

CIRRUS LOGIC INC.;
ONMIVISION TECHNOLOGIES, INC.;
AND TEXAS INSTRUMENTS, INC.*,
Petitioner

v.

GREENTHREAD, LLC,
Patent Owner

IPR2024-00017* (U.S. Patent No. 10,734,195)

IPR2024-00018* (U.S. Patent No. 9,190,502)

IPR2024-00021* (U.S. Patent No. 11,121,222)

Petitioner's Demonstratives

January 31, 2025 Oral Hearing

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BEIJING BOSTON BRUSSELS DUBAI FRANKFURT JOHANNESBURG LONDON
LOS ANGELES NEW YORK PALO ALTO SAN FRANCISCO SEOUL SHANGHAI WASHINGTON

Overview of the Pending IPR Petitions

	Patent (IPR Proceeding)	Key Grounds
Jan 28th Hearing ("Active Region" Claims)	842 patent (IPR2024-00016) 481 patent (IPR2024-00001) 014 patent (IPR2024-00019) 222 patent (cl. 1) (IPR2024-00020)	Kawagoe (obviousness) Wieczorek + Wolf
Jan 31st Hearing ("Drift Layer" Claims)	195 patent (IPR2024-00017) 502 patent (IPR2024-00018) 222 patent (cl. 44) (IPR2024-00021)	Payne (obviousness) Payne + Wolf Onoda (anticipation) Onoda + Wolf

- Overview of the IPR Petitions
- Overview of the '195, '502, and '222 Patents
- The Instituted Grounds
- The Prior Art Discloses All Claim Limitations
- The Prior Art Discloses “A Graded Concentration of Dopants . . . To Aid the Movement of Minority Carriers”
- Petitioner’s Single-Reference Obviousness Ground Based on Payne is Proper

- Greenthread’s Settlement Agreements Do Not Show Nonobviousness
- The Petitions are Timely
- Greenthread’s Attorney Argument on Minority and Majority Carriers is Flawed
- Dr. Banerjee’s Opinions are Reliable

Overview of the '195, '502, and '222 Patents

'195 Patent (Claim 1)

(12) **United States Patent
Rao**

(10) **Patent No.:** US 8,421,195 B2
(45) **Date of Patent:** Apr. 16, 2013

(54) **SEMICONDUCTOR DEVICES WITH
GRADED DOPANT REGIONS**

(76) Inventor: **G. R. Mohan Rao**, McKinney, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/622,496**

(22) Filed: **Jan. 12, 2007**

(65) **Prior Publication Data**
US 2007/0158790 A1 Jul. 12, 2007

Related U.S. Application Data
(62) Division of application No. 10/934,915, filed on Sep. 3, 2004, now abandoned.

1. A CMOS Semiconductor device comprising:

a surface layer;

a substrate;

an active region including a source and a drain, disposed on one surface of said surface layer;

a single drift layer disposed between the other surface of said surface layer and said substrate,

said drift layer having a **graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having a **first static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate**; and

at least one well region disposed in said single drift layer, said well region having a **graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate**.

'195 Patent, Ex. 1001 (-00017), Claim 1

'502 Patent (Claim 7)

(12) **United States Patent
Rao**

(10) **Patent No.:** US 9,190,502 B2
(45) **Date of Patent:** *Nov. 17, 2015

(54) **SEMICONDUCTOR DEVICES WITH
GRADED DOPANT REGIONS**

(71) Applicant: **G. R. Mohan Rao**, Allen, TX (US)

(72) Inventor: **G. R. Mohan Rao**, Allen, TX (US)

(73) Assignee: **Greenthread, LLC**, Dallas, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/515,584**

(22) Filed: **Oct. 16, 2014**

(65) **Prior Publication Data**
US 2015/0035004 A1 Feb. 5, 2015

Related U.S. Application Data
(60) Continuation of application No. 13/854,319, filed on Apr. 1, 2013, now abandoned, which is a continuation of application No. 11/622,496, filed on Jan. 12, 2007, now Pat. No. 8,421,195, which is a division of application No. 10/934,915, filed on Sep. 3, 2004, now abandoned.

7. A semiconductor device comprising:

a surface layer;

a substrate;

an active region including a source and a drain, disposed on one surface of said surface layer;

a single drift layer disposed between the other surface of said surface layer and said substrate,

said drift layer having a **graded concentration of dopants generating a first static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate**; and

at least one well region disposed in said single drift layer, said well region having a **graded concentration of dopants generating a second static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate**.

'502 Patent, Ex. 1001 (-00018), Claim 7

'222 Patent (Claim 44)

(12) **United States Patent**
Rao

(10) **Patent No.:** US 11,121,222 B2
(45) **Date of Patent:** Sep. 14, 2021

(54) **SEMICONDUCTOR DEVICES WITH
GRADED DOPANT REGIONS**

(71) Applicant: **GREENTHREAD, LLC**, Dallas, TX
(US)

(72) Inventor: **G.R. Mohan Rao**, Allen, TX (US)

(73) Assignee: **GREENTHREAD, LLC**, Dallas, TX
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/947,294**

(22) Filed: **Jul. 27, 2020**

(65) **Prior Publication Data**
US 2021/0005716 A1 Jan. 7, 2021

Related U.S. Application Data
(60) Continuation of application No. 16/717,950, filed on
Dec. 17, 2019, now Pat. No. 10,734,481, which is a
(Continued)

44. A CMOS Semiconductor device comprising:

a surface layer;

a substrate;

an active region including a source and a drain, disposed on one surface of the surface layer;

a single drift layer disposed between the other surface of the surface layer and the substrate,

the drift layer having **a graded concentration of dopants** extending between the surface layer and the substrate, the drift layer further having **a first static unidirectional electric drift field to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions;** and

at least one well region disposed in the single drift layer, the well region having **a graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions.**

'222 Patent, Ex. 1001 (-00020), Claim 44

The Instituted IPR Grounds

IPR2024-00017 (U.S. Patent No. 8,421,195)			
Ground	Claims	35 U.S.C §	Prior Art
I	1-2, 4-6	103(a)	Payne
II	1-6	102	Onoda
III	1-6	103(a)	Onoda/Wolf
IV	2, 3	103(a)	Payne/Wolf
V	3	103(a)	Payne/Parrillo

IPR2024-00001 (U.S. Patent No. 9,190,502)			
Ground	Claims	35 U.S.C §	Prior Art
I	7	103(a)	Payne
II	7, 8, 11	102	Onoda
III	7, 8, 11	103(a)	Onoda
IV	8	103(a)	Payne, Parrillo
V	9-11	103(a)	Payne, Wolf
VI	9, 10	103(a)	Onoda, Wolf
VII	12	103(a)	Payne, Silverbrook
VIII	12	103(a)	Onoda, Silverbrook

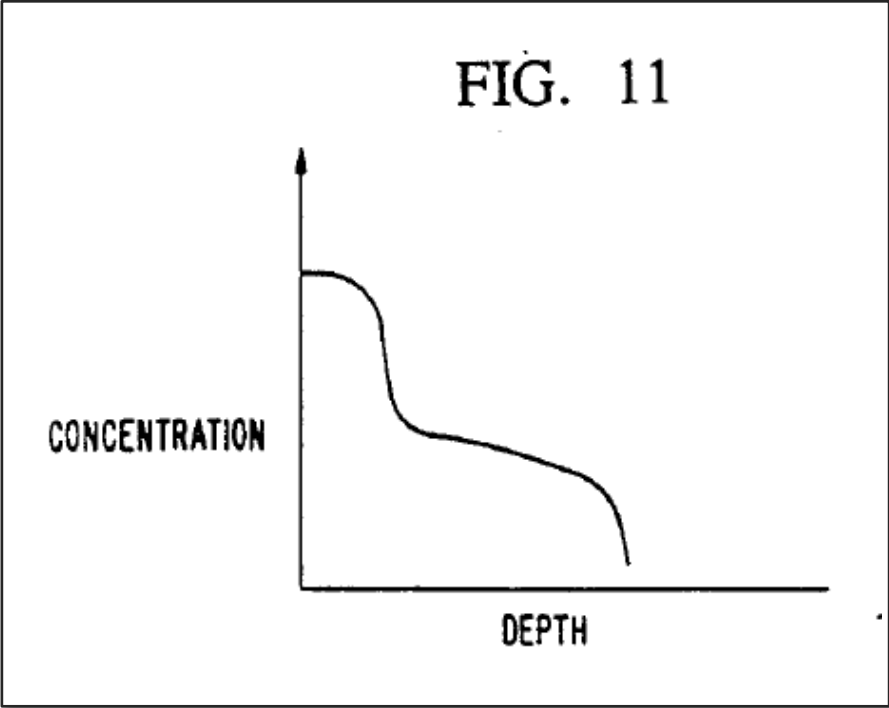
IPR2024-00021 (U.S. Patent No. 11,121,222)			
Ground	Claims	35 U.S.C §	Prior Art
I	44	103(a)	Payne
II	44	102	Onoda
III	44	103(a)	Onoda/Wolf

The Prior Art Discloses All Claim Limitations

Payne (Ex. 1005)

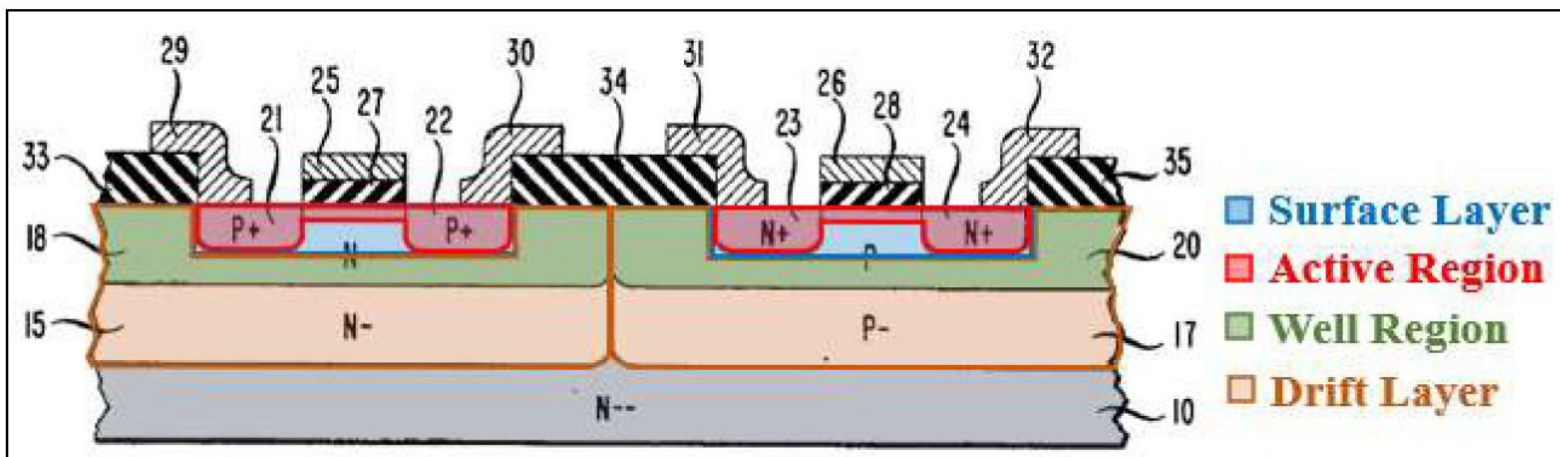
United States Patent [19] [11] **Patent Number:** **4,684,971**
Payne [45] **Date of Patent:** **Aug. 4, 1987**

[54] **ION IMPLANTED CMOS DEVICES**
[75] **Inventor:** **Richard S. Payne**, Andover, Mass.
[73] **Assignee:** **American Telephone and Telegraph Company, AT&T Bell Laboratories, Murray Hill, N.J.**
[21] **Appl. No.:** **243,621**
[22] **Filed:** **Mar. 13, 1981**
[51] **Int. Cl.⁴** **H01L 29/78; H01L 27/02**
[52] **U.S. Cl.** **357/42; 357/23.1; 357/88; 357/91**
[58] **Field of Search** **357/42, 41, 91, 40, 357/88, 89, 23.1**
[56] **References Cited**
U.S. PATENT DOCUMENTS
3,821,781 6/1974 Chang et al. 357/44
4,067,100 1/1978 Kojima et al. 29/578
4,212,100 7/1980 Paivinen et al. 29/571

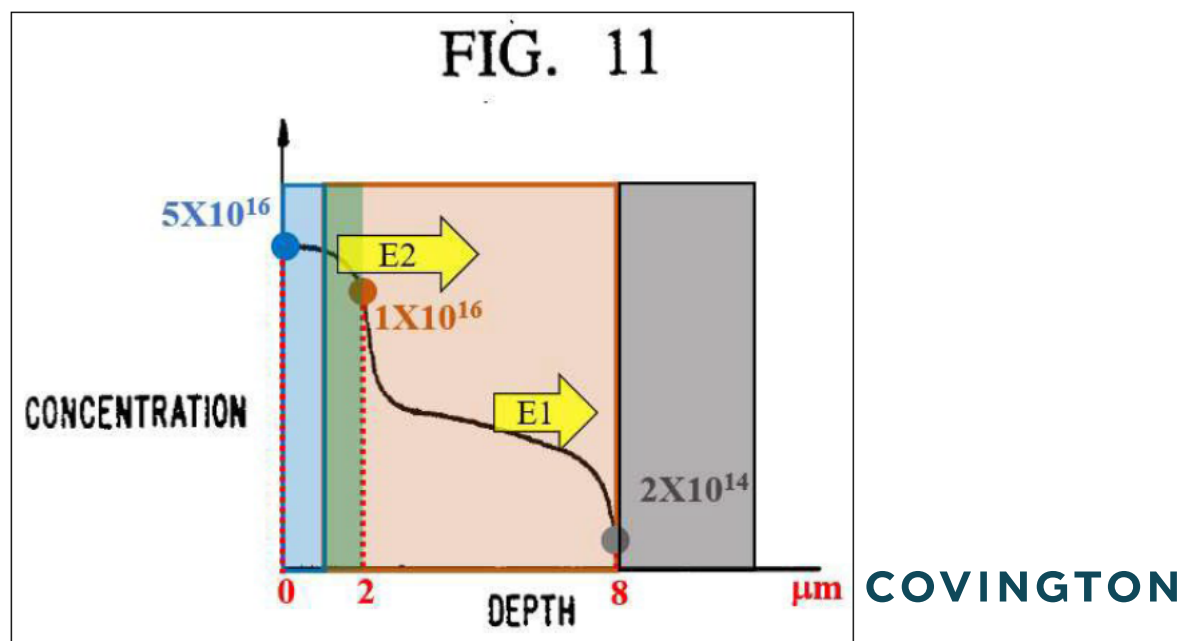


Payne (Ex. 1007) (-00017) (-00018) (-00021), Fig. 11

Payne discloses the elements of '195 Patent Claim 1



Payne (Ex. 1005), Figs. 10-11



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1. A **CMOS Semiconductor device** comprising:

a **surface layer**;

a **substrate**;

an **active region** including a source and a drain, disposed on one surface of said surface layer;

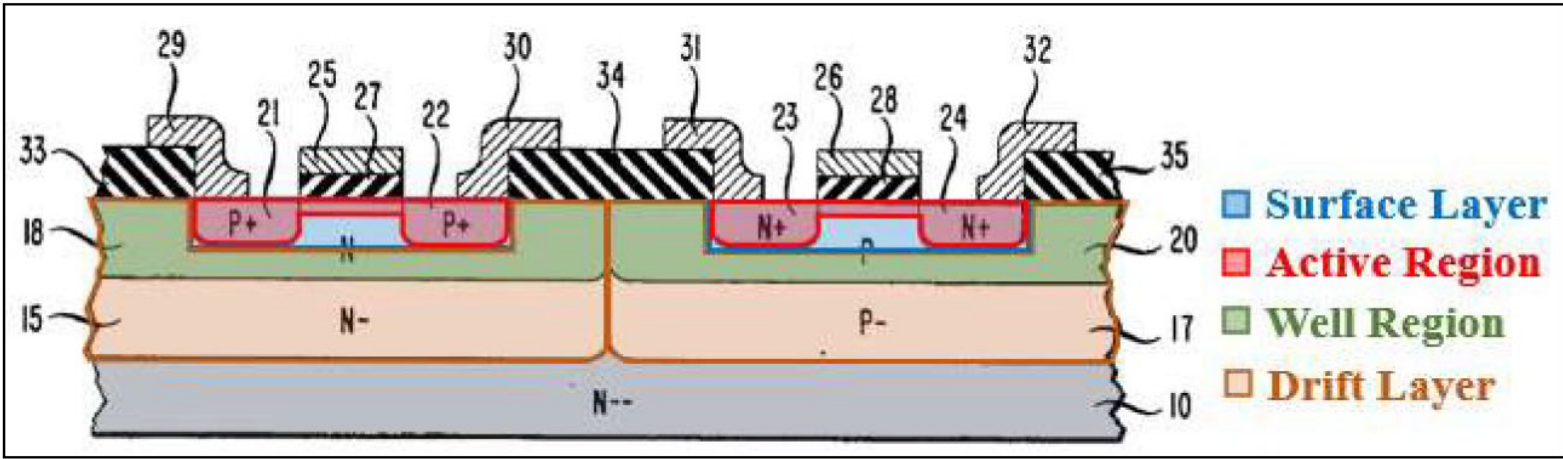
a **single drift layer** disposed between the other surface of said surface layer and said substrate,

said drift layer having a **graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having a **first static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate; and

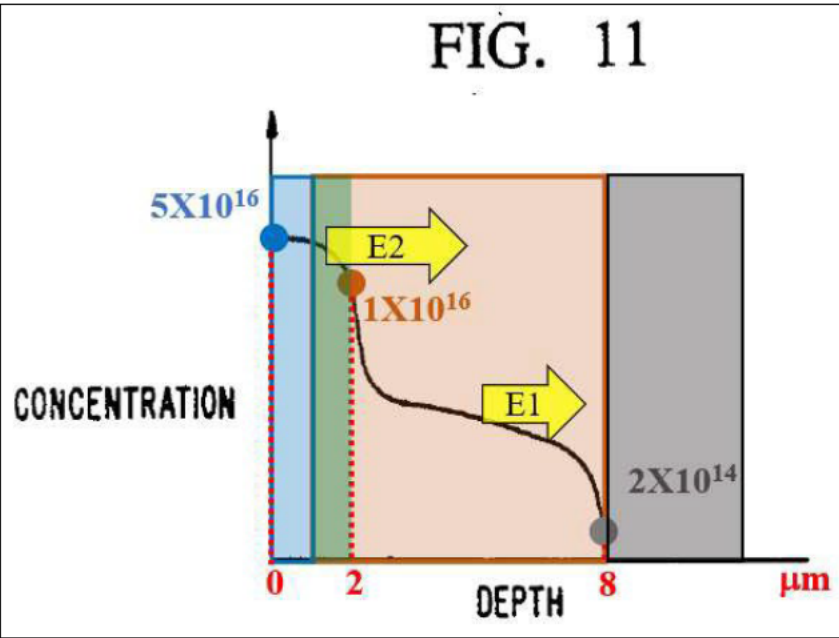
at least one **well region** disposed in said single drift layer, said well region having a **graded concentration of dopants** and a **second static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate.

'195 Patent (Ex. 1001) (-00017), Claim 1

Payne discloses the elements of '502 Patent Claim 7



Payne (Ex. 1005), Figs. 10-11



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7. A **semiconductor device** comprising:

a **surface layer**;

a **substrate**;

an **active region** including a source and a drain, disposed on one surface of said surface layer;

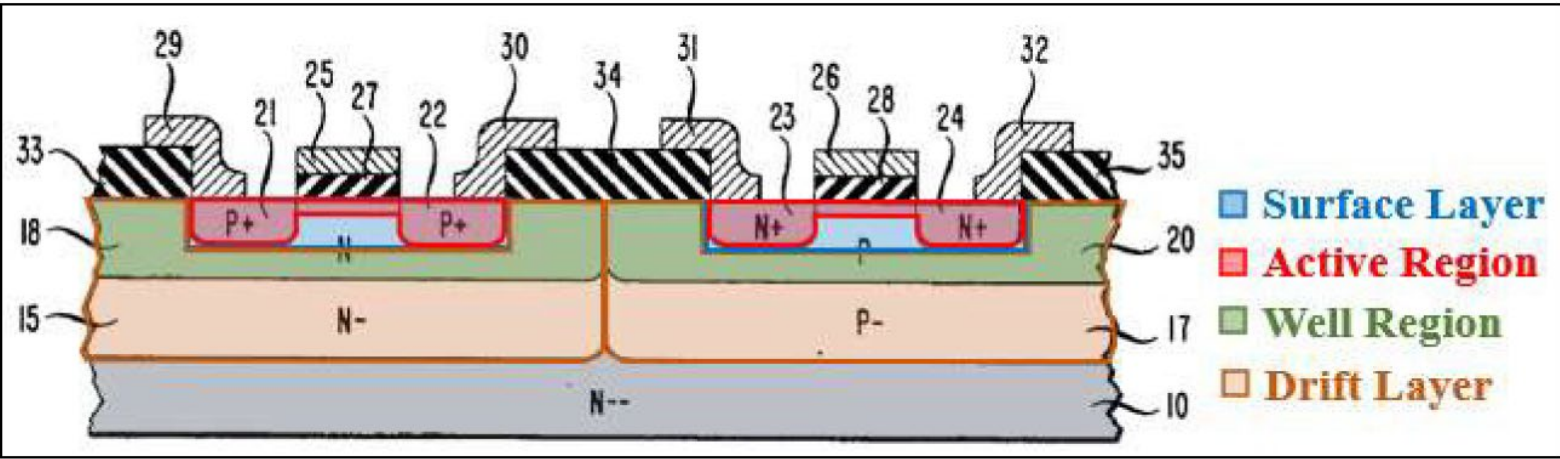
a **single drift layer** disposed between the other surface of said surface layer and said substrate,

said drift layer having a **graded concentration of dopants** generating a **first static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate; and

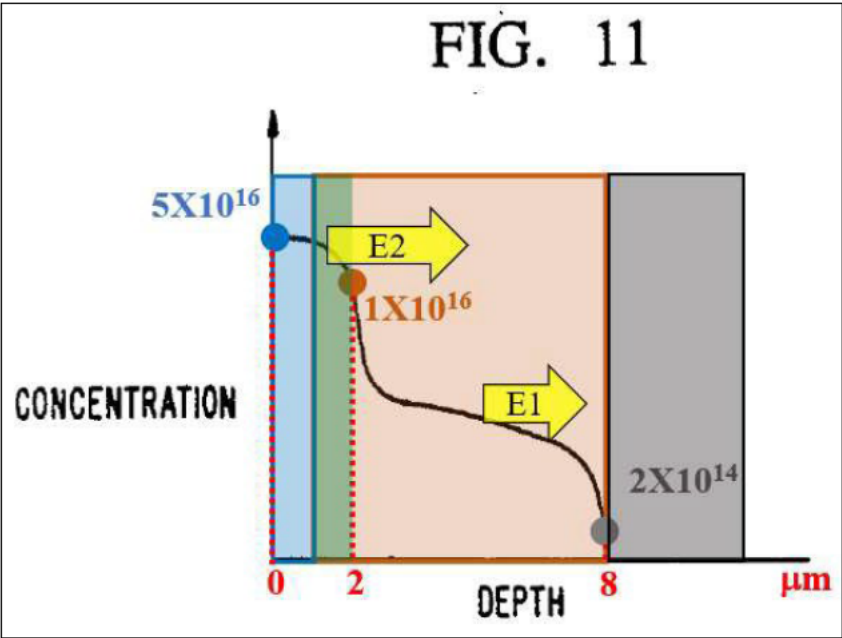
at least one **well region** disposed in said single drift layer, said well region having a **graded concentration of dopants** generating a **second static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate.

'502 Patent (Ex. 1001) (-00018), Claim 7

Payne discloses the elements of '222 Patent Claim 44



Payne (Ex. 1005), Figs. 10-11



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44. A **CMOS Semiconductor** device comprising:

a **surface layer**;

a **substrate**;

an **active region** including a source and a drain, disposed on one surface of the surface layer;

a **single drift layer** disposed between the other surface of the surface layer and the substrate,

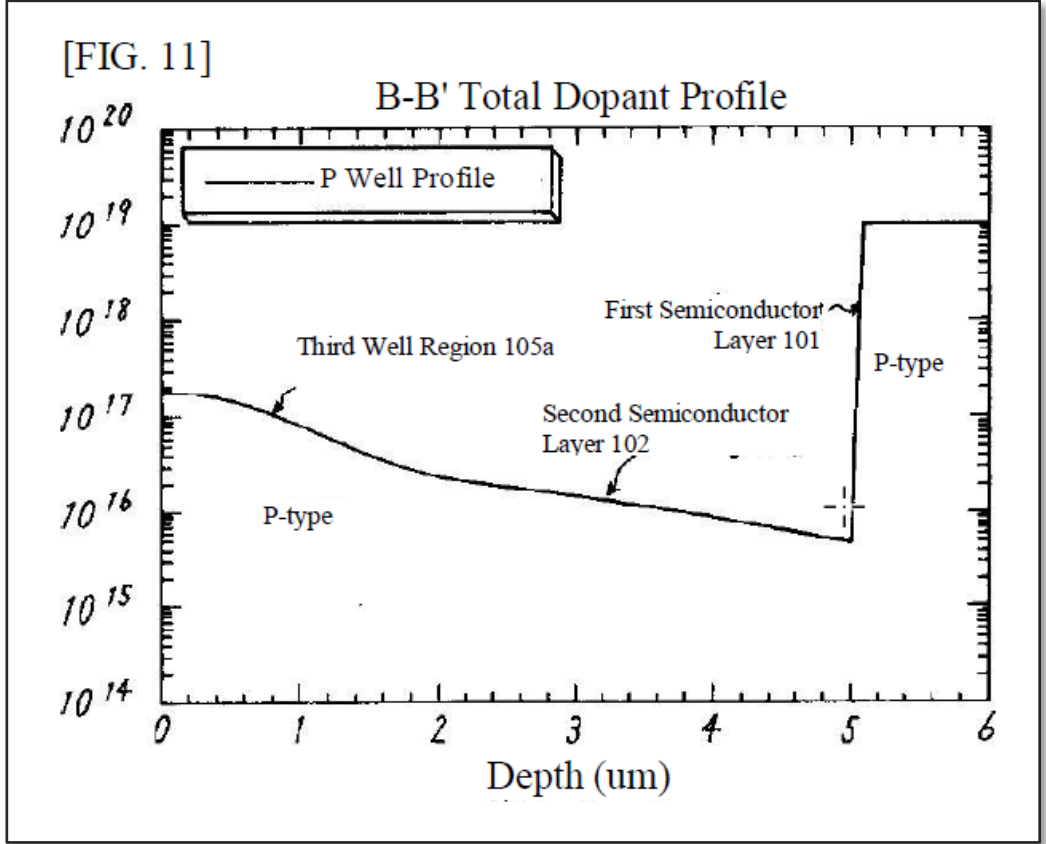
the drift layer having a **graded concentration of dopants** extending between the surface layer and the substrate, the drift layer further having a **first static unidirectional electric drift field** to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions; and

at least one well region disposed in the single drift layer, the well region having a **graded concentration of dopants** and a **second static unidirectional electric drift field** to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions.

'222 Patent (Ex. 1001) (-00021), Claim 44

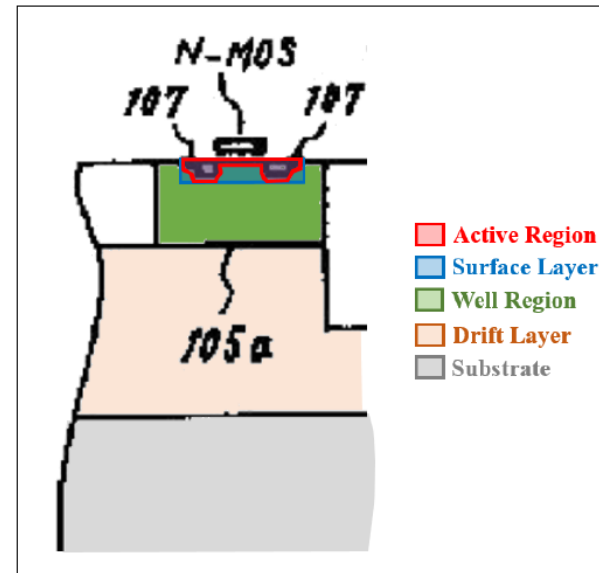
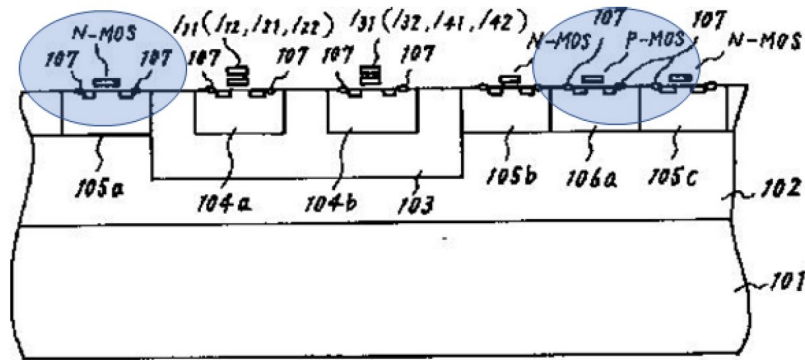
Onoda (Ex. 1042)

(19) Japan Patent Office (JP)		(12) Japanese Unexamined Patent Application Publication (A)		(11) Japanese Unexamined Patent Application Publication Number	
				H8-279598	
				(43) Publication date October 22, 1996	
(51) Int. Cl. ⁶	ID codes	JPO file numbers	FI	Technical indications	
H01L 27/10	491		H01L 27/10 491		
G11C 16/02			G11C 17/00 307 D		
16/04			H01L 27/10 43 ₄		
H01L 27/115			29/78 371		
21/8247					
29/788					
29/792					
Request for examination: Not yet requested: Number of claims: 12 (Total of 39 pages) Continued on last page.					
(21) Application number	H7-82721	(71) Applicant	000006013 MITSUBISHI ELECTRIC CORP. 2-2-3 MARUNOUCHI, CHIYODA-KU, TOKYO		
(22) Date of application	April 7, 1995	(72) Inventor	ONODA, HIROSHI Mitsubishi Electric Co., ULSI Development Research Laboratories 4-1 Mizuhara, Itami City, Hyogo Prefecture		
		(74) Agent	Patent attorney TAKADA, Mamoru (and 4 others)		
(54) [Title the Invention] Semiconductor Integrated Circuit Device, Nonvolatile Semiconductor Storage Device, and Manufacturing Method					



Onoda (Ex. 1042), Fig. 11
Certified translation of JPH8-279598 (Ex. 1043)

Onoda discloses the elements of '195 Patent Claim 1



Onoda (Ex. 1042), Figs. 3, 11

1. A **CMOS Semiconductor device** comprising:

a surface layer;

a **substrate**;

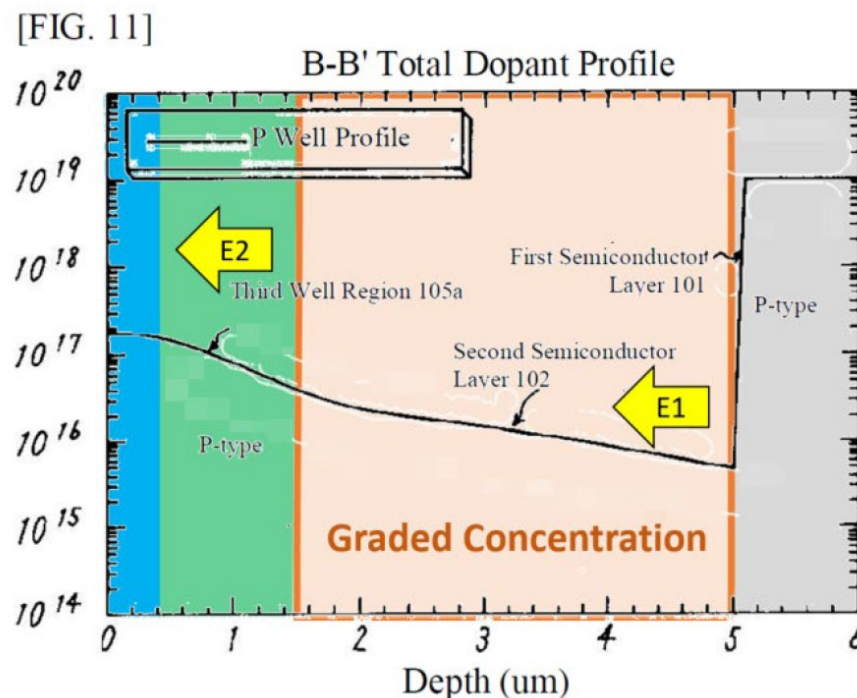
an **active region** including a source and a drain, disposed on one surface of said surface layer;

a **single drift layer** disposed between the other surface of said surface layer and said substrate,

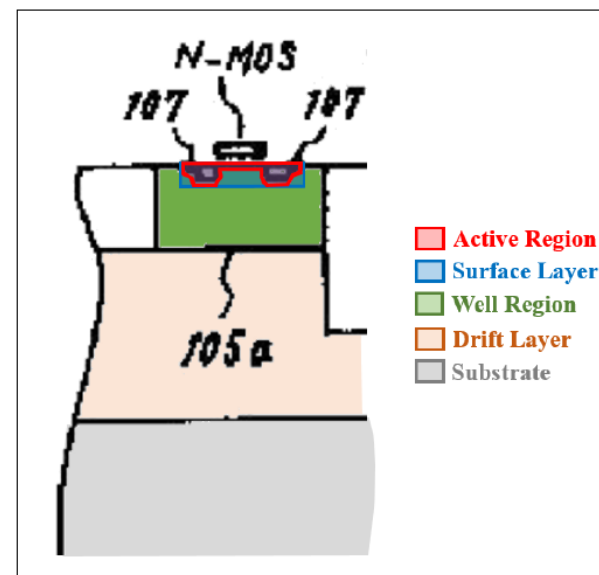
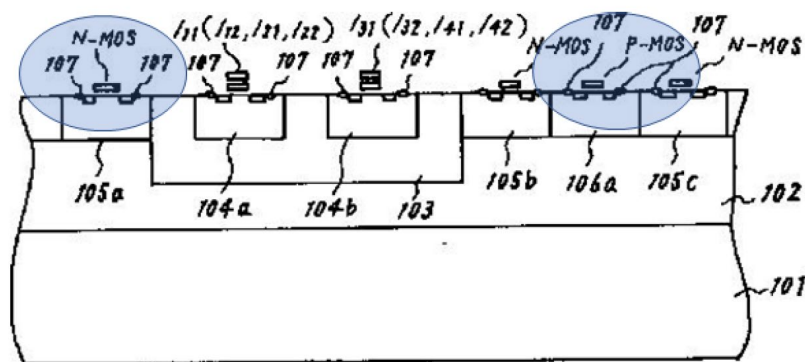
said drift layer having **a graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having **a first static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate**; and

at least one **well region** disposed in said single drift layer, said well region having **a graded concentration of dopants and a second static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate.

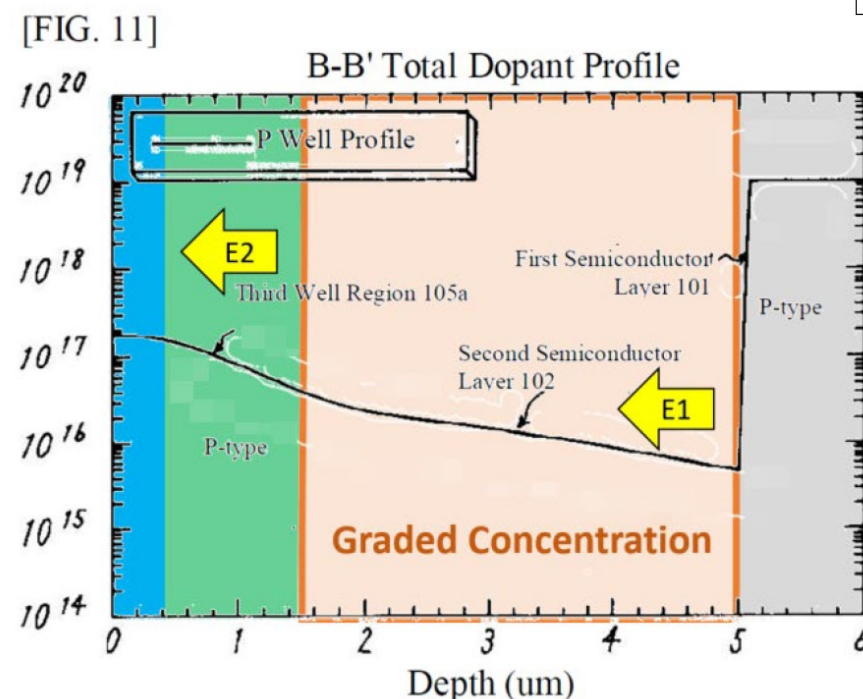
'195 Patent (Ex. 1001) (-00017), Claim 1



Onoda discloses the elements of '502 Patent Claim 7



Onoda (Ex. 1042), Figs. 3, 11



7. A semiconductor device comprising:

a surface layer;

a substrate;

an active region including a source and a drain, disposed on one surface of said surface layer;

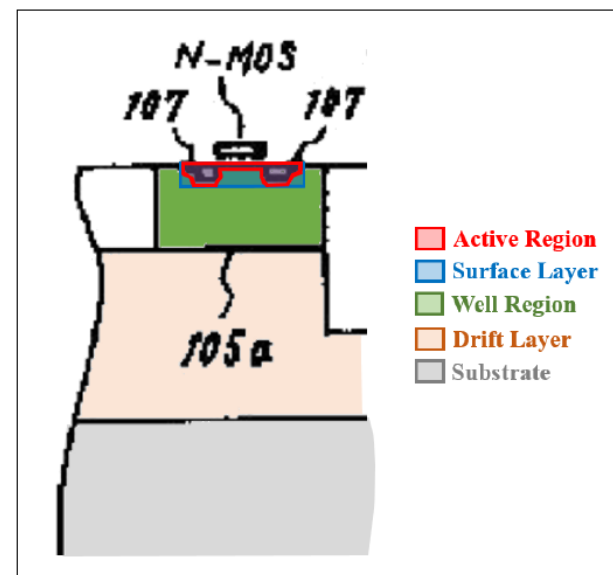
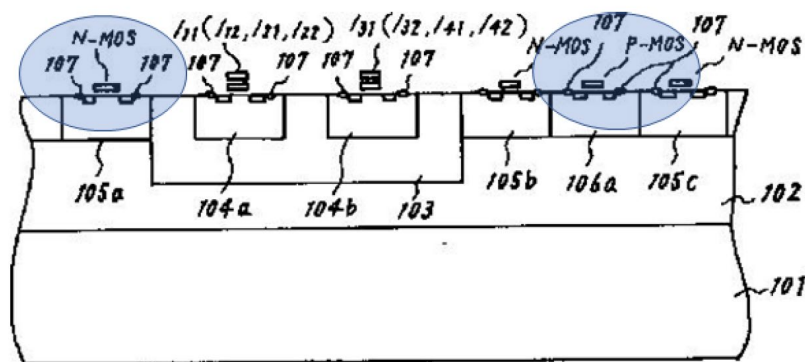
a single drift layer disposed between the other surface of said surface layer and said substrate,

said drift layer having a graded concentration of dopants generating a first static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate; and

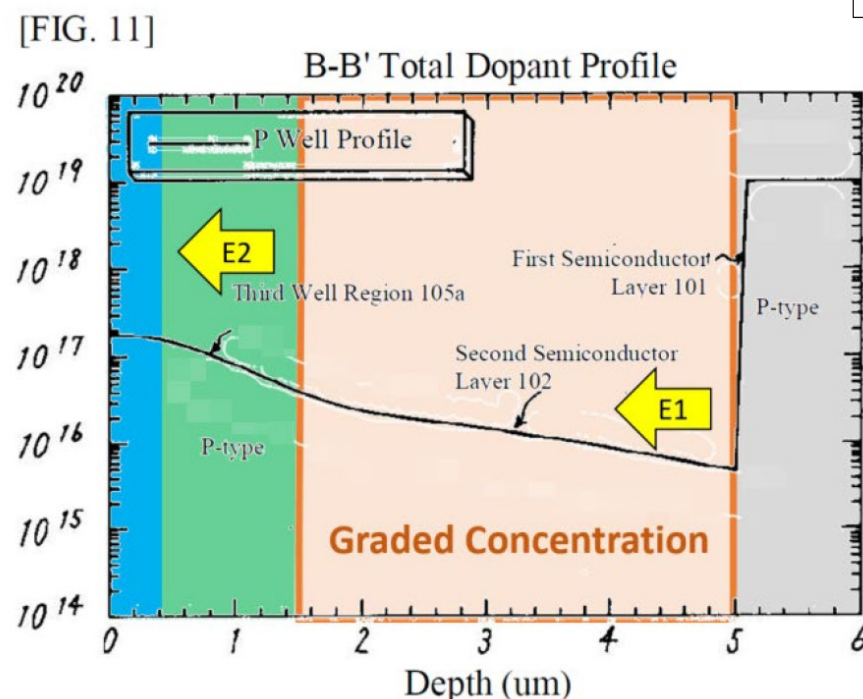
at least one well region disposed in said single drift layer, said well region having a graded concentration of dopants generating a second static unidirectional electric drift field to aid the movement of minority carriers from said surface layer to said substrate.

'502 Patent (Ex. 1001) (-00018), Claim 7

Onoda discloses the elements of '222 Patent Claim 44



Onoda (Ex. 1042), Figs. 3, 11



44. A **CMOS Semiconductor** device comprising:

a **surface layer**;

a **substrate**;

an **active region** including a source and a drain, disposed on one surface of the surface layer;

a **single drift layer** disposed between the other surface of the surface layer and the substrate,

the drift layer having a **graded concentration of dopants** extending between the surface layer and the substrate, the drift layer further having a **first static unidirectional electric drift field** to aid the movement of carriers from the surface layer to an area of the substrate where there are no active regions; and

at least one well region disposed in the single drift layer, the well region having a **graded concentration of dopants** and a **second static unidirectional electric drift field** to aid the movement of carriers from the surface layer to the area of the substrate where there are no active regions.

'222 Patent (Ex. 1001) (-00021), Claim 44

Wolf: CMOS devices technology, including implantation

Chapter 16

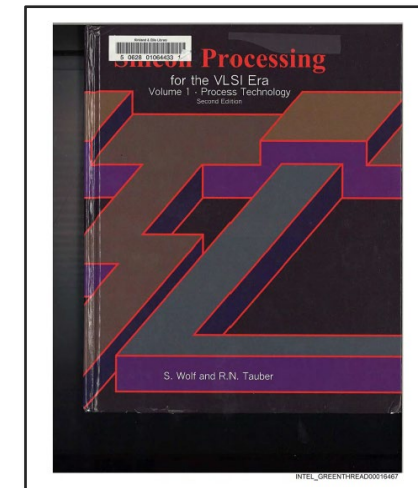
CMOS PROCESS INTEGRATION

In the first fourteen chapters of this book the focus was on the individual process modules employed in IC fabrication. This chapter will consider how these modules can be combined to define a set of manufacturing steps that becomes a recipe for fabricating monolithic silicon integrated circuits. The task of specifying such a sequence of individual process steps is called *process integration*. **Complimentary MOS (or CMOS) technology** is used to demonstrate some examples of such *process sequences* (or *process flows*). CMOS was chosen for our examples because **it is the dominant silicon IC technology of the 1990's. Figure 16-1 shows that about 80 percent of all semiconductor devices and circuits manufactured in 1995 were CMOS ICs. By the end of the 1990s this percentage grew even larger.** Since this text is intended to provide an introduction to *mainstream* silicon IC process technology, it is appropriate to use CMOS as the vehicle for illustrating process flows. Since CMOS technology was preceded by other MOS technologies, their evolution will also be briefly reviewed. How and why CMOS became the dominant semiconductor technology will be presented. Note that CMOS is so-named because it uses both *p*- and *n*-type MOS transistors in its circuits. Figure 16-2 depicts a CMOS inverter.

10.6.5 High-Energy Implantation

Even as junctions of the source/drain and channel region call for ion energies of a few keV or less, the doping of CMOS well junctions requires ion energies ranging from a few hundred keV to several MeV⁹³ (see Fig. 10-41). The particular ion energy used depends on the application and device type. For example, high-speed logic (microprocessors) and DRAM devices use relatively shallow well structures while SRAM and FLASH memories use deep wells, sometimes in combinations with even deeper “triple wells” (which allow for the *n*- and *p*-well junctions to be biased separately from the substrate).

Wolf
(Ex.1008A),
p.807



Wolf (*Silicon Processing for the VLSI Era* (2000)) (Ex. 1008A)

Wolf
(Ex.1008A),
p.423

Parrillo: each tub of a “twin tub” has one or more transistors

United States Patent [19]

Parrillo et al.

[11] **4,435,896**

[45] **Mar. 13, 1984**

[54] **METHOD FOR FABRICATING
COMPLEMENTARY FIELD EFFECT
TRANSISTOR DEVICES**

[75] **Inventors:** **Louis C. Parrillo**, Warren, N.J.;
Richard S. Payne, Andover, Mass.

[73] **Assignee:** **Bell Telephone Laboratories,
Incorporated**, Murray Hill, N.J.

[21] **Appl. No.:** **508,923**

[22] **Filed:** **Jun. 29, 1983**

Related U.S. Application Data

[63] **Continuation-in-part of Ser. No. 328,150, Dec. 7, 1981,
abandoned.**

Dependent Claims:

'195 Patent, Claim 3

'502 Patent, Claim 8

DETAILED DESCRIPTION

In FIGS. 1 to 8 there are shown cross-sectional views of a portion of a twin-tub complementary IGFET device fabricated according to the preferred embodiment of the present invention. The device may, for example, be a VLSI circuit in which case there would be a large number of tubs of each type, each of which might contain one or more transistors. Like reference numerals are used throughout the Figures to denote like parts or regions of the device.

Parrillo (Ex. 1025), 3:22-25, 34-38, Fig. 5

Silverbrook (Ex. 1042)

(12) **United States Patent**
Silverbrook

(10) Patent No.: **US 6,614,560 B1**
(45) Date of Patent: **Sep. 2, 2003**

(54) **INTEGRATED CAMERA CIRCUIT
INCLUDING IMAGE SENSOR, IMAGE
PROCESSING, AND PRINTER DRIVE
CIRCUITS**

(75) Inventor: **Kia Silverbrook, Sydney (AU)**

(73) Assignee: **Silverbrook Research Pty Ltd,
Balmain (AU)**

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/113,104**

(22) Filed: **Jul. 10, 1998**

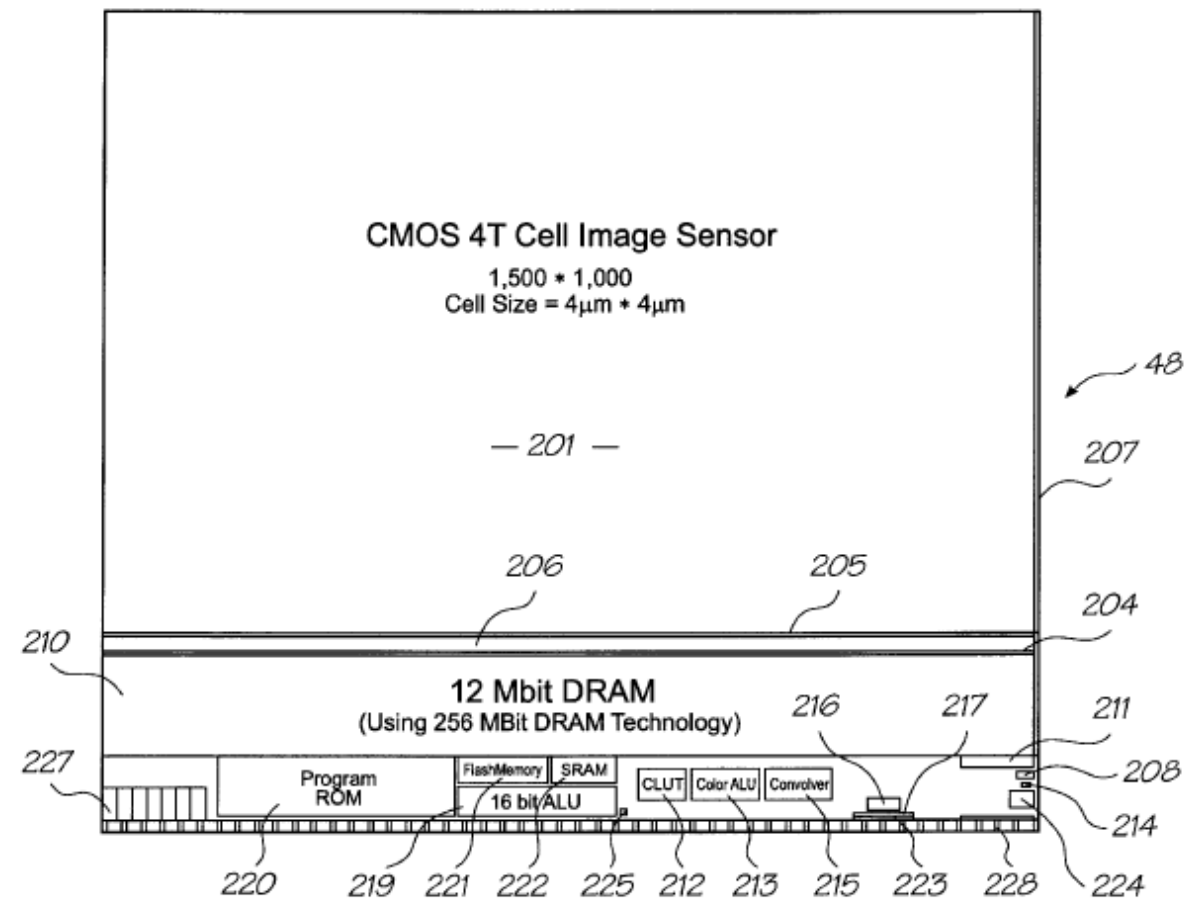
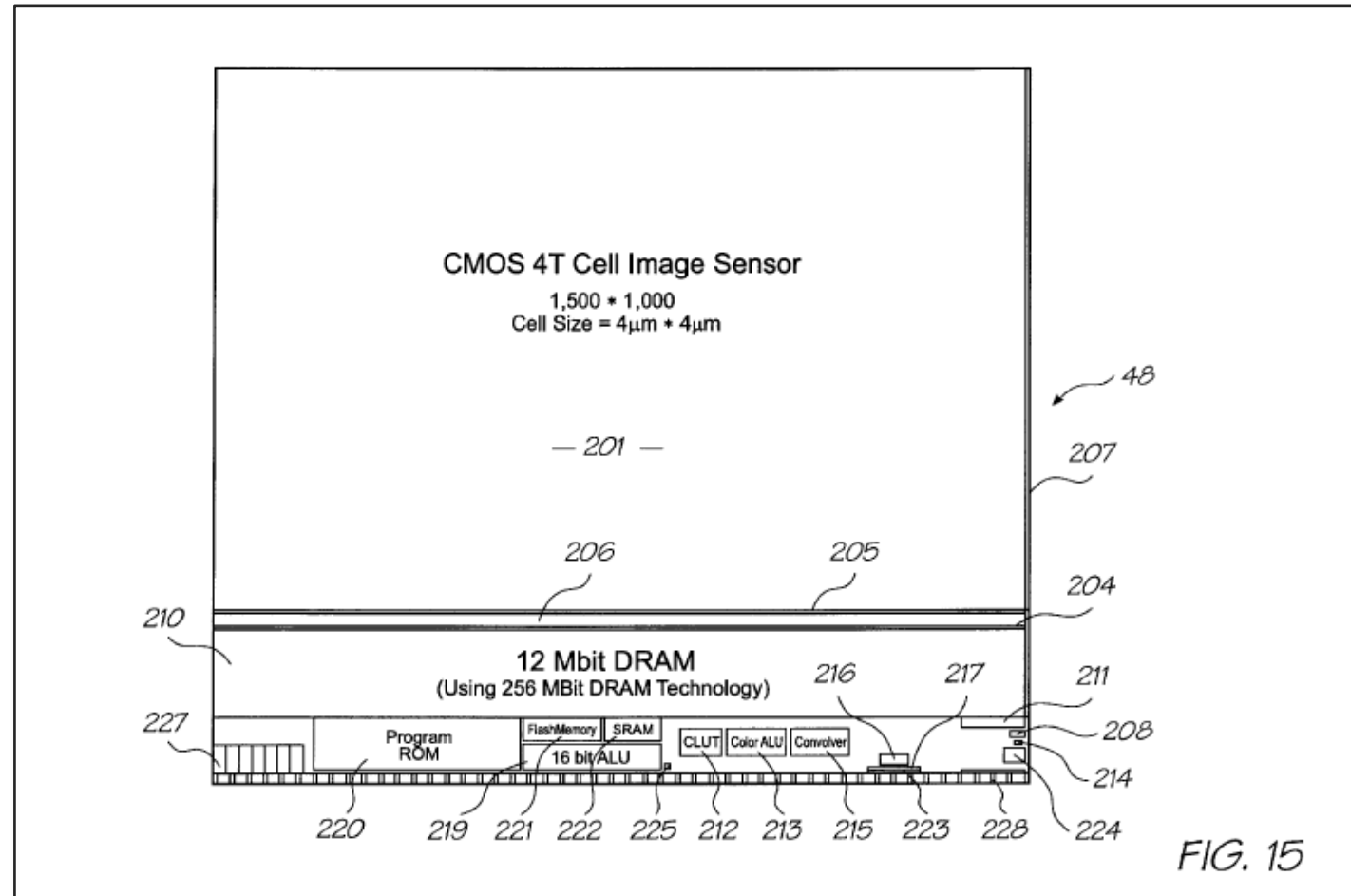


FIG. 15

Silverbrook: “CMOS image sensors” were well known

Dependent Claim: '502 Patent, Claim 12



Turning now to FIG. 15, there is shown an example layout of the Image Capture and Processing Chip (ICP) 48. The Image Capture and Processing Chip 48 provides most of the electronic functionality of the camera with the exception of the print head chip. The chip 48 is a highly integrated system. It combines CMOS image sensing, analog to digital conversion, digital image processing, DRAM storage, ROM, and miscellaneous control functions in a single chip.

Silverbrook (Ex. 1047), Fig. 15, 6:41-49

Prior Art Discloses “a Graded Concentration of
Dopants To Aid the Movement of Minority Carriers”

The Challenged Claims are Directed to a Device

Apparatus claims “**cover what a device *is*, not what a device *does*.**”

ParkerVision, Inc. v. Qualcomm Inc., 903 F.3d 1354, 1361 (Fed. Cir. 2018).

1. A **CMOS Semiconductor device** comprising:

a **surface layer**;

a **substrate**;

an **active region** including a source and a drain, disposed on one surface of said surface layer;

a **single drift layer** disposed between the other surface of said surface layer and said substrate,

said drift layer having **a graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having **a first static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate; and

at least one **well region** disposed in said single drift layer, said well region having **a graded concentration of dopants** and **a second static unidirectional electric drift field** to aid the movement of minority carriers from said surface layer to said substrate.

***ParkerVision*: Prior Art Device, Having a Component “Reasonably Capable” of Performing the Recited Function, Invalidates**

[W]here claim language recites “capability, as opposed to actual operation,” an apparatus that is “reasonably capable” of performing the claimed functions “without significant alterations” can infringe those claims. *Ericsson, Inc. v. D-Link Sys., Inc.*, 773 F.3d 1201, 1217 (Fed. Cir. 2014). The claims in *Ericsson* likewise used language reciting capability, such that **“D-Link’s products only need[ed] to have a component that [wa]s reasonably capable** of ‘arranging information for transmission ... which identifies a type of payload information. ...’ ”

Accordingly, just as D-Link’s products only required a component that was reasonably capable of “arranging information for transmission ... Which identifies a type of payload information ...,” *Ericsson*, 773 F.3d at 1217, **Nozawa's circuit requires only an oscillating signal that is reasonably capable of gating the bias signal in a manner that generates a periodic signal having a plurality of harmonics.”**

ParkerVision, Inc. v. Qualcomm Inc., 903 F.3d 1354, 1361-62 (Fed. Cir. 2018).

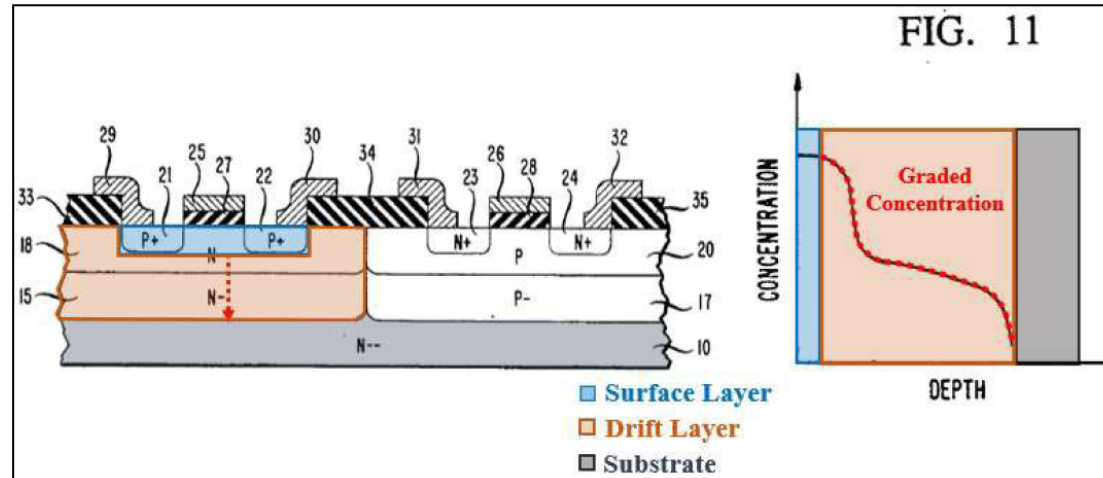
“To Aid The Movement of Minority Carriers” Merely Modifies the Structural Element

Greenthread (*Markman* at District Court):

It is not like Dr. Rao claimed “to aid movement” in a vacuum. Rather he claimed a specific drift layer with graded dopants that create a particular type of electric field. By the time the claim gets to **the phrase “to aid movement,”** it is **merely clarifying what the electric field does.** **Any question about what is meant by “to aid the movement” is answered by the preceding claim language.** Electric drift fields are a well-known phenomenon that cause carriers to move, and a POSITA would have readily recognized that when a “static unidirectional electric drift field” is present that it aids the movement of the minority carriers. If it isn’t present, then it doesn’t. The claim turns on the presence of the “unidirectional electric drift field,” and **the phrase “to aid the movement of minority carriers” merely states what the “unidirectional electric drift field” does.** The drift field points to one direction and charge carriers, when free to move, respond to the drift field by moving in one direction or the other depending on their charge polarity. Ex. 1, ¶88.

Prior art discloses the disputed terms

Payne

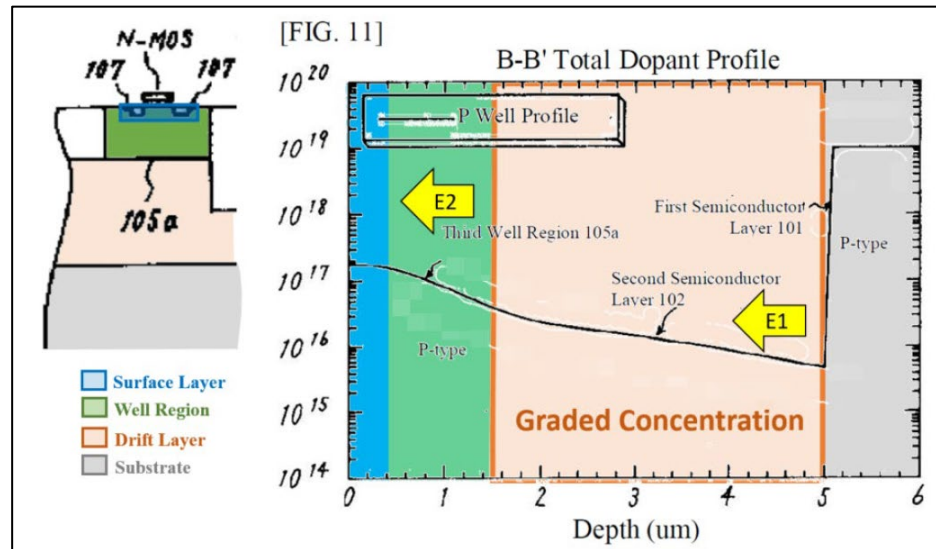


Claim 1 (195):

... said **drift layer having a graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having **a first static unidirectional electric drift field to aid the movement of minority carriers** from said surface layer to said substrate; and

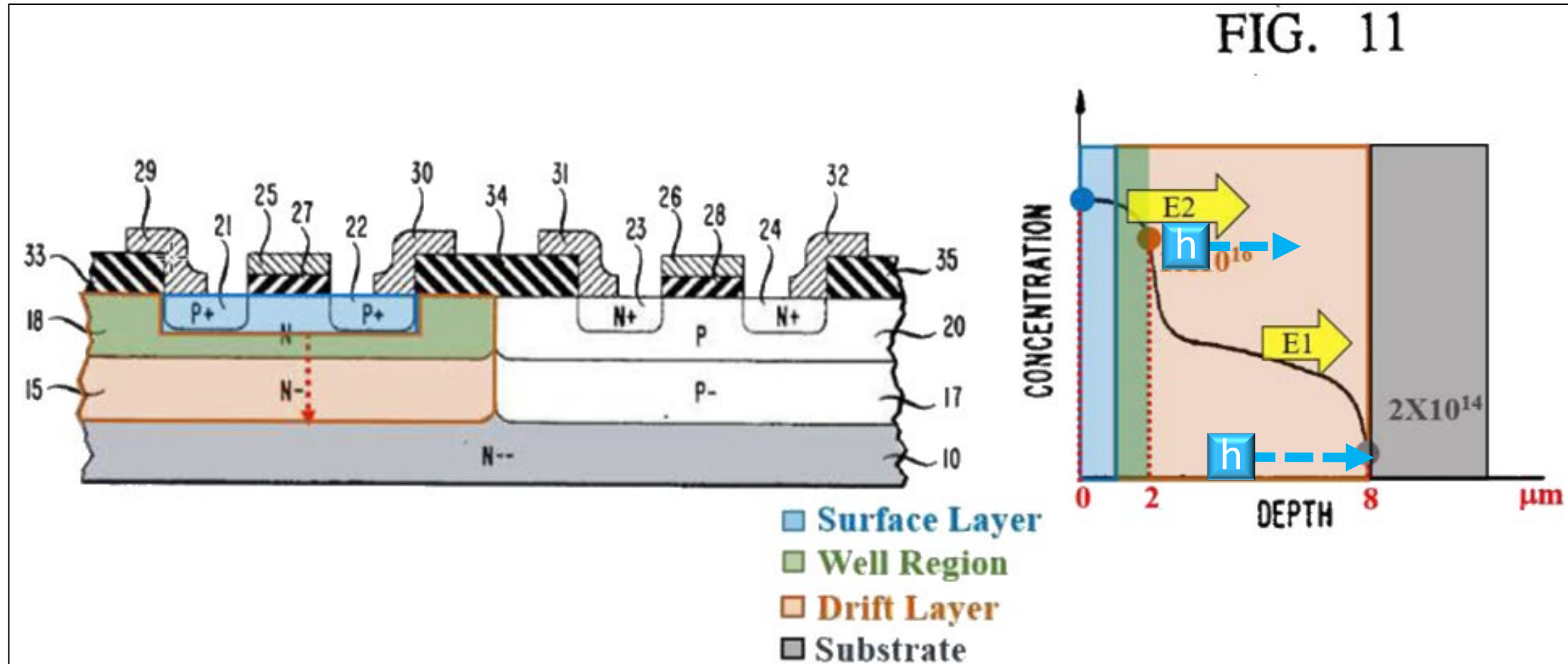
at least one well region disposed in said single drift layer, said **well region having a graded concentration of dopants** and **a second static unidirectional electric drift field to aid the movement of minority carriers** from said surface layer to said substrate.

Onoda



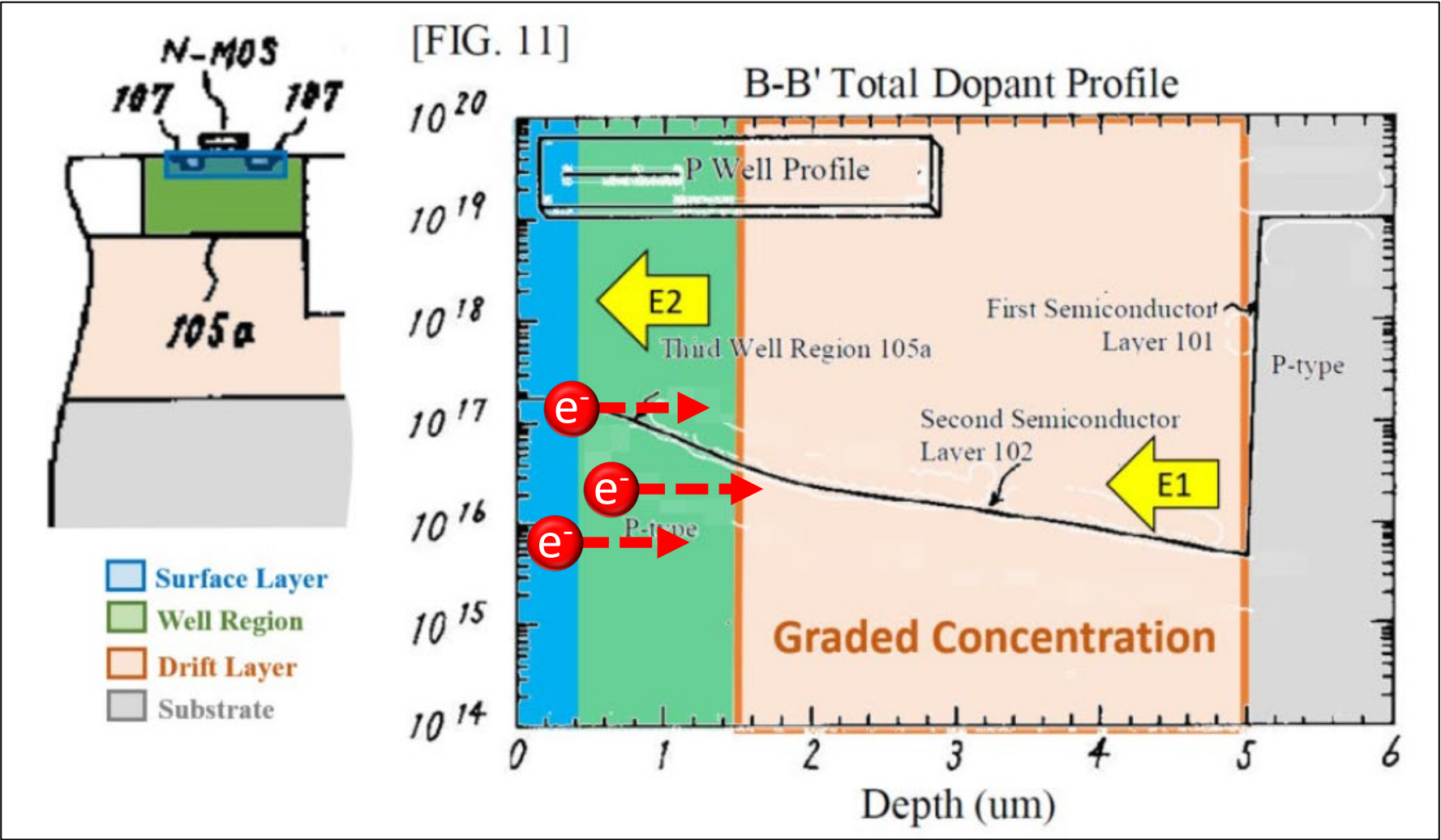
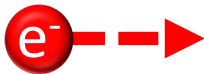
Payne Has a Graded Concentration of Dopants . . . To Aid the Movement of Minority Carriers (Holes, in PMOS)

h →



Payne (Ex. 1005), Figs. 10-11

Onoda Has a Graded Concentration of Dopants . . . To Aid the Movement of Minority Carriers (Electrons, in NMOS)



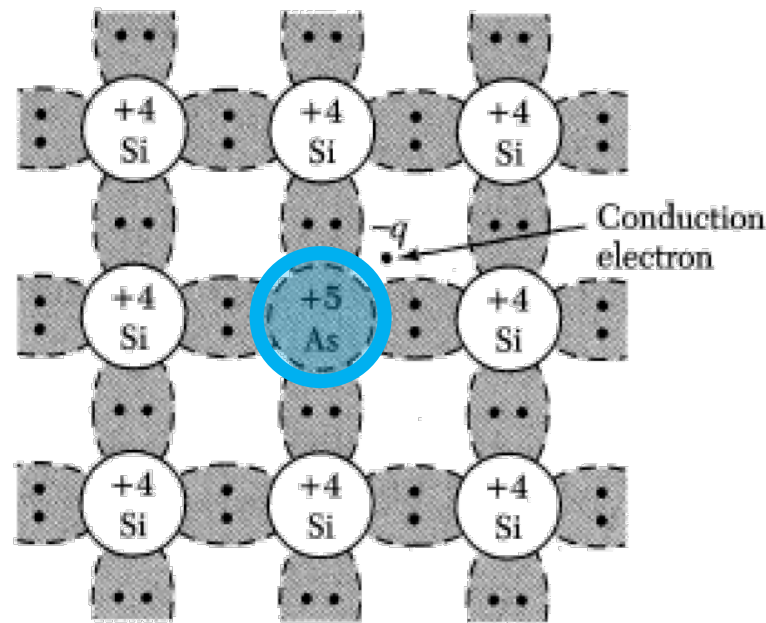
E.g., '195 Reply at 14-15, 24-27
Ex.1060 (Banerjee Supp. Decl.), ¶¶7, 21-25

Onoda (Ex. 1042), Figs. 3, 11

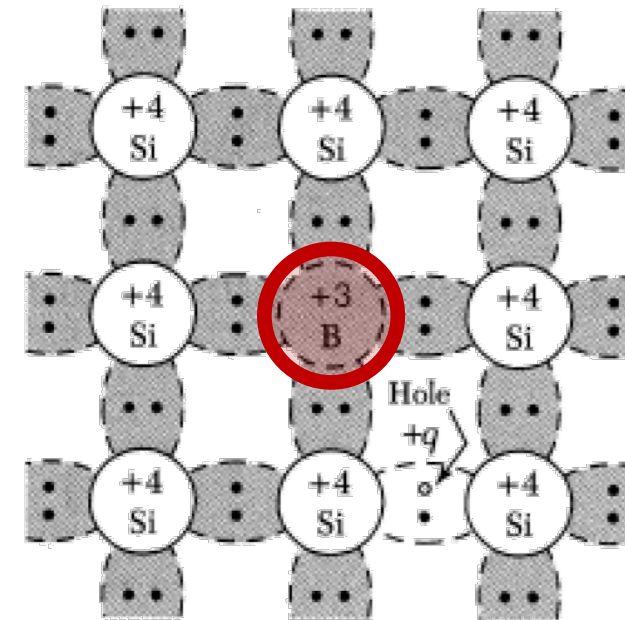
Silicon Semiconductor May be Implanted with N-Type Dopants or P-Type Dopants

N-type dopant (e.g., As)
Donor (positive ions)

P-type dopant (e.g., B)
Acceptor (negative ions)



(a)

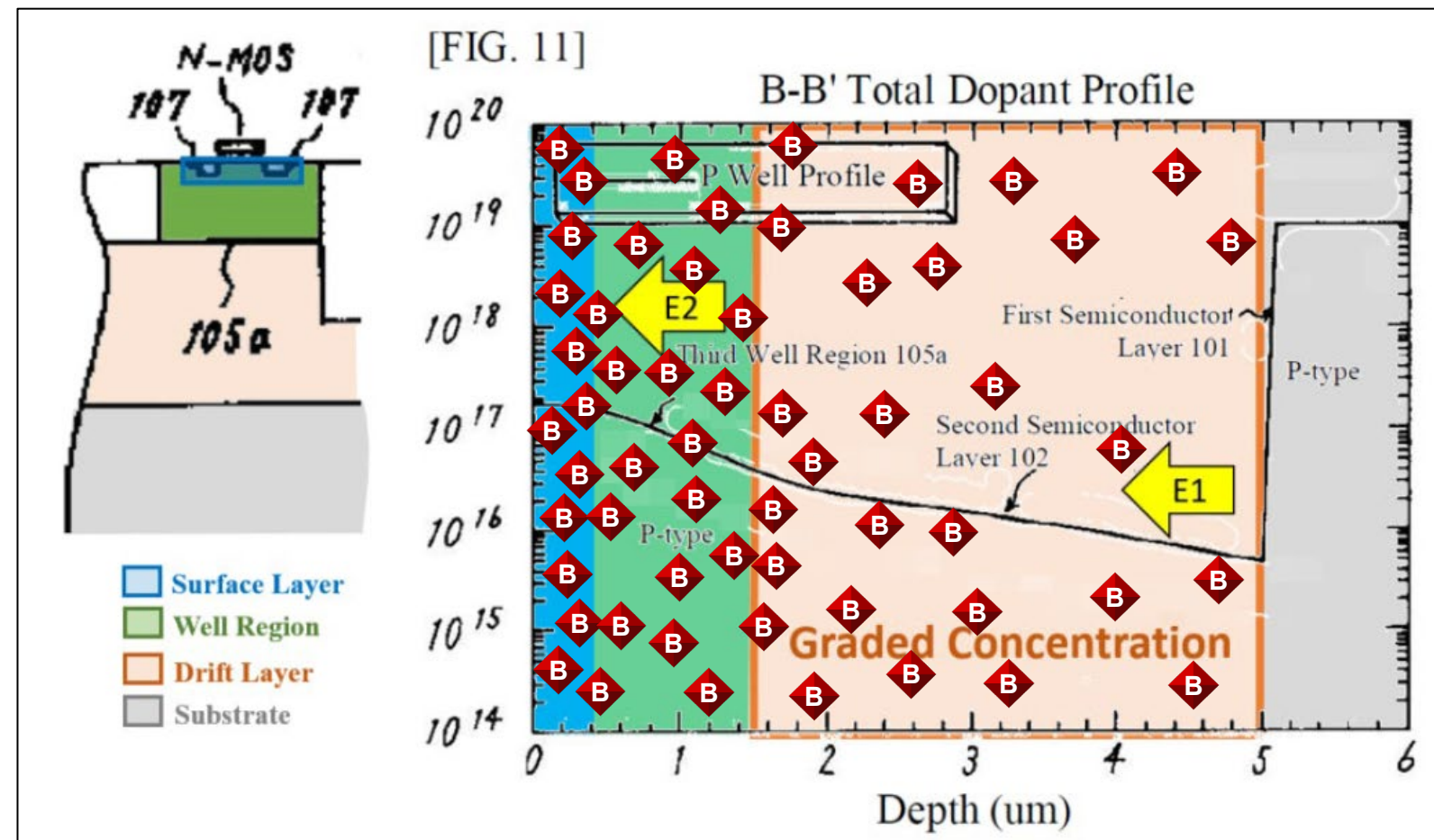


(b)

Fig. 23 Schematic bond pictures for (a) *n*-type Si with donor (arsenic) and (b) *p*-type Si with acceptor (boron).

Size (Ex. 1061) at 28
Ex. 1060 (Banerjee Supp. Declaration) at ¶12

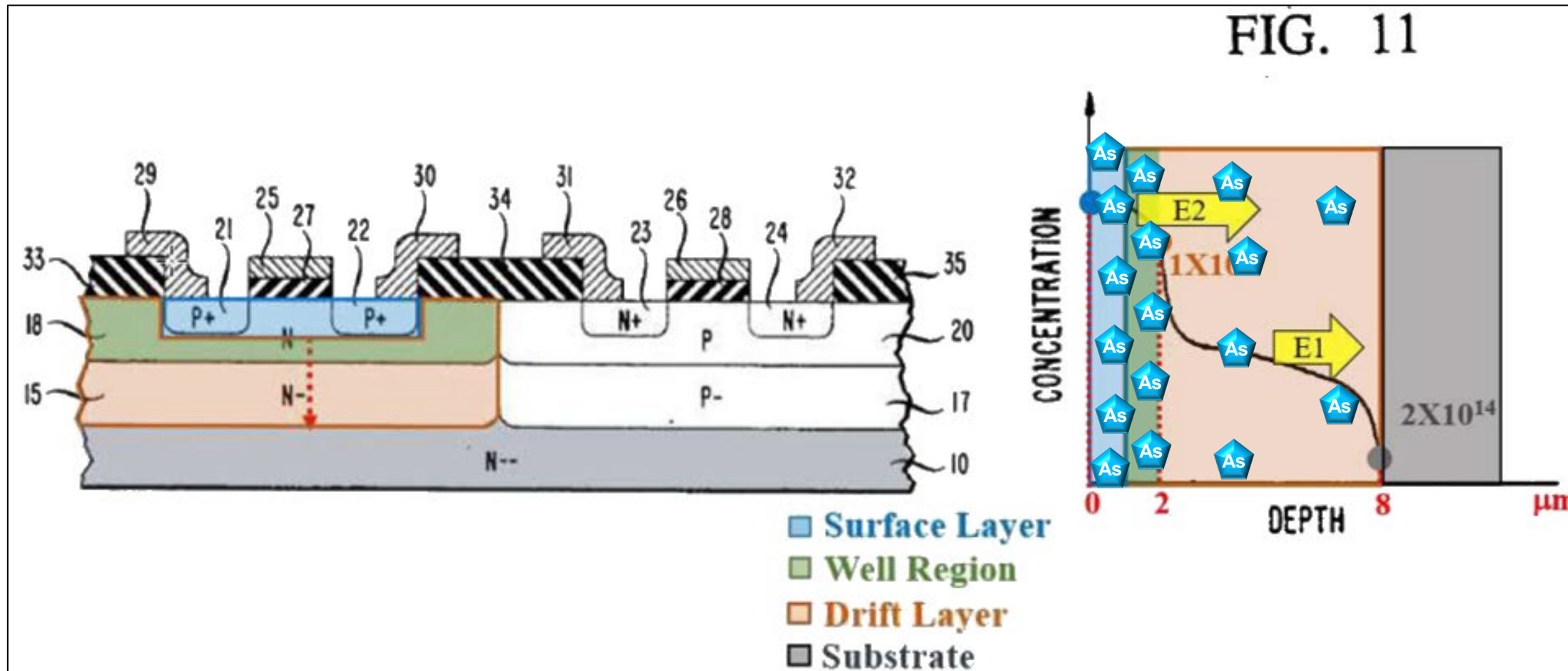
P-type Dopants (e.g., Boron (B)) create Negative Ions in Onoda's NMOS Transistor



E.g., '195 Reply at 14-15, 24-27
Ex.1060 (Banerjee Supp. Decl.), ¶¶7, 21-25

N-type Dopants (e.g., Arsenic (As)) create Positive Ions in Payne's PMOS Transistor

h →



Kamins Confirms That Electric Field Moves Carriers

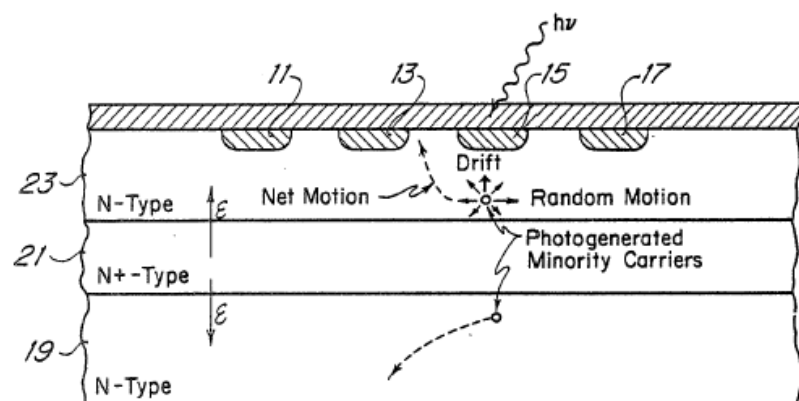


Figure 2

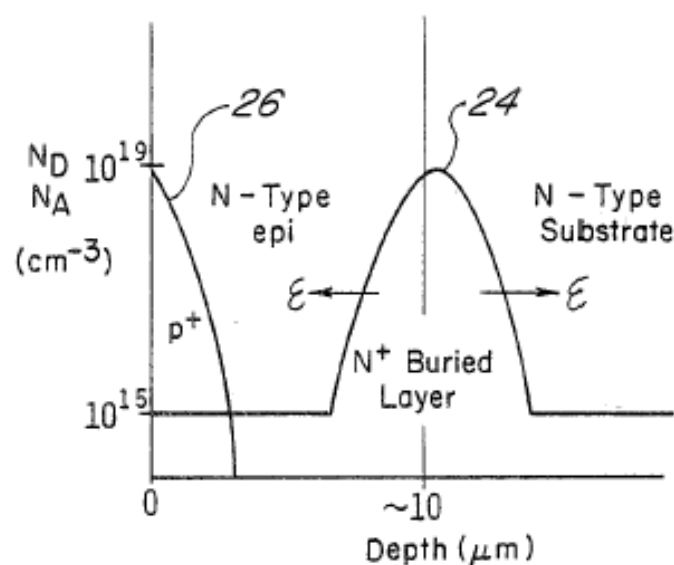


Figure 3

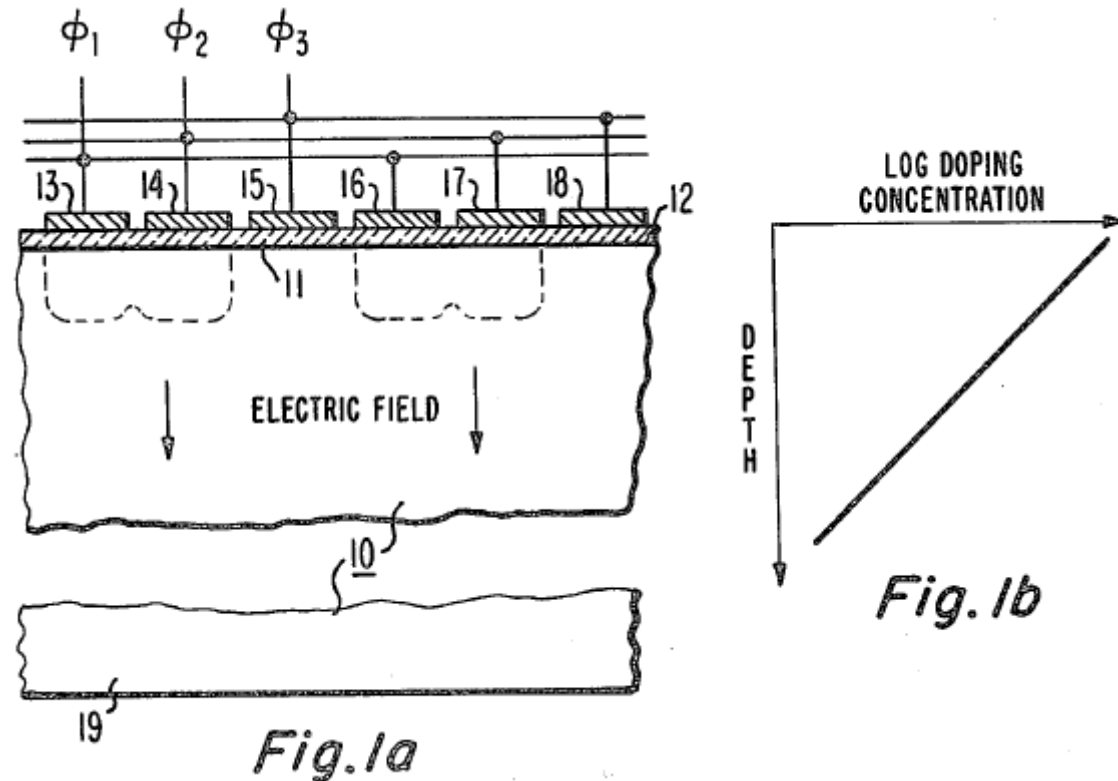
In FIG. 2 there is shown a photosensor array in which crosstalk is significantly reduced by incorporating built-in electric fields into the structure so that a directional drift motion is superposed on the random thermal diffusion of the charge carriers. In the structure of FIG. 2, subsurface electric fields are induced by means of suitable dopant concentration gradients introduced into substrate 19. In particular, a highly doped

FIG. 3 schematically illustrates profiles of doping concentration vs. depth into substrate 19. Curve 24 represents the N-type dopants, while curve 26 indicates the P+-type doping for photosensors 11, 13 etc. The

* * *

tion. The carriers therefore tend to be accelerated either toward the nearest photosensor or away from the surface. More specifically, carriers created below the maximum dopant concentration are accelerated into the substrate where they recombine without contributing to the collected current of any sensor, while carriers created above the maximum dopant concentration are accelerated toward the surface where they increase the collected current of the adjacent photosensor. In either

Jastrzebski Confirms That Electric Field Moves Carriers



These background striation and cross-talk problems are surmounted by constructing CCD shift registers, as exemplified by the FIG. 1a structural segment, in accordance with the present invention, so that there is an electric field normal to the surface 11 that tends to force carriers deeper into the bulk away from the depletion regions induced adjacent to surface 11. This electric field can be a drift field created by a graded concentration of doping in the substrate. In the FIG. 1a structural segment the gradient of doping concentration would be normal, or perpendicular, to the surface 11 of substrate 10, with the doping concentration decreasing with depth from surface 11. The drift field is accordingly

* * *

FIG. 1b is a graph of the logarithm of doping concentration versus depth into the first plane surface 11 of substrate 10 as will result in a uniform drift field. To

Jastrzebski (Ex. 1010) at 5:5-27, Figs. 1a-b
Ex. 1060 (Banerjee Supp. Declaration) at ¶¶ 7, 21-25

Prosecution History: Applicant Urged that No Other “Forces and Fields” Need to be Analyzed to Satisfy the Claims

The Office Action maintains a rejection pursuant to 35 U.S.C. §112, first paragraph, and in particular states that, because “movement of minority carriers is affected by multiple forces and fields” ... it does not appear that simply the presence of ‘a unidirectional drift field’ in itself can achieve ‘drawing all minority carriers from said surface layer to said substrate.’” Office Action at ¶3.

195 Patent File History (Ex. 1002) (-00017) at 289-290 (Apr. 17, 2012 Response)

Prosecution History: Applicant Urged that No Other “Forces and Fields” Need to be Analyzed to Satisfy the Claims

Applicant respectfully disagrees with this position because (as previously argued by Applicant) a unidirectional drift (electric) field necessarily affects all the present minority carriers in the same way – moving all minority carriers in the same direction because of the unidirectional drift due to the existence of the electric field. See “Physics and Technology of Semiconductor Devices,” A.S. Grove, pp. 224-225, John Wiley and Sons, Inc., New York, 1st Edition 1967 (“This same electric field will then be of such direction as to aid the motion of injected holes. Thus the injected minority carriers will now move not only by diffusion but also by drift due to the existence of this electric field.”). Depending on the particular slope of the graded concentration of dopant, all minority carriers are either swept “down” (from the surface layer to the substrate) or “up” (from the substrate to the surface layer). See Applicant’s Figs. 5(b) and 5(c).

195 Patent File History (Ex. 1002) (-00017) at 289-290 (Apr. 17, 2012 Response)

Prosecution History: Applicant Urged that No Other “Forces and Fields” Need to be Analyzed to Satisfy the Claims

The Office Action also states that “such a unidirectional drift field may attempt to apply a force on all minority carriers in a specific direction, it does not appear to ensure (without knowing other parameters of the device) that it will draw ‘all’ minority carriers...” Yet, this argument appears to not consider that the graded dopant concentration itself creates a “built-in” electrical field that forces the movement of carriers into a particular direction, whereby the “direction” of the electrical field and the resulting direction of the carrier movement depends solely on the slope of the graded concentration of dopant. With regard to the existence of a “built-in” electric field created by a graded dopant density, *see*, e.g., Jastrzebski (US 4,481,522) col. 5, lines 11-13 (cited in Office Action). Applicant respectfully submits that this inherent “built-in” unidirectional electric field is the additional parameter for ensuring that all minority carriers are being moved in one direction and which parameter the Office Action deemed to be missing from the disclosure.

195 Patent File History (Ex. 1002) (-00017)
at 289-290 (Apr. 17, 2012 Response)

Examiner’s Office Action:

Whereas it is true that such a unidirectional drift field may attempt to apply a force on all minority carriers in a specific direction, it does not appear to ensure (without knowing other parameters of the device) that it will draw “all” minority carriers from said surface layer to said surface.

195 Patent File History (Ex. 1002) (-00017)
at 270 (Dec. 20, 2011 Office Action)

Beyond “Disclaimer,” Statements During Prosecution Can Clarify the Meaning of the Claim Language

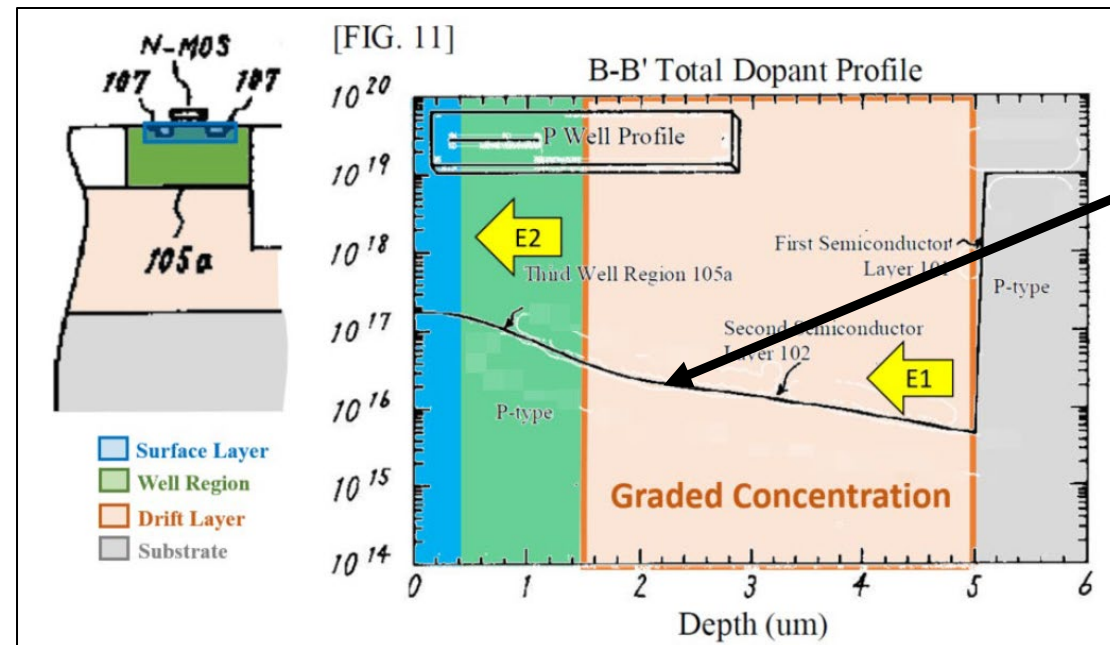
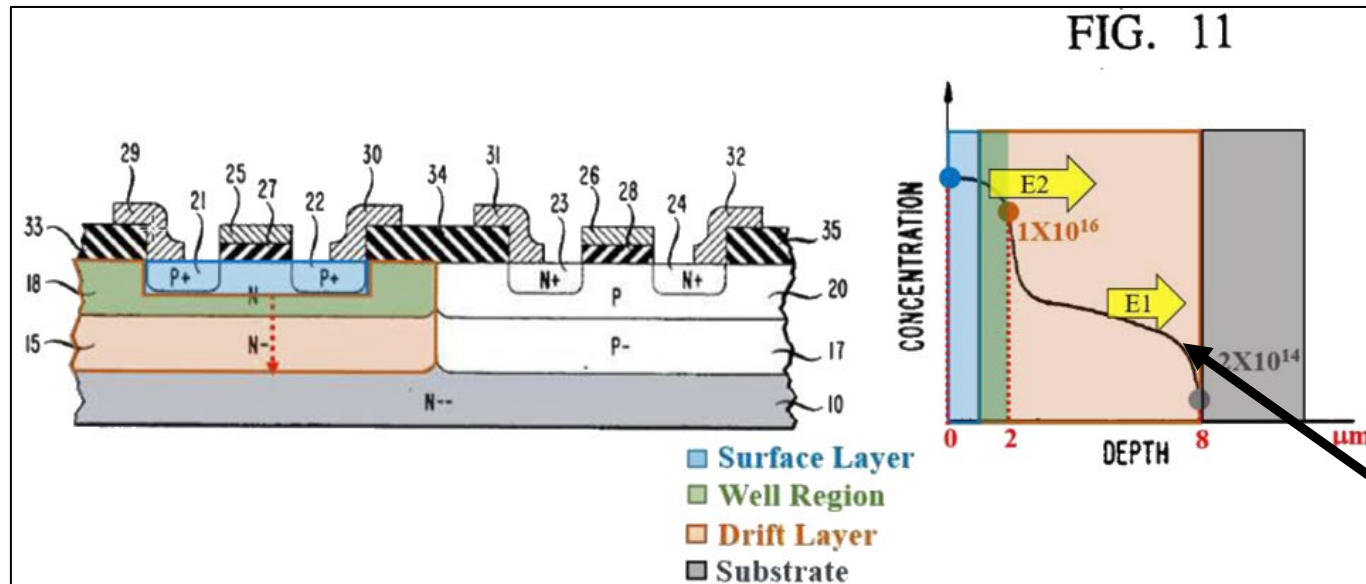
“Iridescent contends that the prosecution history is irrelevant to the claim construction question because there is no clear and unmistakable disavowal of claim scope. We disagree. We have explained that **‘[a]ny explanation, elaboration, or qualification presented by the inventor during patent examination is relevant**, for the role of claim construction is to “capture the scope of the actual invention” that is disclosed, described, and patented.”

Iridescent Networks, Inc. v. AT&T Mobility, LLC, 993 F.3d 1345, 1352-53 (Fed. Cir. 2019).

“The prosecution history is relevant for more than an evaluation of disclaimer—it provides additional context for evaluating how the term would be understood and how it was used in the patent. *Iridescent Networks, Inc. v. AT & T Mobility, LLC*, 933 F.3d 1345, 1353 (Fed. Cir. 2019).”

Ultravision Technologies, LLC v. Govision LLC, 2023 WL 2182285 at *4 (Fed. Cir. 2023) (cit. omitted).

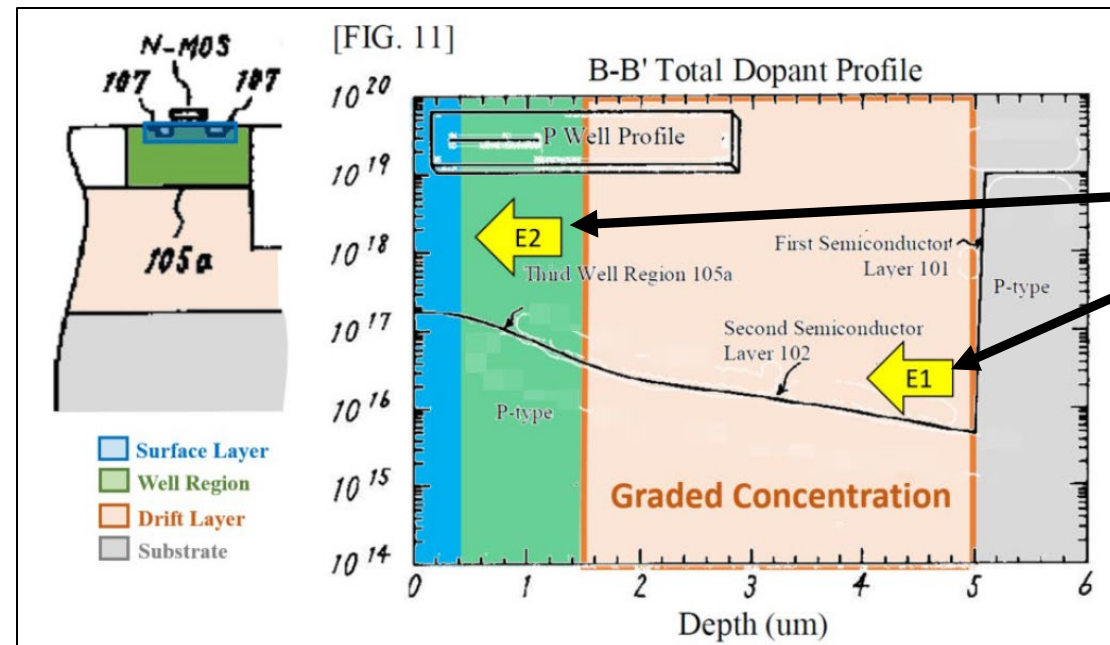
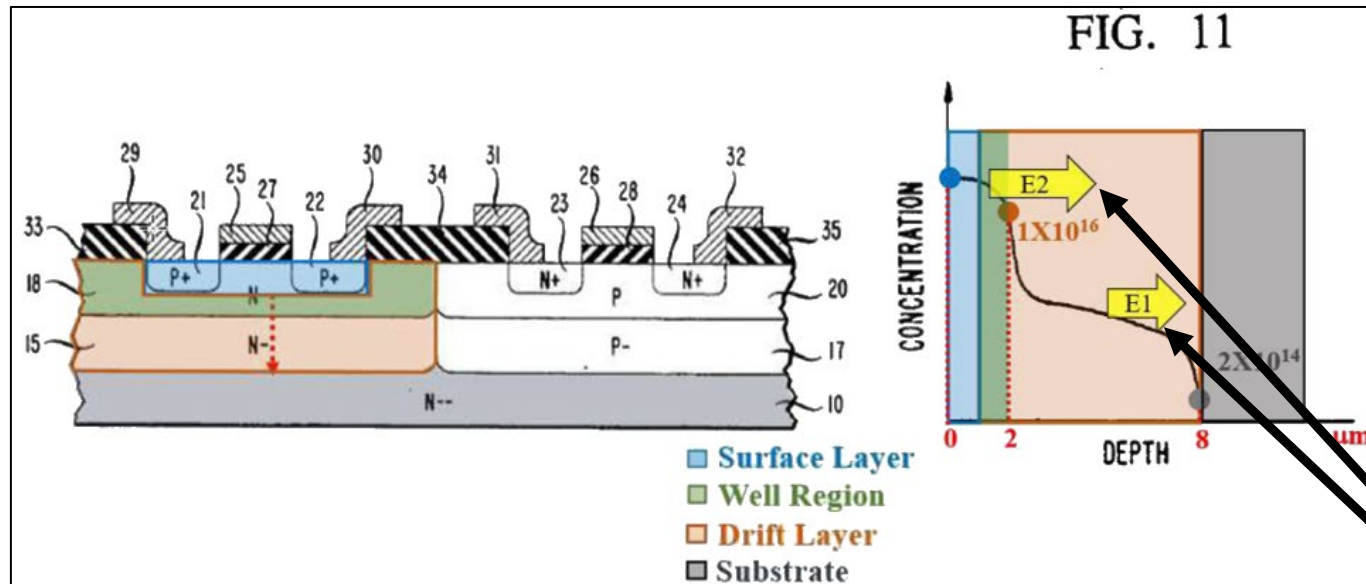
Prior art Discloses “a Graded Concentration . . . to Aid the Movement of Minority Carriers” in the Claimed Direction



Dr. Glew has admitted:

- There are graded dopant concentrations in Payne and Onoda
- Graded dopant concentrations generate electric fields
- Electric fields cause minority carriers to drift in a particular direction

Prior art Includes First and Second Static Unidirectional Electric Drift Fields To Aid the Movement of Minority Carriers



Dr. Glew has admitted:

- There are graded dopant concentrations in Payne and Onoda
- Graded dopant concentrations generate electric fields
- Electric fields cause minority carriers to drift in a particular direction

COVINGTON

Greenthread and Its Expert Acknowledged that “Carriers Will Move” When There’s Graded Dopant Concentration

Greenthread (During Litigation); Dr. Glew Declaration

When the dopant concentration is graded in a particular direction, other charge **carriers will move** in the gradient direction (or opposite direction) depending on the charge carrier’s polarity. This phenomenon is called “**carrier drift.**”

Ex. 2057 (Glew Declaration) at ¶33.

Ex. 1020 (Greenthread Claim Construction Brief) at 1.

Dr. Glew Deposition (IPR2023-01242/43/44):

Q. So when you talk about in paragraph 49 a concentration gradient aiding carrier movement or impeding carrier movement, that cannot be agnostic to the direction of the carrier movement, right?
A. Well, **a field will provide a force** in a direction aiding -- direction – **aiding movement in the direction of the force. That's just basic physics.**

Ex. 1069 (Jul. 16, 2024 Glew Tr.) at 108:15-23.

Greenthread’s “Aid Carrier Movement” Arguments Fail

Greenthread’s Argument	Why This Argument Fails
“Aid carrier movement” requires that a carrier move	Claims are directed to a <u>device</u> with structural features, not a method
“Carrier movement” refers to the net movement of carriers when the device is turned ON	Greenthread rewrites the claims. Drift-induced movement (even when device is OFF) is sufficient
Petitioners now argue that “carrier movement” refers to Brownian motion	Red herring; Petitioners merely provided technical context, that that carriers are constantly moving.
The direction of the slope is insufficient to show “aided”	Nothing in the intrinsic record suggests measuring or comparing slope magnitude
Warrick, WDTX, and EDTX confirm that the claims require measuring the magnitude of the slope	Greenthread mischaracterizes each of these documents
Dr. Banerjee: “3 categories of forces” affect carrier movement	Dr. Banerjee confirmed that these 3 categories of forces don’t alter the carrier movement
Dr. Banerjee: an additional, gate oxide-induced E-field imparts an additional force on the carriers	Claims directed to “ <i>a graded dopant concentration to aid carrier movement</i> ”; other E-fields don’t negate this

See generally '195 Reply; '502 Reply; '222-II Reply;
Ex. 2078 (Dec. 6, 2024 Banerjee Tr.)

The Claims Do Not Require Measuring the Slope
Magnitude and Comparing it with *Other Forces*

Greenthread: Claims Require Slope “Magnitude” and “Other Forces”

Dr. Glew’s Declaration:

Based on Dr. Banerjee’s declaration, it is apparent that for his analysis of the “aid the movement carriers ...” limitation he only considered the downward sloping nature of Kawagoe’s concentration gradient, and not any other aspect of the gradient (e.g., the magnitude of the force it produces on carriers) or whether there are any **external forces (e.g., opposing forces, e.g., due to the intrinsic resistance of silicon)** such that the net force might not be aiding carrier movement in the claimed manner. . . . Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

’195 POR at 8-9; ’502 POR at 7-8; ’222-I POR at 8

The Claims Do Not Require Any Specific Magnitude for the Slope Gradient or Electric Field

Dr. Glew's Declaration:

Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

Claim 1 (195):

... said **drift layer having a graded concentration of dopants** extending between said surface layer and said substrate, said drift layer further having **a first static unidirectional electric drift field to aid the movement of minority carriers** from said surface layer to said substrate; and

at least one well region disposed in said single drift layer, said **well region having a graded concentration of dopants** and **a second static unidirectional electric drift field to aid the movement of minority carriers** from said surface layer to said substrate.

Specification: Aiding Carrier Movement Does Not Hinge on A Specific Magnitude of the Gradient

Dr. Glew's Declaration:

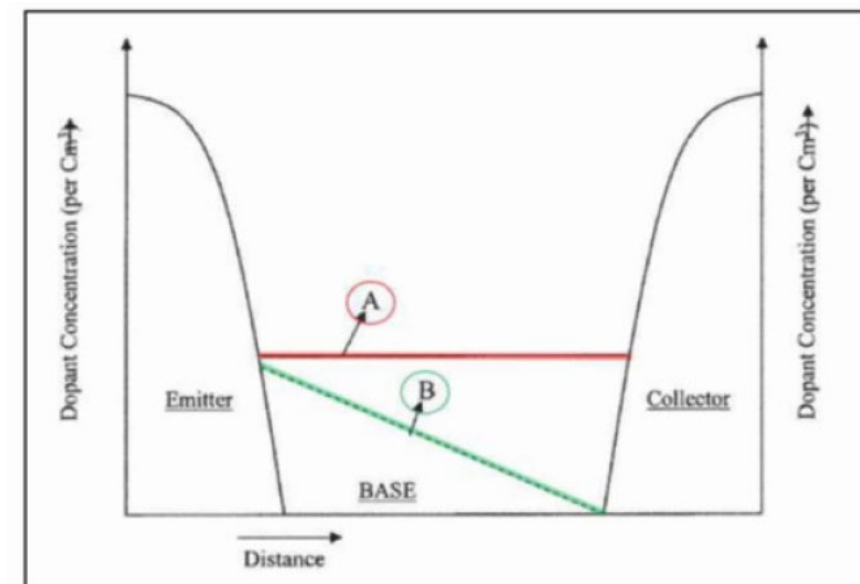
Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

Specification:

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 100x at the emitter-base junction, relative to the base-collector junction (x1). . . . “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.”

'195 Patent (Ex. 1001) (-00017),
2:35-50, Fig. 1



Greenthread Conceded That “Relative Slope” Does Not Imply a Magnitude

Greenthread’s Continuing Prosecution (Aug. 2024):

Dr. Glew’s Declaration:

Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

In order to describe how the term “gradient” is utilized and described and supported in the Specification, Applicant will try to step through how such as introduced and utilized in the Specification. In addition, the declaration under 37 CFR 1.132 of Douglas Holberg as an expert is filed herewith as support for this discussion. Applicant additionally notes that although the below

* * *

The structure of this transistor is described as having a base region that has a donor dopant concentration gradient that is high at the emitter-base junction and low at the base-collector injunction. This corresponds to the label “B” in Figure 1. This is defined as a “relative slope” which means nothing more than the fact that one-side is relatively lower than the other side. This

Aug. 2024 Remarks in 17/728,588 (Ex.1070) at 9;
Aug. 2024 Holberg Declaration in 17/728,588 (Ex.1064) at 5

Greenthread Did Not Mention “Magnitude” of the Gradient During Prosecution

Dr. Glew’s Declaration:

Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

Applicant respectfully disagrees with this position because (as previously argued by Applicant) a unidirectional drift (electric) field necessarily affects all the present minority carriers in the same way – moving all minority carriers in the same direction because of the unidirectional drift due to the existence of the electric field. See “Physics and Technology of Semiconductor Devices,” A.S. Grove, pp. 224-225, John Wiley and Sons, Inc., New York, 1st Edition 1967 (“This same electric field will then be of such direction as to aid the motion of injected holes. Thus the injected minority carriers will now move not only by diffusion but also by drift due to the existence of this electric field.”). Depending on the particular slope of the graded concentration of dopant, all minority carriers are either swept “down” (from the surface layer to the substrate) or “up” (from the substrate to the surface layer). See Applicant’s Figs. 5(b) and 5(c).

195 Patent File History (Ex. 1002) (-00017) at 289-290 (Apr. 17, 2012 Response)

Greenthread Did Not Mention “Magnitude” of the Gradient During Prosecution

Dr. Glew’s Declaration:

Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

The Office Action also states that “such a unidirectional drift field may attempt to apply a force on all minority carriers in a specific direction, it does not appear to ensure (without knowing other parameters of the device) that it will draw ‘all’ minority carriers...” Yet, this argument appears to not consider that **the graded dopant concentration itself creates a “built-in” electrical field that forces the movement of carriers into a particular direction, whereby the “direction” of the electrical field and the resulting direction of the carrier movement depends solely on the slope of the graded concentration of dopant.** With regard to the existence of a “built-in” electric field created by a graded dopant density, *see*, e.g., Jastrzebski (US 4,481,522) col. 5, lines 11-13 (cited in Office Action). Applicant respectfully submits that **this inherent “built-in” unidirectional electric field is the additional parameter for ensuring that all minority carriers are being moved in one direction** and which parameter the Office Action deemed to be missing from the disclosure.

195 Patent File History (Ex. 1002) (-00017) at 289-290 (Apr. 17, 2012 Response)

Dr. Glew Admittedly Did Not Consider Greenthread's Prosecution Statements

Dr. Glew's Deposition:

Q But maybe let me ask you, sitting here right now, when you reviewed the file history for the '195 patent, you must -- did you review all the office actions by the examiner and responses by GreenThread?

A I would say **I glanced at the file history**. There was nothing outstanding that I saw at the time. I didn't -- I included -- I don't think I included any comments in my report on the file history. **It didn't seem relevant** to what the -- any of the issues I was rebutting at the time.

Ex. 1063 (Oct. 16, 2024 Glew Tr.) at 179:17-180:6

Dr. Banerjee Supp. Declaration:

98. During the deposition, Dr. Glew admitted that he had only “glanced” at the prosecution history, because—according to him—“**[i]t didn't seem relevant** to ... any of the issues I was rebutting at the time.” Ex.1063-Glew-Tr. 179:18-180:6. In my opinion, **this is a glaring omission from his analysis, because the above statements of the file history are technical representations that speak to what level of disclosure in the prior art is sufficient to demonstrate the “aid carrier movement” term.**

Ex. 1060 (Banerjee Supp. Declaration) at ¶98

Prosecution History: Regarding Analogous Claims, Applicant Conceded That “Any Magnitude” is Sufficient

Patent Examiner:

Note that **applicant has not claimed a specific magnitude** of the drift electric field and hence **any magnitude of drift electric field, however small, reads on the claim**. The ordinary artisan would have been motivated to modify Currie for at least the purpose of aiding carrier movement in a specific, desired direction.

195 Patent File History (Ex. 1002) (-00017) at 139-40 (Dec. 30, 2009 Office Action)

3. (currently amended) A VLSI digital semiconductor device with graded dopant concentration in the well regions and the active channel regions, to aid carrier movement away from the active surface regions, towards the substrate:

A VLSI Digital Semiconductor device comprising:

a surface region;

a substrate;

an active channel region capable of providing a localized drift electric field without the application of an external potential;

an isolation well region capable of providing a localized drift electric field without the application of an external potential; and

a graded dopant concentration in either the channel region or the well region to aid carrier movement away from the surface region towards the substrate.

195 Patent File History (Ex. 1002) (-00017)
at 123 (Aug. 26, 2009 Amendment &
Response)

Prosecution History: Applicant Conceded That “Any Magnitude” is Sufficient For Analogous Claims

Each of claims 3-7 have been amended to clarify that the claimed invention relates to the field of VLSI digital semiconductor devices which include graded dopant concentrations in regions capable of providing a localized drift electric field without the application of an external potential. The Currie reference discloses a strained layer of Si, Ge or SiGe (Column 3, lines 46-

195 Patent File History (Ex. 1002) (-00017) at 128 (Aug. 26, 2009 Amendment & Response)

Greenthread's Presents Arguments on “Aid Carrier Movement” are Inconsistent with its Litigation Positions

During Prior Litigation:

“To aid the movement” is a simple term that is readily understood by POSITAs and lay persons alike. Ex. 1, ¶85. Any one that has put a little WD40 on a rusty hinge, or stretched before exercising, knows what it means “to aid the movement” of something. **Likewise, nobody would dispute that a wheelchair ramp “aids the movement” of someone in a wheelchair.**

* * * *

By the time the claim gets to the phrase “to aid movement,” it is merely clarifying what the electric field does. Any question about what is meant by “to aid the movement” is answered by the preceding claim language. **Electric drift fields are a well-known phenomenon that cause carriers to move, and a POSITA would have readily recognized that when a “static unidirectional electric drift field” is present that it aids the movement of the minority carriers.**

Ex. 1030 (-00017)(Greenthread Claim Construction Brief) at 25-27.

Now, to Avoid Invalidity:

In “a **complex electronic device**, movement of minority carriers is affected by **multiple forces and fields**” (citing Patent Examiner).

Since **Petitioners do not measure** or account for these forces, and **do not compare** them to the **magnitude of the force exerted by the gradients** in the alleged prior art, they fail to establish that the disclosed gradients would “aid carrier movement.”

'195 POR at 9-10;
'502 POR at 9;
'222-II POR at 9

Speed or Acceleration of Movement is Admittedly Irrelevant

During Prior Litigation:

The claim specifies the graded dopants create an electric field that aids movement of the carriers away from the surface layer. Defendants assert that the specification does not provide guidance on how to assess or measure carrier movement. This is not true. The claims and the specification make clear that the electric field must move the carriers in a particular direction (from the surface layer to the substrate). **Whether the carrier movement has a particular speed or acceleration is beyond the scope of the claim**, as long as it meets the other limitations of the claim.

Ex. 1030 (-00017) (Greenthread Claim Construction Brief) at 29.

Greenthread Asserts That the Claims Hinge on Slope “Magnitude” and “Other Forces”

Greenthread’s Response:

Petitioners’ assumption that the gradients in their prior art references would aid carrier movement fails, because they assume that any gradient would suffice to overcome the **other forces that are present**, such as the inherent resistance of silicon. Since **Petitioners do not measure or account for these forces, and do not compare them to the magnitude of the force exerted by the gradients** in the alleged prior art, they fail to establish that the disclosed gradients would “aid carrier movement.” Ex. 2057, ¶¶46-50.

’195 POR at 8-9; ’502 POR at 7-8; ’222-I POR at 8

Carriers in a Doped Semiconductor are Free to Move

Dr. Glew: Voltage Needed to “Liberate” the Electrons

Dr. Glew’s Declaration:

Therefore, a POSITA would need to know **other parameters of the relevant device (e.g., magnitude of concentration gradient, intrinsic resistance of silicon, presence of any other external forces)** to know whether a drift field associated with a concentration gradient would aid carrier movement.

E.g., Ex. 2057 (Glew Decl.) (-00017), ¶50

Dr. Glew’s Deposition:

A Yes. It's my opinion, position -- it's a fact, I think -- that the mere presence of electrical field isn't sufficient to cause electrons to become charge carriers. **There's a -- essentially a threshold voltage to cause motion** as well as resistance to the materials.

* * * *

Q You mentioned threshold voltage. Are you referring to a voltage that would be applied between the source and a drain for a transistor to conduct?

A Well, I could use threshold voltage in a couple of contexts. That would be one, and that is one that I had mentioned previously. But **there's also a threshold voltage to liberate an extra electron from a crystal structure.**

* * * *

Q Do you recall mentioning threshold voltage in your expert declaration? Is that correct?

A I'm not sure if I used the phrase "threshold voltage." I certainly spoke of that concept, that there's certain voltage required to cause motion, you know. **A small enough voltage won't make an electron free or liberate it from the atoms it's bonded to. A larger voltage will.**

Ex. 1063 (Oct. 16, 2024 Glew Tr.) at 104:21–108:11

Carriers in a doped semiconductor are in “Brownian” motion (i.e., free to move)

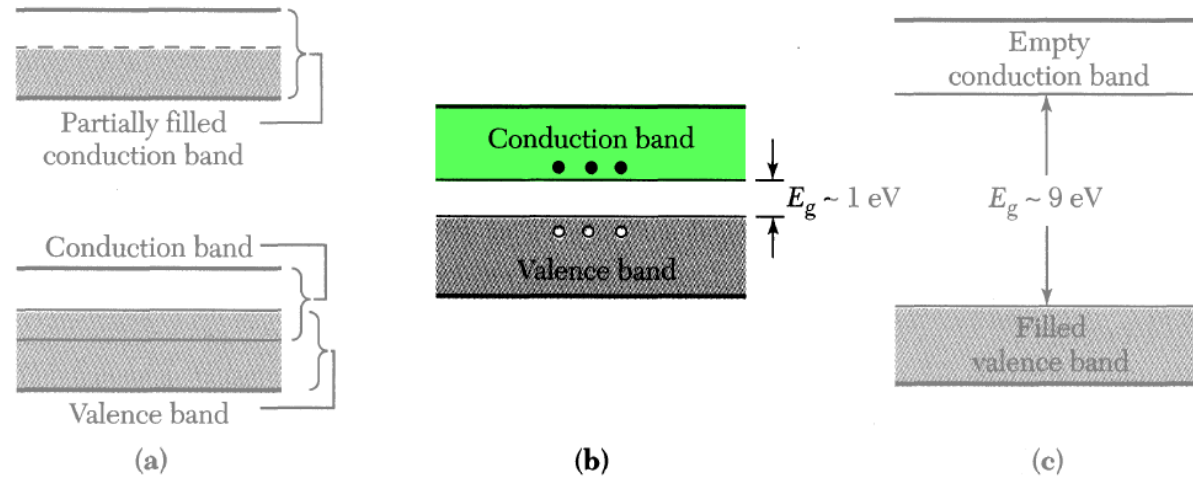


Fig. 19 Schematic energy band representations of (a) a conductor with two possibilities (either the partially filled conduction band shown at the upper portion or the overlapping bands shown at the lower portion), (b) a semiconductor, and (c) an insulator.

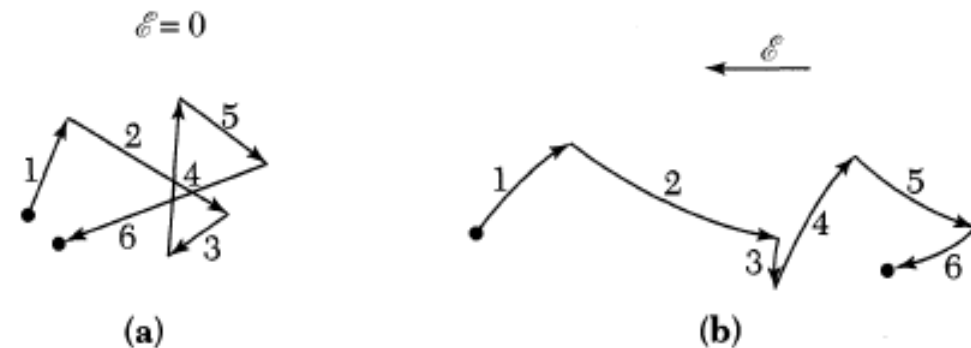


Fig. 1 Schematic path of an electron in a semiconductor. (a) Random thermal motion. (b) Combined motion due to random thermal motion and an applied electric field.

Petitioners Did Not Offer a “Brownian” Claim Construction

Greenthread’s Sur-Reply:

Petitioners now argue that . . . “**aiding carrier movement**” does not refer to the flow of carriers in a semiconductor device, but rather the constant, random, thermal—a.k.a. “**Brownian**”—vibration of individual electrons. That theory and **claim construction** make no sense and should be rejected as an improper new argument.

’842 Sur-Reply at 1; ’481 Sur-Reply at 1;
’014 Sur-Reply at 1; ’222-I Sur-Reply at 1

- Petitioners simply provided context, that carriers in a semiconductor are *already moving* (in Brownian motion), to rebut Dr. Glew’s theory

Dr. Glew’s Deposition:

But **there’s also a threshold voltage to liberate an extra electron from a crystal structure.**

Ex. 1063 (Oct. 16, 2024 Glew Tr.) at 104:21–108:11

Intrinsic Resistance, Silicon Stress, and Temperature do not Preclude Movement of Carriers

Dr. Glew's Declaration:

[A] POSITA would need to know other parameters of the relevant device (e.g., magnitude of concentration gradient, **intrinsic resistance of silicon**, presence of **any other external forces**) to know whether a drift field associated with a concentration gradient would aid carrier movement.

Ex. 2057 (Glew Decl.) (-00016), ¶50; Ex. 2057 (Glew Decl.) (-00016), ¶50;
Ex. 2057 (Glew Decl.) (-00019), ¶50; Ex. 2057 (Glew Decl.) (-00020), ¶50

Dr. Glew's Deposition:

Q Okay. Did you have any other opposing force in mind when you mentioned "e.g.,...intrinsic resistance of silicon"?
A Let me briefly review the paragraph. I gave an example of external forces such as intrinsic resistance. **Other opposing forces potentially could be stress of the device.**

Ex. 1063 (Oct. 16, 2024 Glew Tr.) at 152:11-17

- Carrier don't need to over come any intrinsic resistance. Presents a friction-like force that affects speed or acceleration of movement, which is beyond the scope of the claims
- Temperature variations do not preclude movement

Greenthread Mischaracterizes Dr. Banerjee's Textbook

Greenthread's Sur-Reply:

Dr. Banerjee claims that any electric field would necessarily aid the movement of electrons in Brownian motion. Ex. 2078, 210:16-17. But, when Dr. Banerjee addressed Brownian motion in his textbook, he took a different position. There, he said that “the force [of an electric field] may be *insufficient* to alter appreciably the random path of an individual electron.” Ex. 1062A, 99 (PDF page 50) (emphasis added).

'195 Sur-Reply at 10; '502 Sur-Reply at 10;
'222-II Sur-Reply at 10

Greenthread Mischaracterizes Dr. Banerjee's Textbook

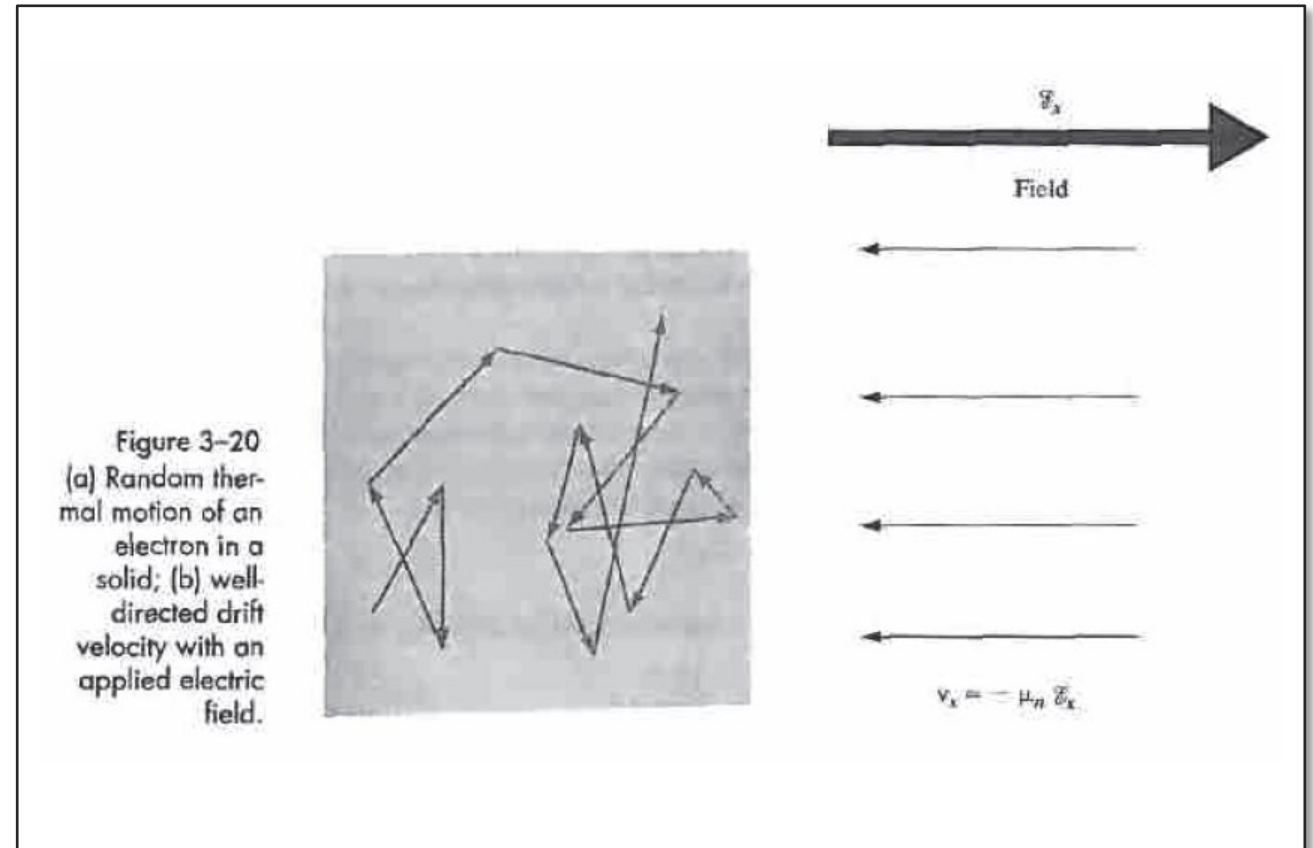
Streetman/Banerjee:

3.4.1 Conductivity and Mobility

The charge carriers in a solid are in constant motion, even at thermal equilibrium. At room temperature, for example, the thermal motion of an individual electron may be visualized as random scattering from lattice vibrations, impurities, other electrons, and defects (Fig. 3-20a). Since the scattering is random, there is no net motion of the group of n electrons/cm³ over any period of time. This is not true of an individual electron, of course. The probability of the electron in Fig. 3-20a returning to its starting point after some time t is negligibly small. However, if a large number of electrons is considered (e.g., 10^{16} cm⁻³ in an n-type semiconductor), there will be no preferred direction of motion for the group of electrons and no net current flow.

If an electric field $\mathcal{E}_x$ is applied in the x -direction, each electron experiences a net force $-q\mathcal{E}_x$ from the field. This force may be insufficient to alter appreciably the random path of an individual electron; the effect when averaged over all the electrons, however, is a net motion of the group in the $-x$ -direction (Fig. 3-20b). If p_x is the x -component of the total momentum of the group, the force of the field on the n electrons/cm³ is

$$-nq\mathcal{E}_x = \left. \frac{dp_x}{dt} \right|_{\text{field}} \quad (3-29)$$



Streetman/Banerjee (Ex.1062A) at 98-99

Eq. is $-nq(\mathcal{E}_x)$ and Not: $-nq(\mathcal{E}_x - \mathcal{E}_{th})$

Greenthread Incorrectly Reads the Disputed Limitations as Referring to “Net Movement”

Dr. Glew Incorrectly Construes “Aid Carrier Movement” as Referring to Net Movement, When the Device is “ON”

- Only considered *net movement* of carriers (requires an applied voltage)
- Did not consider drift-induced “*carrier movement*” in the device OFF state

A **When it is off, there is no motion of carriers.**

* * *

Q **There may not be any net movement of carriers or there may not be any net flow of current, but the carriers are in motion** even though the transistors is not operating; is that correct?

A. To me, the question makes no sense. It's nonsensical. **The movement of carriers is current.** So I just can't fathom what you're asking.

Q Okay. So if the transistor's sitting there and it is not operating but there is a dopant electric field, is your testimony that the electrons would not be in motion?

A It's my testimony that when the current -- excuse me -- when the transistor is off, there should be no **net current flow** in the transistor and that the channel region should not become electron rich and hole poor.

A. . . .I haven't performed an additional analysis of the balance of any stat- --any "off" state activity.

Q . . . I'm just asking you, do you have a position **whether there will be any drift** from the surface to the substrate of the electrons based on the dopant electric field when the transistor is not operating?

A As I've said before, **there should be no net current flow** that would degrade the performance of the device, which is meant not to have current flow **when it's off.**

Ex. 1063 (Oct. 16 2024 Glew Tr.) at 50:10-52:22, 62:10-63:12

Ex. 1060 (Banerjee Supp. Declaration) at ¶¶23-27 (explaining drift and diffusion)

Dr. Banerjee Explained Why Dr. Glew's Interpretation And Analysis is Flawed

95. Based on the portions of the deposition transcript I have cited above, it appears that Dr. Glew is misreading the claims to specifically require a *net movement* of carriers, or a “net current.” However, the claims do not speak to the *net movement* of carriers. Rather, the claims require structural features of the device — here, a “graded dopant concentration” that is capable of aiding the movement of carriers. While I do not dispute Dr. Glew’s assessment that an external voltage must be applied in order to cause *net movement* of carriers, or *net current* to flow, that is beside the point, because even at equilibrium (i.e., where no external voltages are applied to the device) *minority carriers will move via drift* by virtue of the static electric field alone. Further, while all of the challenged claims

Ex. 1060 (Banerjee Supp. Decl.) at ¶¶91-95

Intrinsic Record Does Not Disclose
Any External Forces

The Intrinsic Record Does Not Disclose “External Forces”

- The claims require a “graded concentration of dopants that aids movement”
- Specification does not disclose such external forces
- File history does not disclose external forces

Dr. Banerjee's Conclusions on the “Aid Carrier Movement” Term Account for the “3 Categories of Forces”

Greenthread's Sur-Reply:

According to Dr. Banerjee, those categories are (1) “periodic crystalline potential” (*id.* at 82:9-12), (2) “externally applied forces or a built-in electric field” (*id.* at 83:19-84:1) and (3) “random forces, ... such as lattice vibrations or static random forces due to structural defects in the crystal.” *Id.* at 84:16-21.

'195 Sur-Reply at 3-5; '502 Sur-Reply at 3-5;
'222-II Sur-Reply at 3-5

“Category 1” Considered

Q. Okay. Did you need to make any measurements for any category 1 forces in order to arrive at the conclusions you reached in these proceedings?

A. No, I did not.

Q. And why not?

A. Because the patent talks about these long -- these long range electric fields created by doping gradients and that is not impacted by the different periodic forces.

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.) at 319:10-22.

“Category 2” Considered

Q. Okay. And I believe you mentioned that the second category of force components includes an externally applied fields or doping electric fields; is that accurate?

A. Yes.

Q. Okay. And with respect to doping electric fields, does that include electric fields due to dopant concentration variations?

A. Yes.

Q. And is that force component addressed in your supplemental declaration?

A. Yes.

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.) at 320:1-14.

Dr. Banerjee's Conclusions on the "Aid Carrier Movement" Term Account for the "3 Categories of Forces"

"Category 3" Considered

Q. Okay. And, finally, I believe the third category of force component that you mentioned had to do with random collisions or scattering; is that right?

A. Yes.

Q. And do you recall testifying that that category affects mobility, which, in turn, affects resistivity?

A. Yes.

Q. Okay. And did you address resistivity in your supplemental declaration?

A. Yes.

Q. Okay. And, briefly, does the resistivity affect whether or not carriers will move via drift due to a dopant electric field created by a graded dopant concentration?

A. Resistivity will not impact whether the carriers will move via drift. But I -- as I mentioned during my deposition, it will impact the speed at which they move.

Q. Okay. And do the claims at issue in these proceedings call for any particular speed of carrier movement?

A. They do not.

'195 Sur-Reply at 3-5; '502 Sur-Reply at 3-5;
'222-II Sur-Reply at 3-5

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.) at 319:10-22.

The Prior Art Devices Disclose “a Graded Dopant Concentration . . . To Aid Carrier Movement,” Even if Other Fields Are Present

Greenthread’s Sur-Reply:

Dr. Banerjee testified that the gate electrode and gate oxide on a transistor can create a countervailing electric field that would be present in the active region (or surface). Ex. 2078, 219:16-220:20, 222:19-22; 223:20-224:1. . . . Dr. Banerjee did not consider the effect of these device components on the electric field created by the prior art dopant gradient. Id. at 224:2-8. . . . By failing to consider how “built-in” “structural” features of the prior art work, Dr. Banerjee’s fails to answer the question whether the prior art device was “reasonably capable of operating so as to meet the claim limitations.”

’195 Sur-Reply at 11-12; ’502 Sur-Reply at 11-12; ’222-II Sur-Reply at 11-12

Q. Does the conclusions that you reached in this case, are they affected by the presence of electric fields due to gate oxide or gate electrodes?

A. No.

Q. **Why are they not affected by electric fields due to gate oxide or gate electrodes?**

A. **All the claims are talking about electric fields created by doping gradient.** Gate oxide and gate electrodes are a different matter altogether.

Q. Does **the drift of carriers due to the built-in field created by a graded dopant concentration, is that altered by the presence of other fields**, potential fields stemming from gate oxide or gate electrodes?

A. **No, they are not.**

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.) at 325:2-329:1.

The Prior Art Devices Disclose “a Graded Dopant Concentration . . . To Aid Carrier Movement,” Even if Other Fields Are Present

Q. Do you recall being asked a series of questions about other hypothetical scenarios in which multiple other electric fields may be present?

A. Yes.

Q. As part of the analysis you performed in arriving at your conclusions, did you need to add up different electric field vectors in order to reach your conclusions regarding the challenged claims?

A. No, I did not.

Q. Did you need to, for purposes of arriving at your conclusions for the challenged claims, need to subtract one electric field vector from another electric field vector?

A. No, I did not because nothing in the patents --

A. **The patents are not dealing with net motion. They are dealing with the drift field specifically of minority carriers due to the built-in field due to the doping gradient.**

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.) at 329:2-330:10.

Greenthread Mischaracterizes Warrick and the EDTX / WDTX Claim Construction Orders

Greenthread Mischaracterizes Mr. Warrick's Testimony

22 Q. Is there anything that affects the ease of
1 carrier movement in a semiconductor device?

2 A. So the ease of carrier movement in a
3 semiconductor device, you know, the size of the device
4 matters, the doping of the device matters, the
5 potential on the device matters, the -- yeah, all of --
6 I would say it's probably a long list of these type of
7 physics attributes, which affect the movement of
8 carriers.

* * * *

22 Q. (BY MR. MATICH) Have you seen -- Mr. Warrick,
1 have you seen Exhibit 8 before?

2 A. Not in -- maybe not in its entirety. If you
3 go down, maybe I can see if I have seen portions of it.
4 I don't believe I have seen the entirety of it.

* * * *

2 Q. (BY MR. MATICH) Can you tell me if the
3 gradient there would aid carrier movement downward?

4 MR. LIDDELL: Objection, form.

5 THE WITNESS: I cannot tell you that.

Ex. 2056 (Warrick Tr.) at 71:22-
72:8, 91:22-92:4, 95:2-5.

Greenthread Mischaracterizes EDTX Claim Construction Order

- EDTX addressed: whether dopant concentration should *increase* or *decrease* across a drift layer

Disputed Term	Plaintiff's Proposed Construction	Defendants' Proposed Construction
“single drift layer ... having a graded concentration of dopants ... said drift layer further having a first static unidirectional electric drift field” • '195 Patent Claim 1	no construction necessary	single layer whose concentration of dopants either increases across the layer or decreases across the layer
“single drift layer ... having a graded concentration of dopants generating a first static unidirectional electric drift field” • '502 Patent Claim 7		

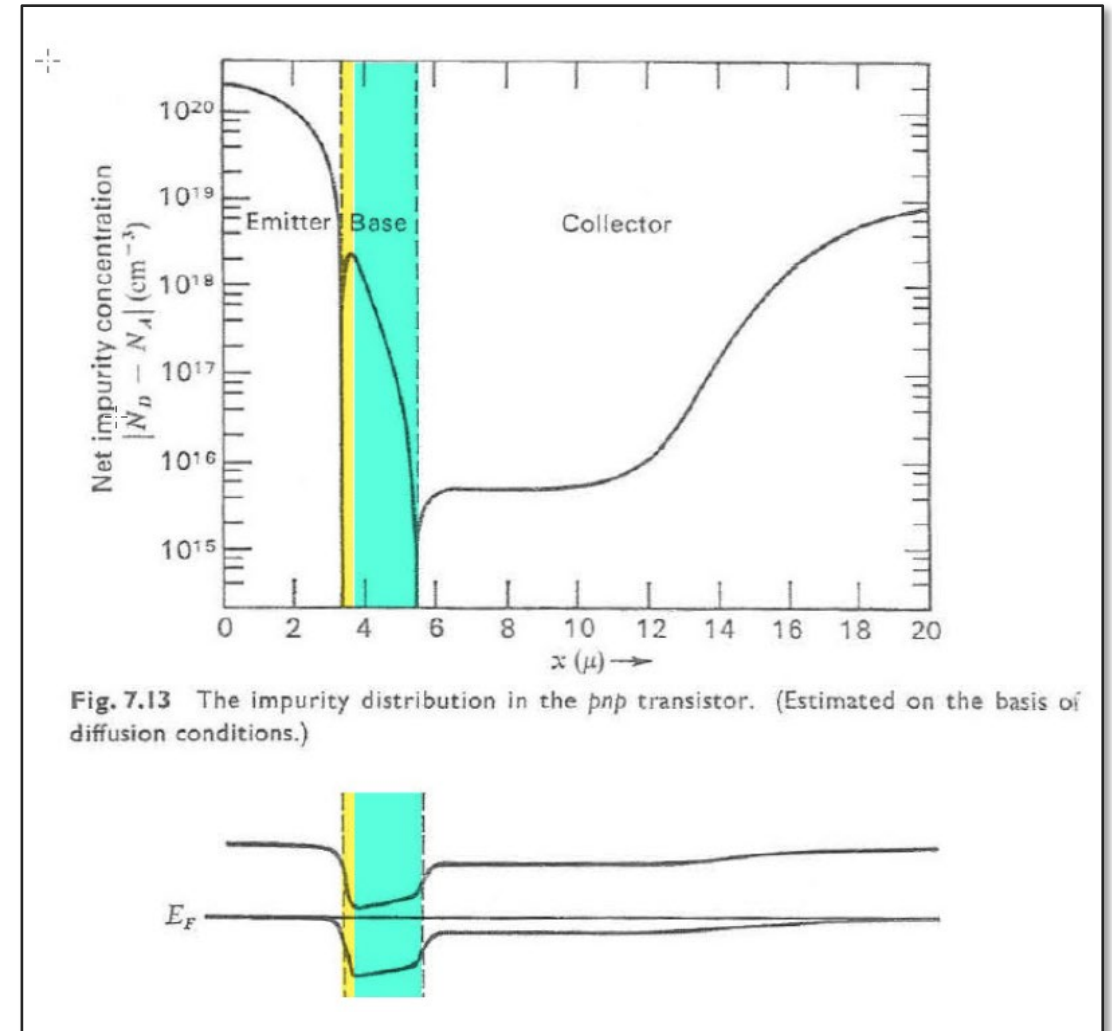
- Greenthread: No construction necessary
- Samsung: Dopant concentration uniformly *increases* or *decreases* across the drift layer
- Court did **not** evaluate whether “to aid carrier movement” hinges on a minimum magnitude of slope

'195 Reply at 21-22;
'502 Reply at 14-16;
'222-II Reply at 14-16

Greenthread Mischaracterizes EDTX Claim Construction Order

Taken in context, that the direction of the electrical field and the carrier movement “depends solely on the slope of the graded concentration of dopant” **does not mandate that the slope must be only increasing or only decreasing to maintain a unidirectional drift field.** For example, the slope has both a direction and a magnitude and Defendant suggests that the direction of the drift electric field depends solely on **the direction** of the slope of the graded concentration of dopant. This is not justified by the prosecution history statements that Defendant cites. In fact, the *Grove* reference cited by the patentee in the above-quoted statement includes Figure 7.13 (reproduced and annotated below) which depicts a dopant concentration that both increases and decreases in the “graded base region” that provides an “electric field . . . of such direction as to aid the motion of injected holes.” A.S. Grove, *Physics and Technology of Semiconductor Devices* 224–25 (1967), Dkt. No. 50-13 at 22–23. In other words, **the patentee cited Grove to support that a graded dopant concentration will provide a unidirectional electric drift field to move the minority carriers in a single direction** and *Grove* discloses a dopant concentration that both increases and decreases in the drift layer. **The prosecution history does not state that the dopant concentration must only increase or only decrease** across the drift layer.

Ex. 2075 (EDTX Claim Construction Order) at 15-16



Grove (Ex. 1068) at 225 (annotated);
Ex. 1060 (Banerjee Supp. Declaration) at ¶29.

- EDTX acknowledged that patentee conceded that “a graded dopant concentration “will provide a[n] electric drift field to move minority carriers in a single direction”

Greenthread Mischaracterizes WDTX Claim Construction Order

- Court evaluated whether “graded dopant concentration” is indefinite

Term	Greenthread’s Proposed Construction	Cirrus’s Proposed Construction	Court’s Preliminary Construction
#4: “graded dopant concentration” / “graded dopant region” / “graded dopant acceptor concentration” / “graded donor dopant concentration” / “graded concentration of dopants” / “graded dopant” / “graded concentration”	Not indefinite. Plain and ordinary meaning, where the plain and ordinary meaning is a graded (or varying) concentration of dopants.	Indefinite	Not indefinite. Plain-and-ordinary meaning, which includes a graded concentration of dopants.
#6: “to aid the movement of minority carriers from...to...”	Plain and ordinary meaning	“to aid the movement of minority carriers starting from...and reaching...”	Plain-and-ordinary meaning

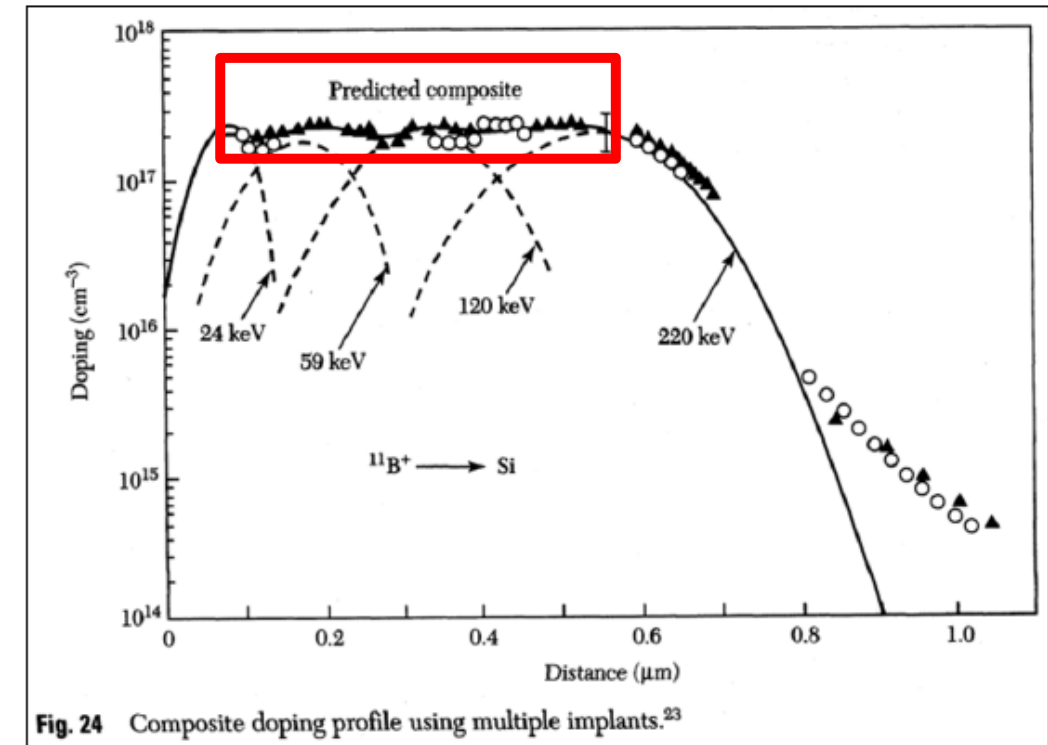
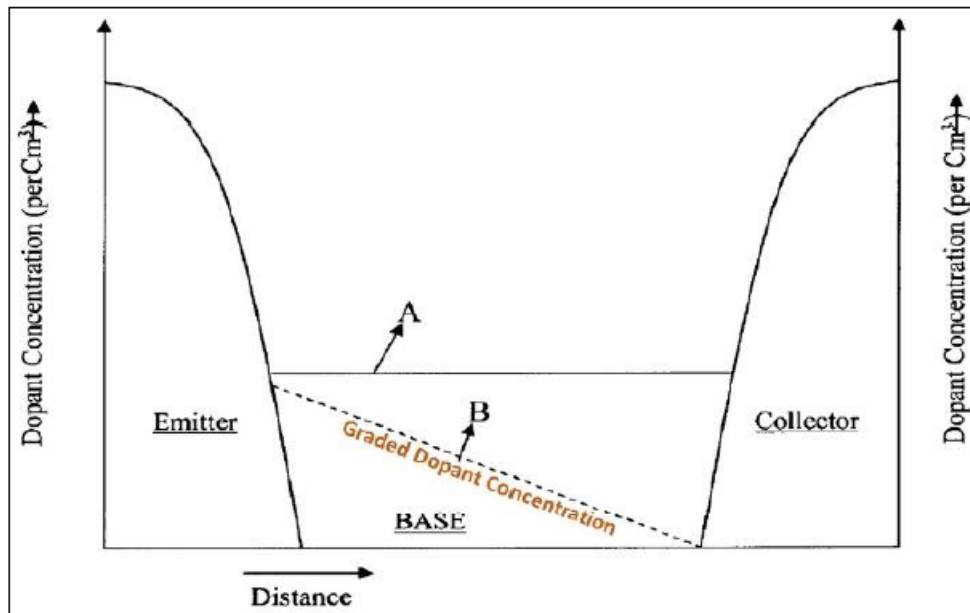
Ex. 2074 (WDTX Claim Construction Order) at 15, 83-84.

- Court did not evaluate whether the “graded” term requires a minimum magnitude to aid movement

'195 Reply at 21-22;
'502 Reply at 14-16;
'222-II Reply at 14-16

Greenthread Mischaracterizes WDTX Claim Construction Order

- Petitioners argued that even a uniform doping has some variations



Size textbook.

- Reference to “sufficiently graded” in Order:
 - Contrasts *uniform* concentration with *graded* concentration
 - May refer to the span of the graded doping (e.g., from the surface towards the substrate)

Ex. 2074 (WDTX Claim Construction Order) at 15, 83-84.

Greenthread’s “Aid Carrier Movement” Arguments Fail

Greenthread’s Argument	Why This Argument Fails
“Aid carrier movement” requires that a carrier move	Claims are directed to a <u>device</u> with structural features, not a method
“Carrier movement” refers to the net movement of carriers when the device is turned ON	Greenthread rewrites the claims. Drift-induced movement (even when device is OFF) is sufficient
Petitioners now argue that “carrier movement” refers to Brownian motion	Red herring; Petitioners merely provided technical context, that that carriers are constantly moving.
The direction of the slope is insufficient to show “aided”	Nothing in the intrinsic record suggests measuring or comparing slope magnitude
Warrick, WDTX, and EDTX confirm that the claims require measuring the magnitude of the slope	Greenthread mischaracterizes each of these documents
Dr. Banerjee: “3 categories of forces” affect carrier movement	Dr. Banerjee confirmed that these 3 categories of forces don’t alter the carrier movement
Dr. Banerjee: an additional, gate oxide-induced E-field imparts an additional force on the carriers	Claims directed to “ <i>a graded dopant concentration to aid carrier movement</i> ”; other E-fields don’t negate this

See generally '195 Reply; '502 Reply; '222-II Reply;
Ex. 2078 (Dec. 6, 2024 Banerjee Tr.)

Petitioner's Single-Reference Obviousness Ground Based on Payne is Proper

Single-Reference Obviousness is a Proper Ground

“While [Patent Owner] argues that use of [the prior art reference] as a single anticipatory reference would have been more properly raised under § 102, **it is well settled that a disclosure that anticipates under § 102 also renders the claim invalid under § 103, for anticipation is the epitome of obviousness.**”

Realtime Data, LLC v. Iancu, 912 F.3d 1368, 1373, (Fed. Cir. 2019)

“The Board thus found the Challenged Claims unpatentable under 35 U.S.C. § 103 in light of a single prior art reference, Suda, which the Board found taught every limitation. **Because no modification to Suda was necessary to arrive at the claimed invention, the Board was ‘not required to make any finding regarding a motivation to’ modify Suda.**”

Unification Techs. LLC v. Micron Tech. Inc., 2024 WL 3738401, at *6 (Fed. Cir. Aug. 9, 2024)
(discussing *Realtime Data*)

Greenthread's Reliance on *M&K Holdings* is Misplaced

“The Board's anticipation finding was not inherent in Samsung's obviousness theory; to the contrary, Samsung's position before the Board contradicted such a conclusion. **Samsung expressly stated in its petition that WD4-v3 did not disclose the “predetermined block” limitation in claim 3**, see J.A. 194; Samsung argued obviousness as a substitute for that lack of disclosure, see *id.*; and Samsung did not assert or otherwise disclose the particular claim interpretation and anticipation theory adopted by the Board.”

M & K Holdings, Inc. v. Samsung Electronics Co., Ltd., 985 F.3d 1376 (Fed. Cir. 2021).

Greenthread's Settlement Agreements Do Not Show Nonobviousness

Evidence of Nexus is Required for License Agreements as Secondary Considerations

“[T]he fact that a patent has been licensed, taken alone, generally is insufficient for purposes of showing commercial success.”

Intron Networked Sols., Inc. v. Acoustic Tech., Inc., No. IPR20170-01031, 2018 WL 10440326, at *10 (P.T.A.B. Aug. 21, 2018).

We “specifically require affirmative evidence of nexus . . . because it is ‘often cheaper to take licenses than to defend infringement suits.’”

Iron Grip Barbell Co. v. USA Sports, Inc., 392 F.3d 1317, 1324 (Fed. Cir. 2004) (cit. omitted).

Litigation Settlements are Not Objective Evidence of Nonobviousness

Greenthread's Response:

Finally, licenses that are part of litigation settlements can also be probative of non-obviousness. ***Fox Factory Inc. v. SRAM LLC*, IPR2017-00472, Paper 64 at 44 (PTAB April 18, 2018).**

'842 POR at 29; '481 POR at 29-30;
'014 POR at 29-30; '222-I POR at 29

The Federal Circuit vacated this *Fox Factory* decision because “the Board **erroneously presumed nexus** between the evidence of secondary considerations and the independent claims.”

Fox Factory, Inc. v. SRAM, LLC, 944 F.3d 1366, 1378 (Fed. Cir. 2019).

On remand, the Board ultimately found **all challenged claims unpatentable**, concluding that “at best, Patent Owner shows a *weak nexus*” for licenses mentioning the challenged patent and “*no nexus* with respect to the remaining licenses” that did not.

Fox Factory, Inc. v. SRAM, LLC, IPR2017-00472, Paper 74, 11, 14-15
(P.T.A.B. Feb. 25, 2021).

No Evidence that Greenthread's Licensees Valued its Patents (Warrants Excluding Rao's Declaration)

Dr. Rao's Deposition:

Q. You had no direct conversations with any representatives or employees of any of the licensees of the licenses that are the exhibits to your declaration, Exhibit 1; is that correct?

A. Our outside counsel worked with Mr. John and myself in whatever they had to because they represented us. So we, as far as I know, **I did not directly talk to any of them**, and whatever happened between our counsel and us, it's privileged.

Q. My question related to conversations you had, not with your attorneys, but with any representatives or employees of the licensees of the licenses that are exhibits to your declaration, Exhibit 1.

A. I believe I answered it earlier. That's what directly is, **no, I did not talk to any of the employees.**

Q. And am I also -- to your knowledge, that's true of Mr. John, he had no conversations with employees or representatives of any of the licensees of the licenses attached to your declaration, Exhibit 1?

A. To the best of my knowledge, **Mr. John never told me he had any conversations with any employee.**

Ex. 1066 (Rao Dep. Tr.) at 23:5-24:11

RPX's Involvement Shows Licenses Were Motivated by Litigation Costs



FAQs

We are a unique solution to all forms of patent risk

Only RPX has the scale and independence to efficiently acquire patent portfolios pre-litigation and out of active litigation. Only RPX can spread the cost of reducing patent litigation across a large network of participating companies. Only RPX has accurate litigation cost data and a proven actuarial model to provide affordable, comprehensive patent litigation insurance. And only RPX can deliver – to companies of any size and with a patent litigation problem of any severity – significant, quantifiable, and cost-effective reduction of risk.

We provide compelling cost savings

RPX's interests are 100% aligned with those of our clients. We work to ensure that each RPX client avoids more in legal costs and settlements each year than they pay RPX in subscription fees. We quantify the cost savings we have delivered collaboratively with the client. Together, we review the RPX acquisitions relevant to the client and determine a specific "avoided cost". The cumulative avoided cost is applied against the client's annual fee to calculate the dollar savings we have delivered for the year. We have been very successful delivering cost savings to all of the members in our network, a key factor in our consistently strong annual renewal rate.

The Petitions are Timely

The Board and Director Have Already Rejected Greenthread's Arguments

- Petitioners filed these IPR proceedings in response to specific lawsuits filed by Greenthread.

- Arms-length customer/supplier relationships, without more, do not create privity.

See, e.g., WesternGeco LLC v. ION Geophysical Corp., 889 F.3d 1308, 1319-22 (Fed. Cir. 2018);
Wi-Fi One, LLC v. Broadcom Corp., 887 F.3d 1329, 1340-41 (Fed. Cir. 2018);
Samsung Electronics Co. Ltd. v. Netlist Inc., IPR2022-00615, Paper 64 at 22-26 (PTAB, June 30, 2023)

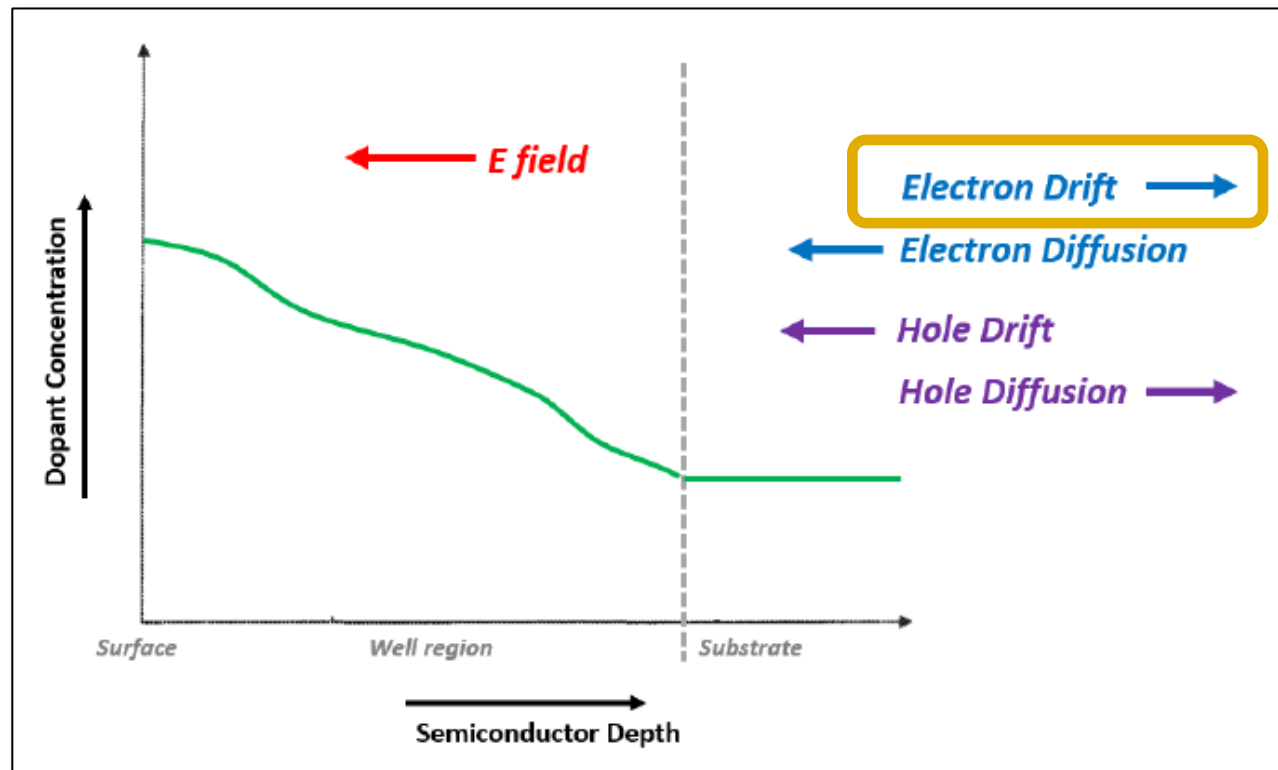
- No evidence showing that any Petitioner is in privity with any prior petitioners.

Worlds, Inc. v. Bungie, Inc., 903 F.3d 1237, 1242-44 (Fed. Cir. 2018)

The Board and Director Have Already Rejected Greenthread's Arguments

- It would be fundamentally unfair to allow Greenthread to manufacture privity between Petitioners and any prior litigant.
 - Privity arguments hinge on Greenthread's agreement with RPX, as creating a time bar for Petitioners
 - Petitioners were strangers to the RPX agreement, and to prior litigations
- Greenthread's conduct does not warrant denying Petitioners their day in court.

Carrier Movement in a Doped Semiconductor

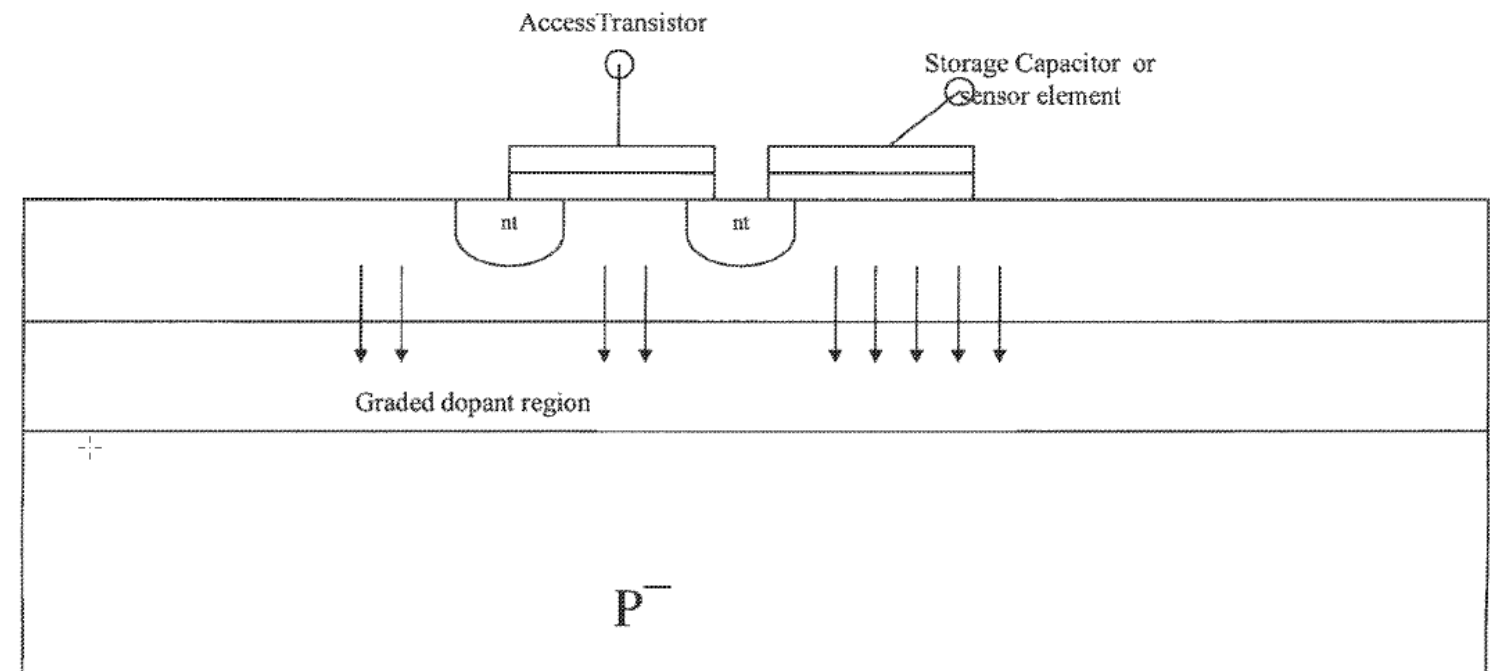
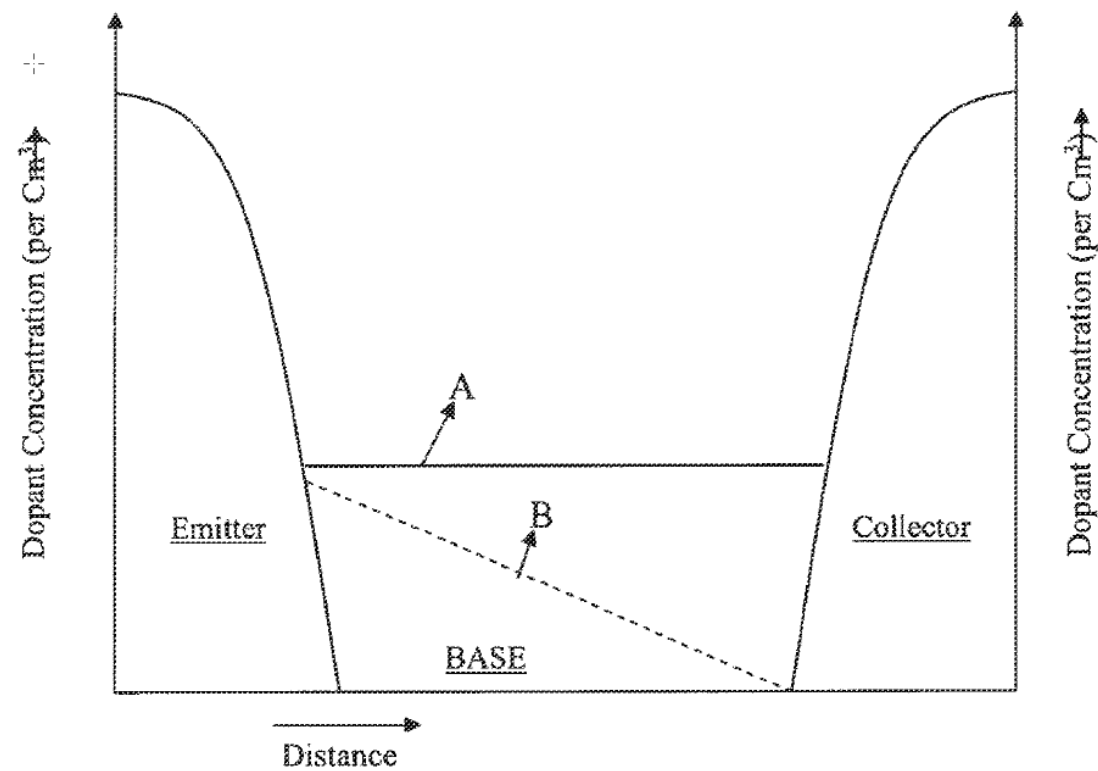


P-type dopants:

- E-field towards the surface
- Minority carrier (electrons) drift from surface towards substrate

Ex. 1060 (Banerjee Supp. Declaration) at ¶¶23-27
(explaining drift and diffusion)

Greenthread's Specification Cites Relate to *Bipolar* Transistors

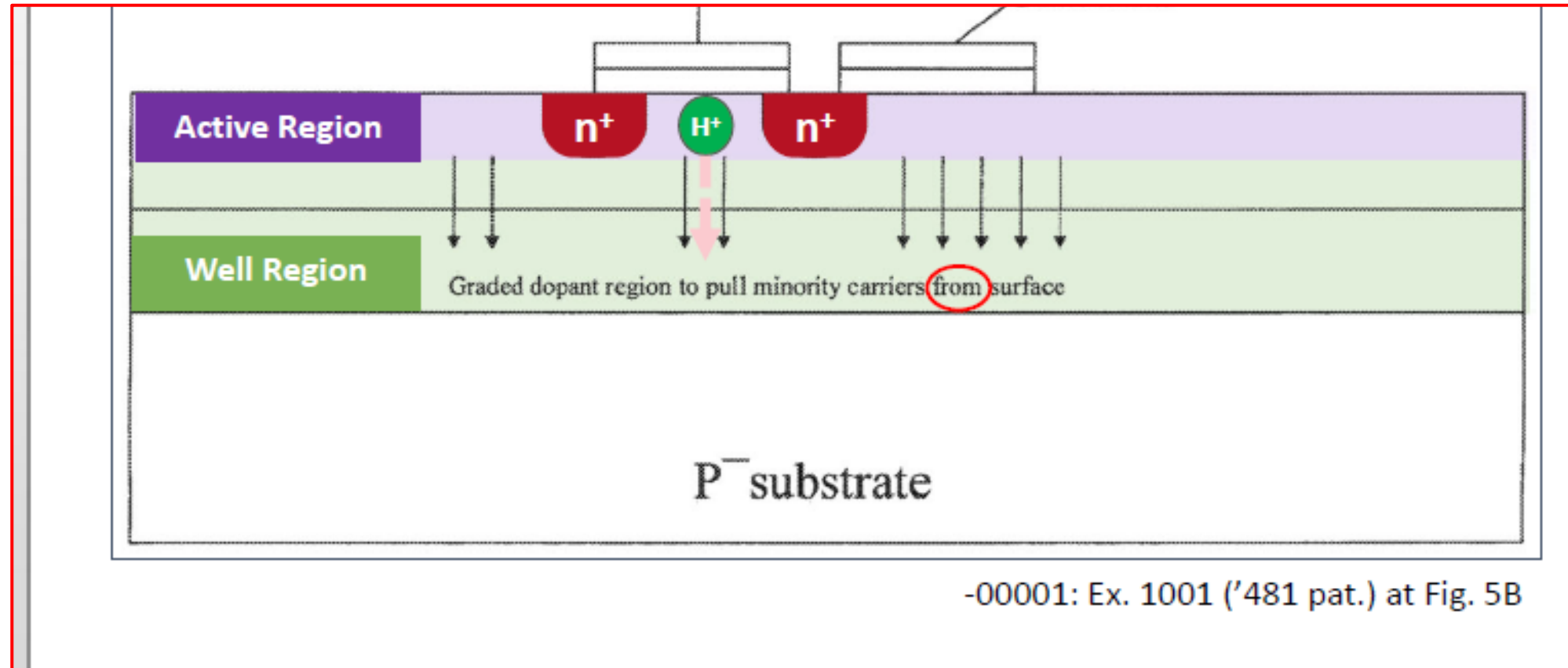


'195 Patent (Ex.1001) (-00017) at Figs. 1, 5B

Greenthread's Attorney Argument on Minority and Majority Carriers is Flawed

Greenthread's Interpretation of “Majority” / “Minority” Carrier Is Flawed

Greenthread's Position (Incorrect):



Greenthread Demonstratives
(Jan 28th Hearing) Slide 8

Greenthread argues that what are majority and minority carriers is dictated by what occurs during operation of a transistor

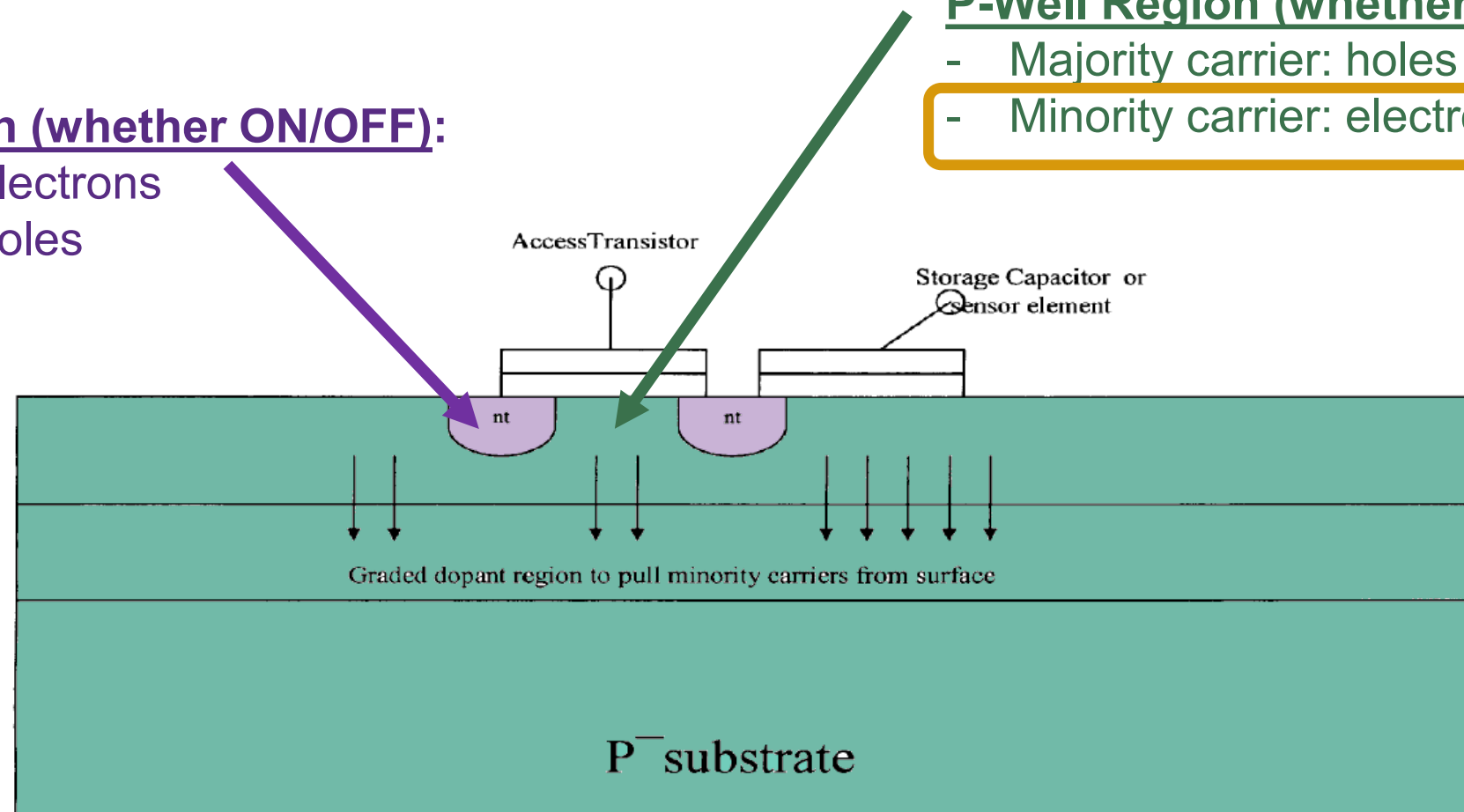
Dr. Banerjee Explained that “Majority” / “Minority” Carrier Type Hinges on the Doping Type of a Given Region

NMOS Source/Drain (whether ON/OFF):

- Majority carrier: electrons
- Minority carrier: holes

P-Well Region (whether ON/OFF):

- Majority carrier: holes
- Minority carrier: electrons



NMOS in a p-well (Figure 5B)

COVINGTON

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.), 301:1-12

Ex. 1060 (Banerjee Supp. Decl.), ¶83

' 195 Reply at 19;

"502 Reply at 13;

'222-II Reply at 13

Dr. Banerjee Explained that “Majority” / “Minority” Carrier Type Hinges on the Doping Type of a Given Region

Dr. Banerjee’s Supp. Declaration:

83. Dr. Glew is incorrect in believing that the holes are minority carriers in the channel of the transistor depicted in Fig. 5B. As explained above, when a gate voltage in excess of V_T is applied to an n -type FET, the inversion layer will have more electrons than holes. *See supra* Section IV.D. However, the term “majority carrier” refers to the carrier type that is provided by the dopants; the other type is the “minority carrier.” In the p -type channel, well, and substrate, the minority carriers are electrons and majority carriers are holes. Regardless of the fact that once the channel is inverted, there is an excess of electrons compared to holes in the inversion region. In a n -type channel, well and substrate, the minority carriers are holes and the majority carriers are electrons. *See* Ex. 1061 (Sze) at 37 (discussing donors and acceptors). *See supra* Section IV.E and IV.F.

Ex. 1060 (Banerjee Supp. Decl.), ¶83

Dr. Banerjee’s Deposition:

Q. Is it your position that **the majority carrier or minor carrier will change depending on where you are in the semiconductor device?**

A. Yes. It will depend on what the doping type is in that region. If the doping type is donors, electrons have the majority, holes are the minority. **If the doping type is acceptors,** holes are the majority, **electrons are the minority.** And that's not my position. **That's accepted terminology.**

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.), 301:1-12

The File History Contradicts Greenthread's Current Position

195 Prosecution History:

(Ex. 1002) (-00017) at 254 (Oct. 12, 2011 Response)

function.” The specification further states that “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.” In other words, the drift field for the holes (minority carriers) is unidirectional, i.e., from the emitter (surface layer) to the collector (substrate) because of the particular slope of the donor concentration. This unidirectional drift

Greenthread's Continuing Prosecution (Aug. 2024):

Aug. 2024 Remarks in 17/728,588 (Ex.1070) at 11

the base of a transistor in the disclosed embodiment. But it is still nothing more than a region through which carriers are transmitted and the function of that gradient is to create “a suitable aiding drift electric field, to help the holes (minority carriers in a p-n-p transistor) traverse from emitter to collector.” The emitter is just one boundary with the base and the collector is the other boundary with the base, but the base is just a region disposed therebetween through which holes (minority carriers for a p-n-p transistor or electrons as minority carriers for an n-p-n transistor) can traverse. The gradient just affects the function of that traversal within the particular region, which region just happens to be a base. But that function is not restricted only to a transistor; rather, it

The Specification Refers to Majority Carriers from Source and Drain During Conduction

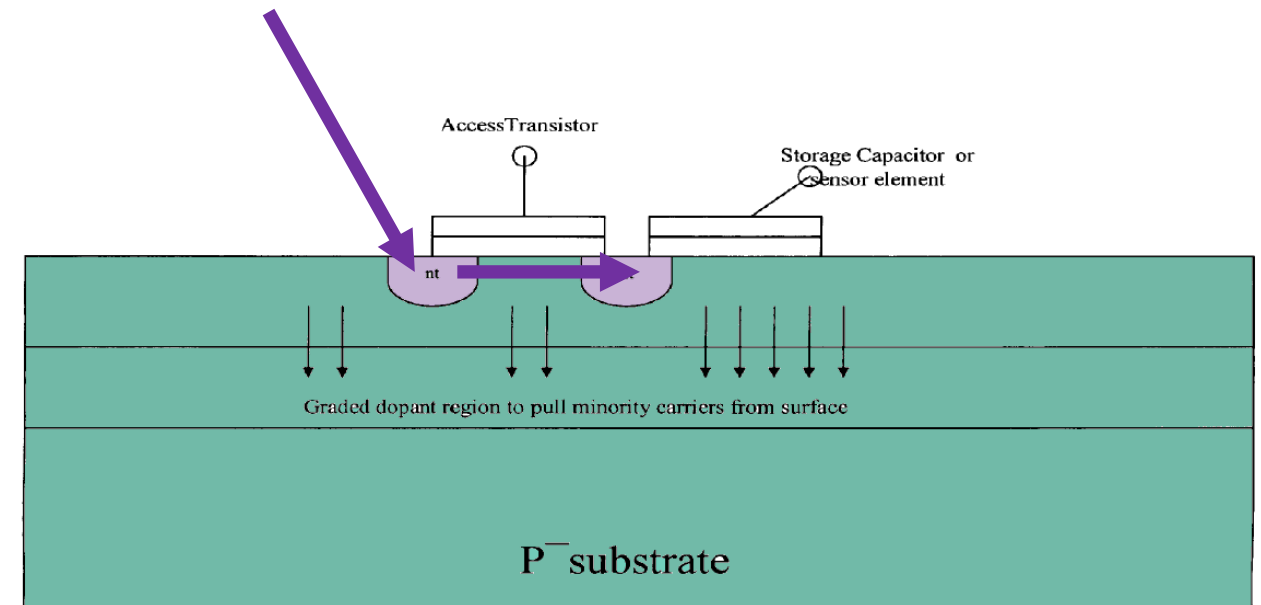
Specification:

In contrast to BJTs, MOS devices are majority carrier devices for conduction. The conduction is channel dominated. The

The graded dopant can also be implemented in surface channel MOS devices to accelerate majority carriers towards the drain. In nonvolatile memory devices, to decrease program-

E.g., 195 Patent (Ex. 1001) (-00017), 1:43-44, 3:41-43

NMOS Source: Majority carrier: electrons



Ex. 1060 (Banerjee Supp. Decl.), ¶83

' 195 Reply at 19;
'502 Reply at 13;
'222-II Reply at 13

The Specification Mirrors Dr. Banerjee's Explanation of "Majority/Minority"

Specification:

In contrast to BJTs, MOS devices are majority carrier devices for conduction. The conduction is channel dominated. The

The graded dopant can also be implemented in surface channel MOS devices to accelerate majority carriers towards the drain. In nonvolatile memory devices, to decrease program-

E.g., 195 Patent (Ex. 1001) (-00017), 1:43-44, 3:41-43

Dr. Banerjee's Deposition:

Q. . . .When this sentence is mentioning majority carriers, do you have an understanding of what region of the device they are referring to when they mention majority carriers?

A. Once again, majority carriers in a region location refer to the carriers created by the dopants. Assuming you are looking at an NMOS, the majority carriers are the source of the electrons and would flow from the source to the drain.

Ex. 2078 (Dec. 6, 2024 Banerjee Tr.), 335:17-336:16

Ex. 1060 (Banerjee Supp. Decl.), ¶83

' 195 Reply at 19;
"502 Reply at 13;
'222-II Reply at 13

Greenthread's Belated Claim Construction Argument for “Minority Carriers” Should be Rejected

“To act as its own lexicographer, a patentee **must clearly set forth a definition** of the disputed claim term other than its plain and ordinary meaning’ and **must ‘clearly express an intent to redefine the term.’**”

Kyocera Senco Industrial Tools Inc. v. Int’l Trade Comm., 22 F.4th 1369, 1378 (Fed. Cir. 2022)
(citing *Thorner v. Sony Computer Ent. Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012))

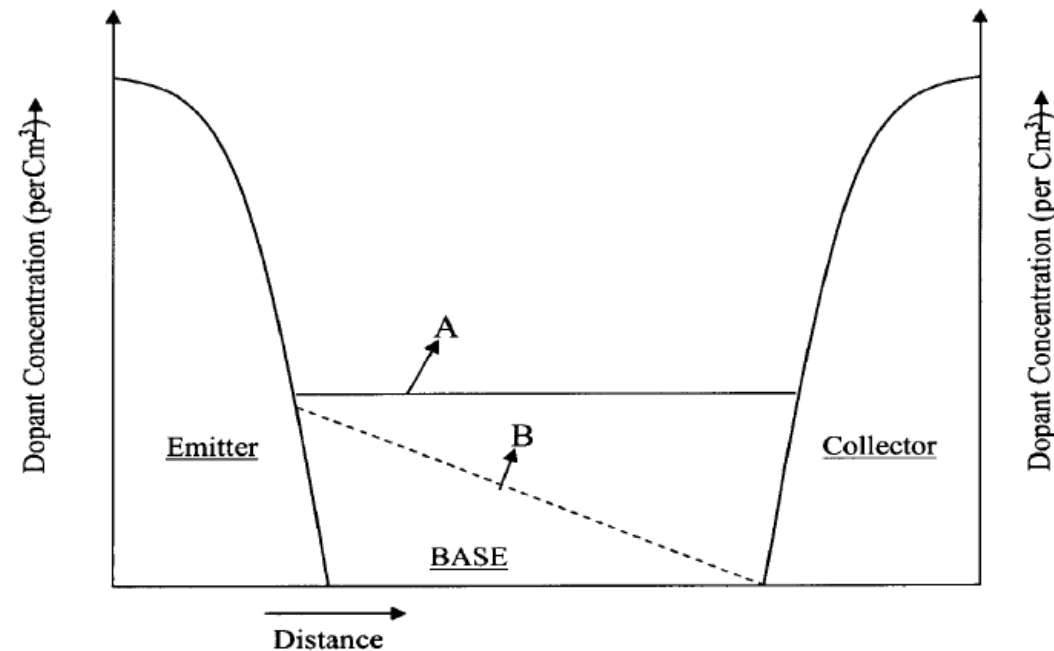
Specification:

In contrast to BJTs, MOS devices are majority carrier devices for conduction. The conduction is channel dominated. The

The graded dopant can also be implemented in surface channel MOS devices to accelerate majority carriers towards the drain. In nonvolatile memory devices, to decrease program-

E.g., 195 Patent (Ex. 1001) (-00017), 1:43-44, 3:41-43

Majority and Minority Carriers are Dictated by the Dopant Type



Specification:

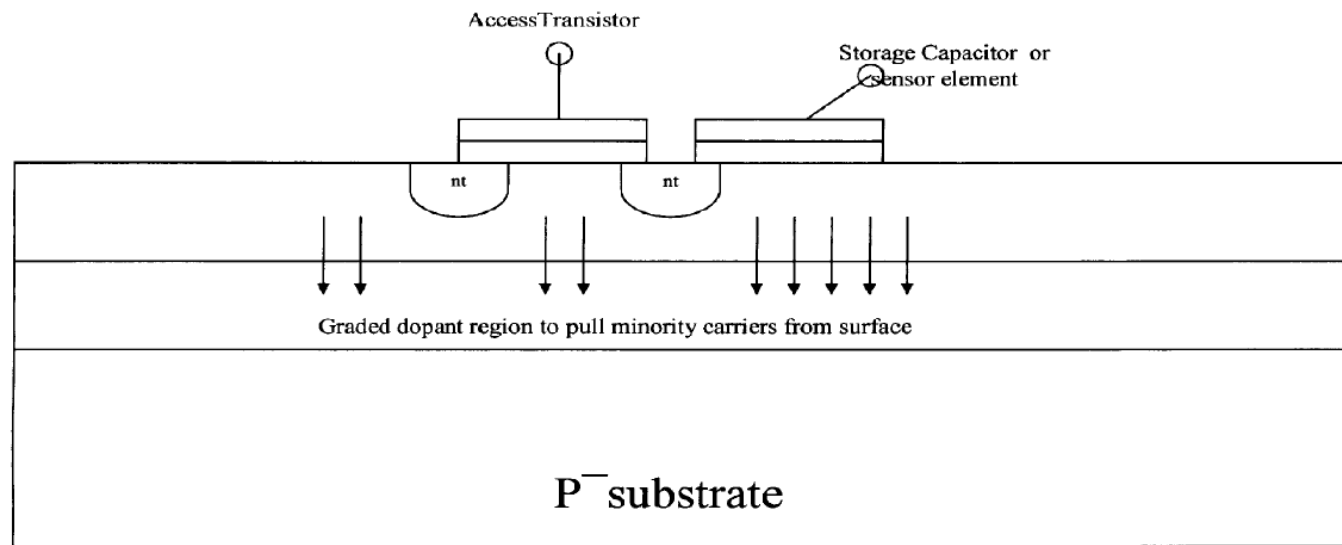
The relative doping concentrations of emitter and collector regions varies from 10^{18} to $10^{20}/\text{cm}^3$, whereas the base region is 10^{14} to $10^{16}/\text{cm}^3$ depending on the desired characteristics of the BJT. In graded base p-n-p transistors, the donor dopant concentration may be 10 to 100 $\times$ at the emitter-base junction, relative to the base-collector junction (1 $\times$). The gradient can be linear, quasi linear, exponential or complementary 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 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 $\times$ -5 $\times$. Similar performance improvements are also applicable to n-p-n transistors.

'195 Patent (Ex. 1001) (-00017) at 2:35-50, Fig. 1

Ex. 1060 (Banerjee Supp. Decl.), ¶83

'195 Reply at 19;
'502 Reply at 13;
'222-II Reply at 13

Certain Claims Require “a Graded Concentration” to Aid Minority Carrier Movement “*To Said Surface Layer*”



'195 Patent, Claim 8

8. A CMOS Semiconductor device comprising:
a surface layer;
a substrate;
an active region including a source and a drain, disposed on one surface of said surface layer,
a single drift layer disposed between the other surface of said surface layer and said substrate, said drift layer having a graded concentration of dopants extending between said surface layer and said substrate, said drift layer further having a first static unidirectional electric drift field to aid the movement of minority carriers from said substrate to said surface layer; and
at least one well region disposed in said single drift layer, said well region having a graded concentration of dopants and a second static unidirectional electric drift field to aid the movement of minority carriers from said substrate TO SAID SURFACE LAYER.

'195 Patent (Ex. 1001) (-00017) at cl. 8

Ex. 1060 (Banerjee Supp. Decl.), ¶83

'195 Reply at 19;
'502 Reply at 13;
'222-II Reply at 13

Majority and Minority Carriers are Dictated by the Dopant Type

Grove Textbook at 225 (cited During Prosecution):

In the case of *pn*p transistors, because of the impurity concentration gradient, the electrons within the base tend to diffuse toward the collector. Thus an electric field must be present, pushing the electrons toward the emitter-base junction. This same electric field will then be of such direction as to aid the motion of injected holes. Thus the injected minority carriers will now move not only by diffusion but also by drift due to the existence of this electric field. As a result, the transit time across the base will decrease and the upper frequency limitation of the transistor associated with this transit time will increase.² Correspondingly, the transport factor will also increase.

Grove (Ex. 1068) at 224-225

Limitations and Modifications of the Simple Theory

225

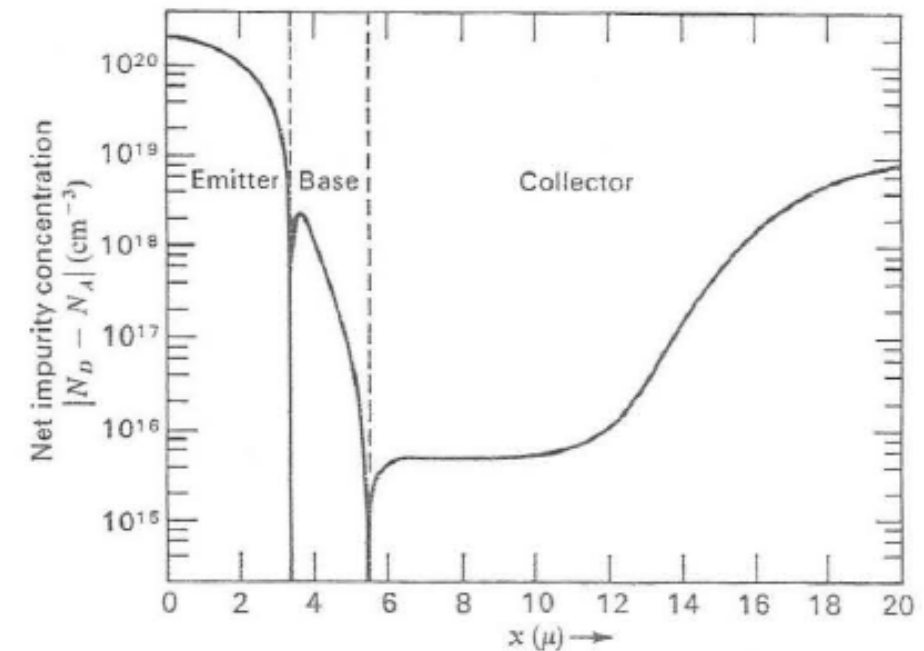


Fig. 7.13 The impurity distribution in the *pn*p transistor. (Estimated on the basis of diffusion conditions.)

Ex. 1060 (Banerjee Supp. Decl.), ¶¶, 29-32, 83

'195 Reply at 19;

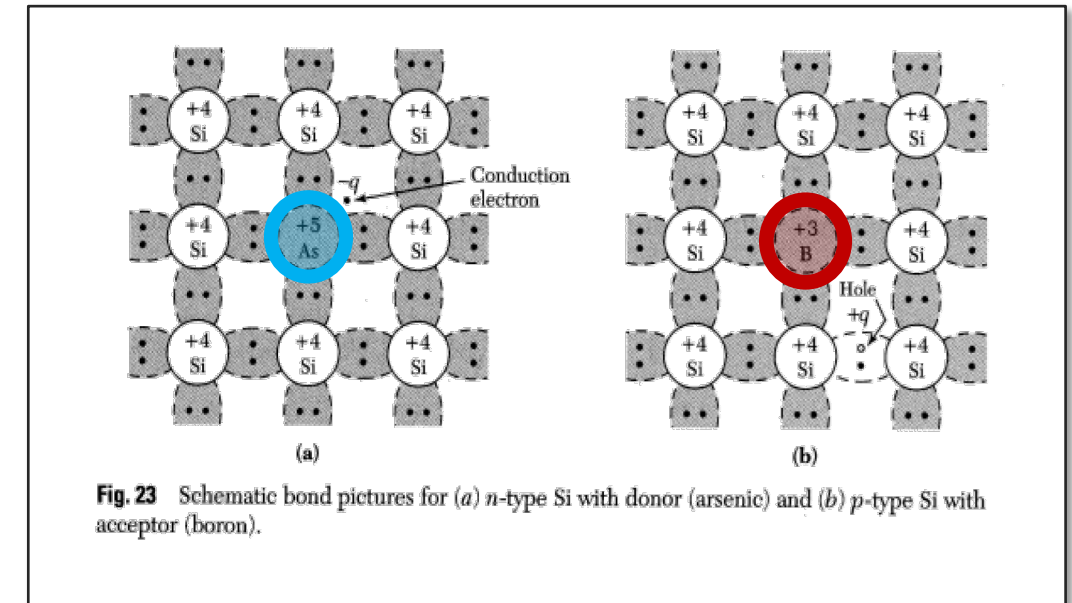
'502 Reply at 13;

'222-II Reply at 13

Majority and Minority Carriers are Dictated by the Dopant Type

2.7 DONORS AND ACCEPTORS

When a semiconductor is doped with impurities, the semiconductor becomes *extrinsic* and impurity energy levels are introduced. Figure 23a shows schematically that a silicon atom is replaced (or substituted) by an arsenic atom with five valence electrons. The arsenic atom forms covalent bonds with its four neighboring silicon atoms. The fifth electron has a relatively small binding energy to its host arsenic atom and can be “ionized” to become a conduction electron at a moderate temperature. We say that this electron has been “donated” to the conduction band. The arsenic atom is called a *donor* and the silicon becomes *n-type* because of the addition of the negative charge carrier. Similarly, Fig. 23b shows that when a boron atom with three valence electrons substitutes for a silicon atom, an additional electron is “accepted” to form four covalent bonds around the boron, and a positively charged “hole” is created in the valence band. This is a *p-type* semiconductor, and the boron is an *acceptor*.



Size (Ex. 1061) at 37-38
Ex. 1060 (Banerjee Supp. Declaration) at ¶12

Ex. 1060 (Banerjee Supp. Decl.), ¶83

'195 Reply at 19;
"502 Reply at 13;
'222-II Reply at 13

Majority and Minority Carriers are Dictated by the Dopant Type

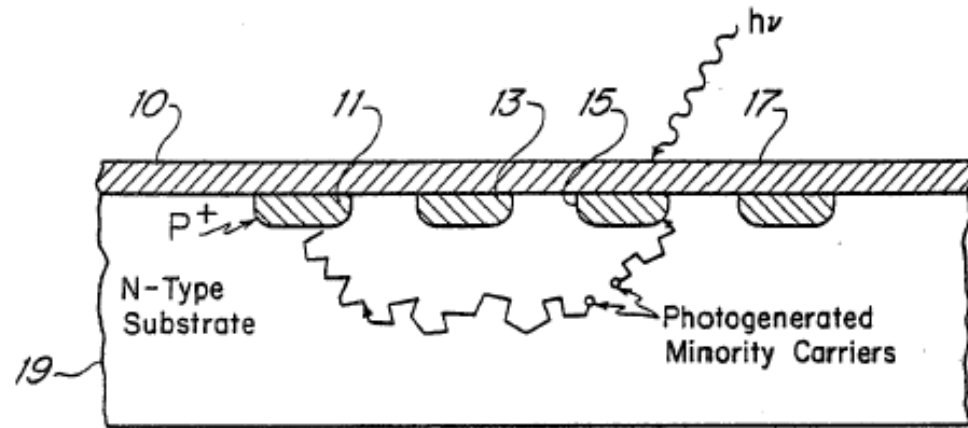


Figure 1 (PRIOR ART)

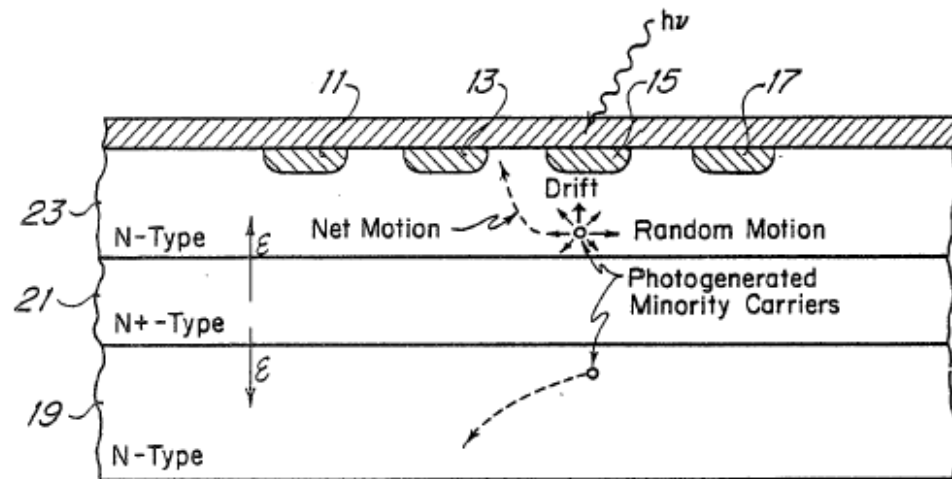


Figure 2

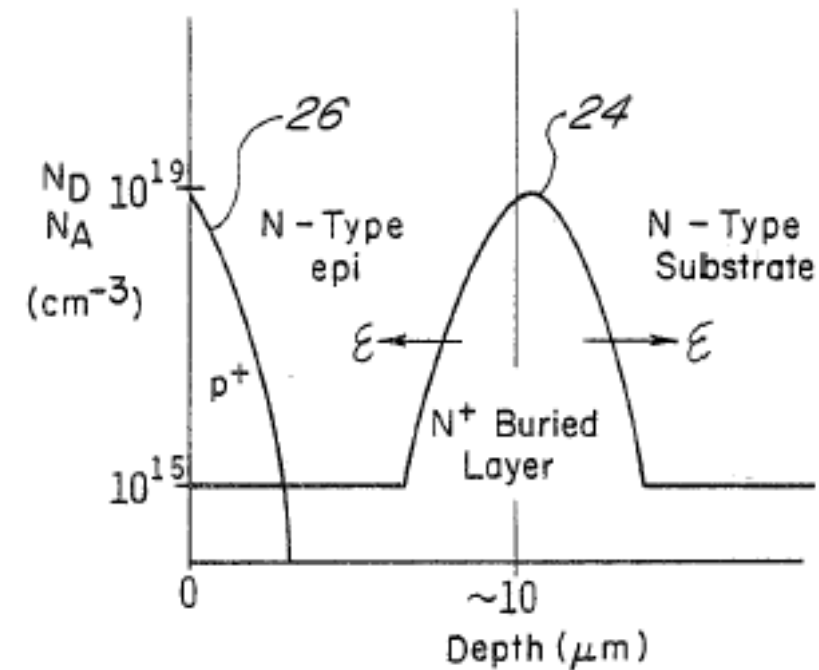


Figure 3

'195 Pet. at 16-36
'502 Pet. at 21-38
'222-II Pet. at 24-46

'195 Reply at 19;
 '502 Reply at 13;
 '222-II Reply at 13

Kamins (Ex. 1009) (-00017) at Figs. 1-3
Ex. 1060 (Banerjee Supp. Declaration) at ¶¶ 28, 83

Dr. Banerjee's Opinions are Reliable

Dr. Banerjee's Opinions are Reliable

3. I have been asked to provide my opinions regarding whether claims 1-18 of the '842 Patent (the "Challenged Claims") are invalid as obvious to a person having ordinary skill in the art at the time of the alleged invention. In connection with this effort, I have reviewed declarations provided in connection with other *Inter Partes Review* Petitions filed against the '842 Patent (specifically, Ex. 1003 in IPR2023-00308 filed on behalf of Petitioner Intel Corporation, and Ex. 1003 in IPR2023-01243 filed on behalf of Petitioner Semiconductor Components Industries, LLC). After having conducted my own independent analysis on the '842 Patent, I concur with the analyses provided in those declarations. For efficiency, I have excerpted portions of those declarations in drafting this declaration.

5. I am not currently, and have not at any time in the past been, an employee of any petitioner or real-party-in-interest. Other than set out above, I have no affiliation, contractual connection, or financial connection with any Petitioner or Real-party-in-interest, or any of their respective subsidiaries or parents. I similarly have no financial interest in, or affiliation with the Patent Owner.

Ex. 1003 (Banerjee Decl.) (-00016) at ¶¶3, 5

Banerjee's Redirect Was Not Improper



Patent Trial and Appeal Board

PRECEDENTIAL

Standard Operating Procedure 2

Designated: 07/10/2019

concludes. The prohibition of conferring with the witness ends once cross-examination concludes, and, if relevant, begins again when re-cross commences, and continues until re-cross concludes. The prohibition does not exist, however, during the time frame between conclusion of cross-examination and start of re-cross. As noted by our colleagues in *Google Inc. and Apple Inc. v. Jongerius Panoramic Tech., LLC*, IPR2013-00191, Paper 48, 3 (PTAB, Feb. 6, 2014), counsel is “permitted to confer with the witness before redirect examination begins.”

Focal Therapeutics, Inc. v. Senorx, Inc.,
IPR2014-00116, Paper 19 (PTAB July 21, 2014)

END
