Payment was successfully received in RAM                                                                       | \$ 785           |
| RAM confirmation Number                                                                                        | E2019BGI54309861 |
| Deposit Account                                                                                                |                  |
| Authorized User                                                                                                |                  |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: |                  |

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|-----------------|-----------------------------------------------------|---------------------------------------|------------------------------------------|------------------|------------------|
|                 |                                                     |                                       |                                          |                  |                  |
| File Listing:   |                                                     |                                       |                                          |                  |                  |
| Document Number | Document Description                                | File Name                             | File Size(Bytes)/ Message Digest         | Multi Part /.zip | Pages (if appl.) |
| 1               | Application Data Sheet                              | 01_ADS.pdf                            | 1256470                                  | no               | 9                |
|                 |                                                     |                                       | 8e730ddd811fbab6a29252ca95593c0306f704af |                  |                  |
| Warnings:       |                                                     |                                       |                                          |                  |                  |
| Information:    |                                                     |                                       |                                          |                  |                  |
| 2               |                                                     | 02_ContinuationApp.pdf                | 55332                                    | yes              | 11               |
|                 |                                                     |                                       | 59627a5ff61886b2e5831c18766807a3826882e9 |                  |                  |
|                 | Multipart Description/PDF files in .zip description |                                       |                                          |                  |                  |
|                 | Document Description                                |                                       | Start                                    | End              |                  |
|                 | Abstract                                            |                                       | 11                                       | 11               |                  |
|                 | Claims                                              |                                       | 8                                        | 10               |                  |
|                 | Specification                                       |                                       | 1                                        | 7                |                  |
| Warnings:       |                                                     |                                       |                                          |                  |                  |
| Information:    |                                                     |                                       |                                          |                  |                  |
| 3               | Oath or Declaration filed                           | 04_Declaration.pdf                    | 102840                                   | no               | 1                |
|                 |                                                     |                                       | 657df698e088c5b8077d08d11f4c84dc03a479dc |                  |                  |
| Warnings:       |                                                     |                                       |                                          |                  |                  |
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| 4               | Internet Communications Authorized                  | 05_Email_Authorization.pdf            | 21660                                    | no               | 1                |
|                 |                                                     |                                       | bfe2be1f1bd817991c381cbb5bc7e547219eead2 |                  |                  |
| Warnings:       |                                                     |                                       |                                          |                  |                  |
| Information:    |                                                     |                                       |                                          |                  |                  |
| 5               | Miscellaneous Incoming Letter                       | 06_AffirmativeRecessionDisclaimer.pdf | 14648                                    | no               | 1                |
|                 |                                                     |                                       | 984ed6d914f7a2a1af5e8f505464f0835414427b |                  |                  |

Greenthread Ex. 2070, p. 118 of 1

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                   |                 |                                          |    |    |
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| Warnings:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                   |                 |                                          |    |    |
| Information:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   |                 |                                          |    |    |
| 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Drawings-other than black and white line drawings | 03_Drawings.pdf | 491140                                   | no | 10 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                   |                 | 01bac4c726779b544a5b9d15fc160cbbc90fbd30 |    |    |
| Warnings:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                   |                 |                                          |    |    |
| Information:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   |                 |                                          |    |    |
| 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Fee Worksheet (SB06)                              | fee-info.pdf    | 35143                                    | no | 2  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                   |                 | 1bfda9a587b8cb57d5dc02353cf44f03c0191cce |    |    |
| Warnings:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                   |                 |                                          |    |    |
| Information:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   |                 |                                          |    |    |
| Total Files Size (in bytes):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                   |                 | 1977233                                  |    |    |
| <p><b>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</b></p> <p><b><u>New Applications Under 35 U.S.C. 111</u></b><br/>If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><b><u>National Stage of an International Application under 35 U.S.C. 371</u></b><br/>If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><b><u>New International Application Filed with the USPTO as a Receiving Office</u></b><br/>If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p> |                                                   |                 |                                          |    |    |

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  |                        |                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                  | Application Number     |                |
| Title of Invention                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |
| The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application. |                                                  |                        |                |

**Secrecy Order 37 CFR 5.2:**

|                          |                                                                                                                                                                                                                                       |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> | Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.) |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Inventor Information:**

|                                                                                                                                      |                       |                   |             |                      |    |
|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------|-------------|----------------------|----|
| Inventor                                                                                                                             | 1                     | <div>Remove</div> |             |                      |    |
| Legal Name                                                                                                                           |                       |                   |             |                      |    |
| Prefix                                                                                                                               | Given Name            | Middle Name       | Family Name | Suffix               |    |
|                                                                                                                                      | G.R. Mohan            |                   | Rao         |                      |    |
| Residence Information (Select One) • US Residency Non US Residency Active US Military Service                                        |                       |                   |             |                      |    |
| City                                                                                                                                 | Allen                 | State/Province    | TX          | Country of Residence | US |
| Mailing Address of Inventor:                                                                                                         |                       |                   |             |                      |    |
| Address 1                                                                                                                            | 1611 Willingham Drive |                   |             |                      |    |
| Address 2                                                                                                                            |                       |                   |             |                      |    |
| City                                                                                                                                 | Allen                 | State/Province    | TX          |                      |    |
| Postal Code                                                                                                                          | 72013                 | Country           | US          |                      |    |
| All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. |                       |                   |             |                      |    |
| <div>Add</div>                                                                                                                       |                       |                   |             |                      |    |

**Correspondence Information:**

|                                                                                                                                       |                    |                      |                         |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------|-------------------------|
| Enter either Customer Number or complete the Correspondence Information section below.<br>For further information see 37 CFR 1.33(a). |                    |                      |                         |
| <input type="checkbox"/> An Address is being provided for the correspondence information of this application.                         |                    |                      |                         |
| Customer Number                                                                                                                       | 40672              |                      |                         |
| Email Address                                                                                                                         | patents@naifeh.com | <div>Add Email</div> | <div>Remove Email</div> |

**Application Information:**

|                                         |                                                  |                                           |                                     |
|-----------------------------------------|--------------------------------------------------|-------------------------------------------|-------------------------------------|
| Title of the Invention                  | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                                           |                                     |
| Attorney Docket Number                  | GRTD.01.01.DV6                                   | Small Entity Status Claimed               | <input checked="" type="checkbox"/> |
| Application Type                        | Nonprovisional                                   |                                           |                                     |
| Subject Matter                          | Utility                                          |                                           |                                     |
| Total Number of Drawing Sheets (if any) | 10                                               | Suggested Figure for Publication (if any) |                                     |

|                                           |                                                  |                        |                |
|-------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                           |                                                  | Application Number     |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |

**Filing By Reference:**

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

|                                                        |                          |                                            |
|--------------------------------------------------------|--------------------------|--------------------------------------------|
| Application number of the previously filed application | Filing date (YYYY-MM-DD) | Intellectual Property Authority or Country |
|                                                        |                          |                                            |

**Publication Information:**

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not be** the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

**Representative Information:**

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

|                    |                                                  |                        |                                                         |
|--------------------|--------------------------------------------------|------------------------|---------------------------------------------------------|
| Please Select One: | <input checked="" type="radio"/> Customer Number | US Patent Practitioner | <input type="radio"/> Limited Recognition (37 CFR 11.9) |
| Customer Number    | 40672                                            |                        |                                                         |

**Domestic Benefit/National Stage Information:**

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

|                          |                 |                          |                                    |
|--------------------------|-----------------|--------------------------|------------------------------------|
| Prior Application Status | Pending         | Remove                   |                                    |
| Application Number       | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
|                          | Continuation of | 15590282                 | 2017-05-09                         |

|                                           |                                                  |                        |                |
|-------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                           |                                                  | Application Number     |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |

|                                                                                                                       |                 |                          |                                    |               |                         |
|-----------------------------------------------------------------------------------------------------------------------|-----------------|--------------------------|------------------------------------|---------------|-------------------------|
| Prior Application Status                                                                                              |                 | Patented                 |                                    | Remove        |                         |
| Application Number                                                                                                    | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD)           | Patent Number | Issue Date (YYYY-MM-DD) |
| 15590282                                                                                                              | Continuation of | 14931636                 | 2015-11-03                         | 9647070       | 2017-05-09              |
| Prior Application Status                                                                                              |                 | Patented                 |                                    | Remove        |                         |
| Application Number                                                                                                    | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD)           | Patent Number | Issue Date (YYYY-MM-DD) |
| 14931636                                                                                                              | Continuation of | 14515584                 | 2014-10-16                         | 9190502       | 2015-11-17              |
| Prior Application Status                                                                                              |                 | Abandoned                |                                    | Remove        |                         |
| Application Number                                                                                                    | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |               |                         |
| 14515584                                                                                                              | Continuation of | 13854319                 | 2013-04-01                         |               |                         |
| Prior Application Status                                                                                              |                 | Patented                 |                                    | Remove        |                         |
| Application Number                                                                                                    | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD)           | Patent Number | Issue Date (YYYY-MM-DD) |
| 13854319                                                                                                              | Continuation of | 11622496                 | 2007-01-12                         | 8421195       | 2013-04-16              |
| Prior Application Status                                                                                              |                 | Abandoned                |                                    | Remove        |                         |
| Application Number                                                                                                    | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |               |                         |
| 11622496                                                                                                              | Division of     | 10934915                 | 2004-09-03                         |               |                         |
| Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the <b>Add</b> button. |                 |                          |                                    |               | Add                     |

## Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)<sup>i</sup> the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

|                                                                                                        |                      |                          |                                          |
|--------------------------------------------------------------------------------------------------------|----------------------|--------------------------|------------------------------------------|
| Remove                                                                                                 |                      |                          |                                          |
| Application Number                                                                                     | Country <sup>i</sup> | Filing Date (YYYY-MM-DD) | Access Code <sup>j</sup> (if applicable) |
|                                                                                                        |                      |                          |                                          |
| Additional Foreign Priority Data may be generated within this form by selecting the <b>Add</b> button. |                      |                          |                                          |
| Add                                                                                                    |                      |                          |                                          |

|                                           |                                                  |                |
|-------------------------------------------|--------------------------------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> | Attorney Docket Number                           | GRTD.01.01.DV6 |
|                                           | Application Number                               |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                |

## Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> | <p>This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.</p> <p>NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.</p> |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                           |                                                  |                |
|-------------------------------------------|--------------------------------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> | Attorney Docket Number                           | GRTD.01.01.DV6 |
|                                           | Application Number                               |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                |

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE:** This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

|                                           |                                                  |                        |                |
|-------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                           |                                                  | Application Number     |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |

## Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

|                  |   |                        |
|------------------|---|------------------------|
| <b>Applicant</b> | 1 | <a href="#">Remove</a> |
|------------------|---|------------------------|

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

[Clear](#)

|                                           |                                          |                |
|-------------------------------------------|------------------------------------------|----------------|
| <input checked="" type="radio"/> Assignee | Legal Representative under 35 U.S.C. 117 | Joint Inventor |
|-------------------------------------------|------------------------------------------|----------------|

|                                                     |                                                  |
|-----------------------------------------------------|--------------------------------------------------|
| Person to whom the inventor is obligated to assign. | Person who shows sufficient proprietary interest |
|-----------------------------------------------------|--------------------------------------------------|

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

|                   |                  |
|-------------------|------------------|
| Organization Name | GREENTHREAD, LLC |
|-------------------|------------------|

**Mailing Address Information For Applicant:**

|               |                  |                |       |
|---------------|------------------|----------------|-------|
| Address 1     | 4544 Harrys Lane |                |       |
| Address 2     |                  |                |       |
| City          | Dallas           | State/Province | TX    |
| Country       | US               | Postal Code    | 75229 |
| Phone Number  |                  | Fax Number     |       |
| Email Address |                  |                |       |

Additional Applicant Data may be generated within this form by selecting the Add button. [Add](#)

## Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

|                                           |                                                  |                        |                |
|-------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                           |                                                  | Application Number     |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                      |                      |                      |                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|----------------------|
| <b>Assignee</b>   1                                                                                                                                                                                                                                                                                                                                                                                                                                    |                      |                      |                      |                      |
| Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication. |                      |                      |                      |                      |
| <div>Remove</div>                                                                                                                                                                                                                                                                                                                                                                                                                                      |                      |                      |                      |                      |
| If the Assignee or Non-Applicant Assignee is an Organization check here. <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                      |                      |                      |                      |                      |
| Prefix                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Given Name           | Middle Name          | Family Name          | Suffix               |
| <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| <b>Mailing Address Information For Assignee including Non-Applicant Assignee:</b>                                                                                                                                                                                                                                                                                                                                                                      |                      |                      |                      |                      |
| Address 1                                                                                                                                                                                                                                                                                                                                                                                                                                              |                      | <input type="text"/> |                      |                      |
| Address 2                                                                                                                                                                                                                                                                                                                                                                                                                                              |                      | <input type="text"/> |                      |                      |
| City                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | State/Province       | <input type="text"/> |                      |
| Country <sup>i</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input type="text"/> | Postal Code          | <input type="text"/> |                      |
| Phone Number                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="text"/> | Fax Number           | <input type="text"/> |                      |
| Email Address                                                                                                                                                                                                                                                                                                                                                                                                                                          | <input type="text"/> |                      |                      |                      |
| Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. <div>Add</div>                                                                                                                                                                                                                                                                                                                       |                      |                      |                      |                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                 |           |        |                     |                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------|--------|---------------------|-------------------|
| <b>Signature:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |           |        |                     | <div>Remove</div> |
| <b>NOTE:</b> This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).                                                                                                    |                                 |           |        |                     |                   |
| This Application Data Sheet <b>must</b> be signed by a patent practitioner if one or more of the applicants is a <b>juristic entity</b> (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, <b>all</b> joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of <b>all</b> joint inventor-applicants. |                                 |           |        |                     |                   |
| See 37 CFR 1.4(d) for the manner of making signatures and certifications.                                                                                                                                                                                                                                                                                                                                                                                                                             |                                 |           |        |                     |                   |
| Signature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | /Bill R. Naifeh, Reg No. 44962/ |           |        | Date (YYYY-MM-DD)   | 2019-12-17        |
| First Name                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Bill R.                         | Last Name | Naifeh | Registration Number | 44962             |
| Additional Signature may be generated within this form by selecting the Add button. <div>Add</div>                                                                                                                                                                                                                                                                                                                                                                                                    |                                 |           |        |                     |                   |

|                                           |                                                  |                        |                |
|-------------------------------------------|--------------------------------------------------|------------------------|----------------|
| <b>Application Data Sheet 37 CFR 1.76</b> |                                                  | Attorney Docket Number | GRTD.01.01.DV6 |
|                                           |                                                  | Application Number     |                |
| Title of Invention                        | SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS |                        |                |

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

# Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

- 1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
- 2 A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
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## **ABSTRACT**

Most semiconductor devices manufactured today, have uniform dopant concentration, either in the lateral or vertical device active (and isolation) regions. By grading the dopant concentration, the performance in various semiconductor devices can be significantly improved. Performance improvements can be obtained in application specific areas like increase in frequency of operation for digital logic, various power MOSFET and IGBT ICs, improvement in refresh time for DRAMs, decrease in programming time for nonvolatile memory, better visual quality including pixel resolution and color sensitivity for imaging ICs, better sensitivity for varactors in tunable filters, higher drive capabilities for JFETs, and a host of other applications.

**WHAT IS CLAIMED IS:**

1. A semiconductor device, comprising:
  - a substrate of a first doping type at a first doping level having first and second surfaces;
  - a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity to the first doping type;
  - a second active region separate from the first active region disposed adjacent to the first active region;
  - circuitry formed in at least one of the first active region or second active region; and
  - at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the first surface to the second surface of the substrate.
2. The semiconductor device of Claim 1, wherein the substrate is a p-type substrate.
3. The semiconductor device of Claim 1, wherein the substrate is an n-type substrate.
4. The semiconductor device of Claim 1, wherein the substrate has epitaxial silicon on top of a nonepitaxial substrate.
5. The semiconductor device of Claim 1, wherein the first active region and second active region contain p-channel and n-channel devices.
6. The semiconductor device of Claim 1, wherein the first active region and second active region contain either p-channel or n-channel devices.
7. The semiconductor device of Claim 1, wherein the first active region and second active region are each separated by at least one isolation region.

8. The semiconductor device of Claim 1, wherein the graded dopant is fabricated with an ion implantation process.
9. A semiconductor device, comprising:
  - a substrate of a first doping type at a first doping level having first and second surfaces;
  - a first active region disposed adjacent the first surface of the substrate with a second doping type opposite in conductivity to the first doping type;
  - a second active region separate from the first active region disposed adjacent to the first active region;
  - circuitry formed in at least one of the first active region or second active region; and
  - at least a portion of at least one of the first and second active regions having at least one graded dopant concentration to aid carrier movement from the surface to the substrate.
10. The semiconductor device of Claim 9, wherein the substrate is a p-type substrate.
11. The semiconductor device of Claim 9, wherein the substrate is an n-type substrate.
12. The semiconductor device of Claim 9, wherein the substrate has epitaxial silicon on top of a nonepitaxial substrate.
13. The semiconductor device of Claim 9, wherein the first active region and second active region contain p-channel and n-channel devices.
14. The semiconductor device of Claim 9, wherein the first active region and second active region contain either p-channel or n-channel devices.
15. The semiconductor device of Claim 9, wherein the first active region and second active region are each separated by at least one isolation region.

16. The semiconductor device of Claim 9, wherein the graded dopant is fabricated with an ion implantation process.

## **SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

**[0001]** This application is a Continuation of U.S. Patent Application No. 15/590,282, filed May 9, 2017, published on August 24, 2017, as U.S. Publication No. 2017-0243876. Application No. 15/590,282 is a continuation of U.S. Patent Application No. 14/931,636, filed November 3, 2015, published on June 16, 2016 as U.S. Publication No. 2016-0172447, now U.S. Patent No. 9,647,070, issued on May 9, 2017. Application No. 14/931,636 is a continuation of U.S. Patent Application No. 14/515,584, filed October 16, 2014, published on February 5, 2015, as U.S. Publication No. 2015-0035004, now U.S. Patent No. 9,190,502, issued on November 17, 2015, (GRTD-32613). Application No. 14/515,584 is a Continuation of U.S. Patent Application No. 13/854,319 filed April 1, 2013, published on August 29, 2013, as U.S. Publication No. 2013-0221488 (GRTD-32626). Application No. 13/854,319 is a Continuation of 11/622,496, filed January 12, 2007, published on July 12, 2007, as Publication No. 2007-0158790, now U.S. Patent No. 8,421,195, issued on April 16, 2013 (GRTD-32611). Application No. 11/622,496, is a Division of U.S. Patent Application No. 10/934,915, filed September 3, 2004, published on March 9, 2006, as U.S. Publication No. 2006-0049464 (GRTD-32625). Patent Nos. 9,647,070, 9,190,502, and 8,421,195, and Patent Application Publication Nos. 2017-0243876, 2016-0172447, 2015-0035004, 2013-0221488, 2007-0158790, and 2006-0049464, are incorporated herein by reference in their entirety.

### **TECHNICAL FIELD**

**[0002]** This present invention relates to all semiconductor devices and systems. Particularly it applies to diffused diodes, avalanche diodes, Schottky devices, power MOS transistors, JFET's, RF bipolar transistors, IGBTs (Insulated Gate Bipolar Transistors), varactors, digital VLSI, mixed signal circuits and sensor devices including camera ICs employing CCD (Charge Coupled Device) as well as CMOS technologies.

## BACKGROUND

**[0003]** Bipolar Junction Transistors (BJT) are classified as minority carrier devices because minority carriers are the principle device conduction mechanism. However, majority carriers also play a small but finite role in modulating the conductivity in BJTs. Consequently, both carriers (electrons and holes) play a role in the switching performance of BJTs. The maximum frequency of operation in BJTs is limited by the base transit time as well as the quick recombination of the majority carriers when the device is switched off (prior to beginning the next cycle). The dominant carrier mechanism in BJTs is carrier diffusion. The carrier drift current component is fairly small, especially in uniformly doped base BJTs. Efforts have been made in graded base transistors to create an aiding drift field to enhance the diffusing minority carrier's speed from emitter to collector. However, most semiconductor devices, including various power MOSFETs (traditional, DMOS, lateral, vertical and a host of other configurations), IGBT's (Insulated Gated Base Transistors), still use a uniformly doped 'drift epitaxial' region in the base. FIG. 1 shows the relative doping concentration versus distance in a BJT. FIG. 2 shows the uniformly doped epi region in an IGBT. In contrast to BJTs, MOS devices are majority carrier devices for conduction. The conduction is channel dominated. The channel can be a surface in one plane in planar devices. The surface can also be on the sidewalls in a vertical device. Other device architectures to combine planar and vertical conductions are also possible. The maximum frequency of operation is dictated primarily by source-drain separation distance. Most MOS devices use a uniformly doped substrate (or a well region). When a MOSFET is optimally integrated with a BJT in a monolithic fashion, an IGBT results. The IGBT inherits the advantages of both MOSFET and BJT. It also brings new challenges because the required characteristics (electron transit and hole recombination as fast as possible in n-channel IGBT) necessitate different dopant gradients either in the same layer at different positions, or at the interfaces of similar or dissimilar layers.

**[0004]** Retrograde wells have been attempted, with little success, to help improve soft error immunity in SRAMs and visual quality in imaging circuits. FIG. 3A shows a typical CMOS VLSI device employing a twin well substrate, on which active devices are

subsequently fabricated. FIGS. 3B, 3C, and 3D illustrate device cross sections, as practiced today. Retrograde and halo wells have also been attempted to improve refresh time in DRAMs (dynamic random-access memories), as well as, reducing dark current (background noise) and enhance RGB (Red, Green, Blue) color resolution in digital camera ICs. Most of these techniques either divert the minority carriers away from the active regions of critical charge storage nodes at the surface, or, increase minority carrier density locally as the particular application requires.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0005]** For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

**[0006]** FIG. 1 illustrates the relative doping profiles of emitter, base and collector for the two most popular bipolar junction transistors: namely, uniform base (“A”) and graded base (“B”);

**[0007]** FIG. 2 illustrates the cross section of a commercial IGBT with a uniform epitaxial drift region (base);

**[0008]** FIGS. 3A, 3B, 3C, and 3D illustrate cross sections of commonly used prior art CMOS silicon substrates; FIG. 3A showing a typical prior art IC with two wells (one n<sup>+</sup> well in which p-channel transistors are subsequently fabricated and one p<sup>+</sup> well in which n-channel transistors are subsequently fabricated); FIG 3B showing a prior art EEPROM (Electrically Erasable Programmable Read-Only Memory) memory cell having a tunnel insulator; FIG. 3C showing a prior art DRAM memory cell; and FIG. 3D showing a prior art NAND flash memory cell;

**[0009]** FIG. 4 illustrates the cross section of an IGBT, using one embodiment of the invention described here, where the dopant is optimally graded in the epitaxial drift region; and

**[0010]** FIGS. 5A, 5B, and 5C illustrate the cross sections of a CMOS silicon substrate with two wells and an underlying layer using embodiments of the invention to improve performance in each application—VLSI logic, DRAM/image IC, nonvolatile memory IC.

**DETAILED DESCRIPTION**

**[0011]** The relative doping concentrations of emitter and collector regions varies from  $10^{18}$  to  $10^{20}/\text{cm}^3$ , whereas the base region is  $10^{14}$  to  $10^{16}/\text{cm}^3$  depending on the desired characteristics of the BJT. In graded base p-n-p transistors, the donor dopant concentration may be 10 to 100× at the emitter-base junction, relative to the base-collector junction (1×). The gradient can be linear, quasi linear, exponential or complimentary error function. The relative slope of the donor concentration throughout the base creates a suitable aiding drift electric field, to help the holes (p-n-p transistor) transverse from emitter to collector. Since the aiding drift electric field helps hole conduction, the current gain at a given frequency is enhanced, relative to a uniformly-doped (base) BJT. The improvement in cut-off frequency (or, frequency at unity gain,  $f_T$ ) can be as large as 2×-5×. Similar performance improvements are also applicable to n-p-n transistors.

**[0012]** As illustrated in FIG. 4, in one embodiment according to the invention, a donor gradient is established from the emitter-drift epitaxial base region junction of the punch-through IGBT, to the drift epitaxial base region— $n^+$  buffer layer boundary (electrons in this case are accelerated in their transit from emitter to collector). The “average” base resistance is optimized so that conductivity modulation and lifetime (for minority carriers) in the base region are not compromised. By sweeping the carriers towards the  $n^+$  buffer region a number of advantages are obtained. First, the frequency of operation (combination of  $t_{on}$  and  $t_{off}$  as is known in the IGBT commercial nomenclature) can be enhanced. Second, and maybe more importantly, during  $t_{off}$ , holes can be recombined much quicker at the  $n^+$  buffer layer, compared to the uniformly doped  $n^-$  epitaxial drift region by establishing a different dopant gradient near the  $n^+$  buffer layer. It should be noted that the drift region can also be a non-epitaxial silicon substrate. Although epitaxy enhances lifetime, it is not mandatory. Different layers of dopant regions can be transferred through wafer to wafer bonding (or other similar transfer mechanisms) for eventual device fabrication. The “reverse recovery time” for an IGBT is significantly improved due to the optimized graded dopant in the so called “drift region” as well as at the interfaces of the drift region. Graded dopants can also be implemented in the  $n^+$  buffer

layer as well as other regions adjacent to the respective layers. Two important performance enhancements are the result of dopant gradients. For example, in an n-channel IGBT, electrons can be swept from source to drain rapidly, while at the same time holes can be recombined closer to the  $n^+$  buffer layer. This can improve  $t_{on}$  and  $t_{off}$  in the same device.

**[0013]** As illustrated in FIGS. 5A, 5B, and 5C, donor gradient is also of benefit to very large scale integrated circuits (VLSI)—VLSI logic, DRAM, nonvolatile memory like NAND flash. Spurious minority carriers can be generated by clock switching in digital VLSI logic and memory ICs. These unwanted carriers can discharge dynamically-held “actively held high” nodes. In most cases, statically-held nodes (with  $V_{cc}$ ) cannot be affected. Degradation of refresh time in DRAMs is one of the results, because the capacitor holds charge dynamically. Similarly, degradation of CMOS digital images in digital imaging ICs is another result of the havoc caused by minority carriers. Pixel and color resolution can be significantly enhanced in imaging ICs with the embodiments described herein. Creating “subterranean” recombination centers underneath the wells (gold doping, platinum doping) as is done in some high-voltage diodes is not practical for VLSI circuits. Hence, a novel technique is described herein which creates a drift field to sweep these unwanted minority carriers from the active circuitry at the surface into the substrate in a monolithic die as quickly as possible. In a preferred embodiment, the subterranean  $n^-$  layer has a graded donor concentration to sweep the minority carriers deep into the substrate. One or more of such layers can also be implemented through wafer to wafer bonding or similar “transfer” mechanisms. This  $n^-$  layer can be a deeply-implanted layer. It can also be an epitaxial layer. As desired, the  $n^-$  well and  $p^-$  wells can also be graded or retrograded in dopants to sweep those carriers away from the surface as well. The graded dopant can also be implemented in surface channel MOS devices to accelerate majority carriers towards the drain. To decrease programming time in nonvolatile memory devices, carriers should be accelerated towards the surface when programming of memory cells is executed. The graded dopant can also be used to fabricate superior Junction Field-Effect transistors where the “channel pinch-off” is controlled by a graded channel instead of a uniformly doped channel (as practiced in the prior art).

**[0014]** One of ordinary skill and familiarity in the art will recognize that the concepts taught herein can be customized and tailored to a particular application in many advantageous ways. For instance, minority carriers can be channeled to the surface to aid programming in nonvolatile memory devices (NOR, NAND, multivalued-cell). Moreover, single-well, and triple-well CMOS fabrication techniques can also be optimized to incorporate these embodiments individually and collectively. Any modifications of such embodiments (described here) fall within the spirit and scope of the invention. Hence, they fall within the scope of the claims described below.

**[0015]** Although the invention has been described with reference to specific embodiments, these descriptions are not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the invention will become apparent to persons skilled in the art upon reference to the description of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

**[0016]** It is therefore, contemplated that the claims will cover any such modifications or embodiments that fall within the true scope of the invention.

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**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN  
APPLICATION DATA SHEET (37 CFR 1.76)****Title of  
Invention****SEMICONDUCTOR DEVICES WITH GRADED DOPANT REGIONS**

As the below named inventor, I hereby declare that:

This declaration  
is directed to:

The attached application, or



United States application or PCT International application number \_\_\_\_\_

filed on \_\_\_\_\_

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001  
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**LEGAL NAME OF INVENTOR**Inventor: G.R. Mohan Rao

Date (Optional):

Sept 30, 2015Signature: G.R. Mohan Rao

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