12 Acknowledgment

Under Construction

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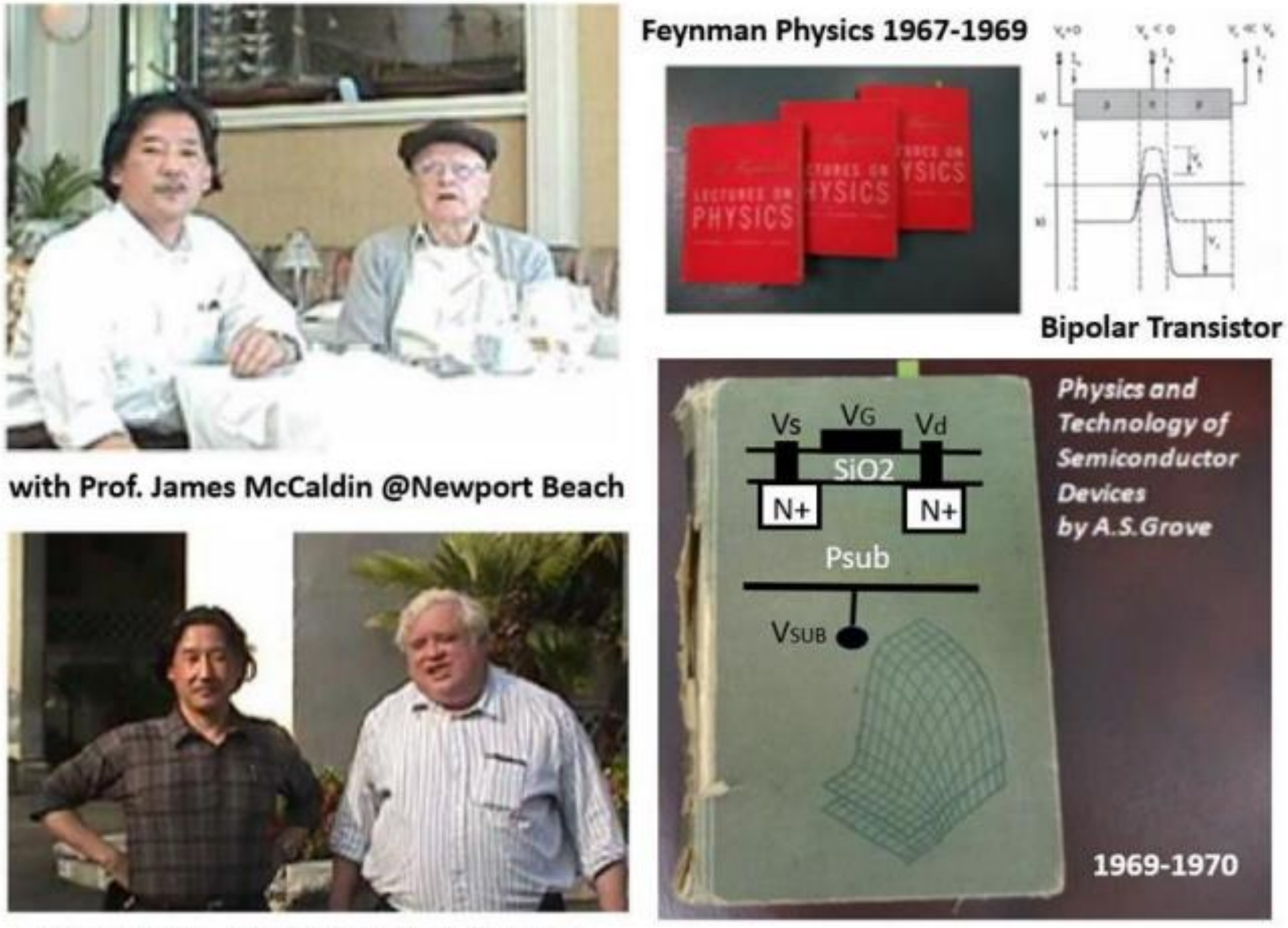
The author expresses sincere gratitude to Prof. James McCaldin for introducing and teaching Hagiwara the basic semiconductor device physics at Caltech in 1969.

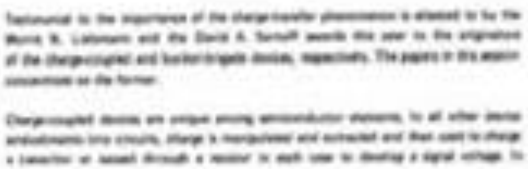


with Prof. James McCaldin @Newport Beach

with Prof. Tom McGill @Caltech Campus

12 Acknowledgment

The author expresses sincere gratitude to Prof. C.A. Mead and Prof. T.C. McGill, for advising the original 1971 work at Caltech on the Ga_2O_3 – Au Schottky Barrier interface study and characterization, and for guiding the 1974 PhD thesis work on the Charge Transfer Analysis of Buried Channel CCD Image sensors

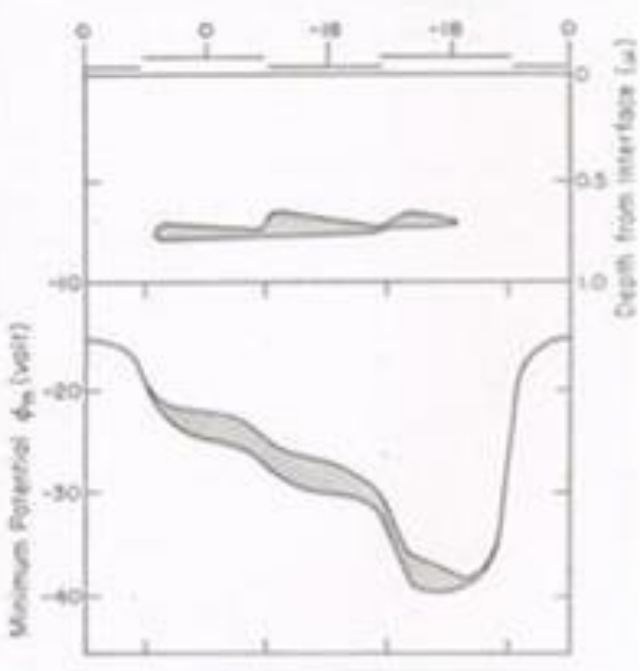


Charge-Coupled Devices and Applications

Chairman

Lewis M. Terman

My PhD thesis paper
on buried channel CCD
at ISSCC1974 in Philadelphia, USA



Prof. T. C. McGill

Prof. C. A. Mead

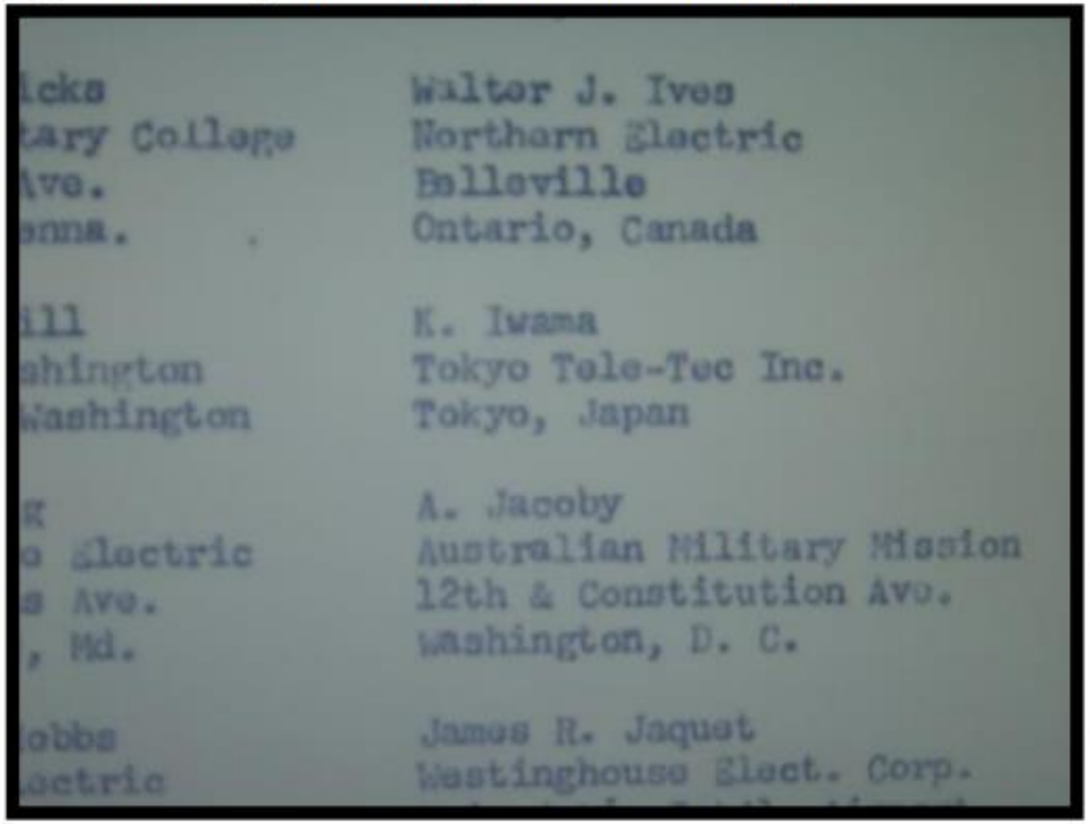
My first publication was a PhD thesis paper published at the ISSCC1974 in Philadelphia in Feb 1974. CalTech/JPL NASA (IBM) computers were used to perform three dimensional (x, y and t) BCCD device simulations for polysilicon and aluminum overlapping gate buried channel CCD structure with the two dimensional Poisson 's equation and time domain continuity equation.

12 Acknowledgment

Sony Image Sensor R/D efforts started with the strong initiative of Kazuo Iwama in 1969.

Kazuo Iwama in ISSCC1954 !

ICTC(ISSCC) 1954 Attendee List
@ University of Pennsylvania, Philadelphia、1954



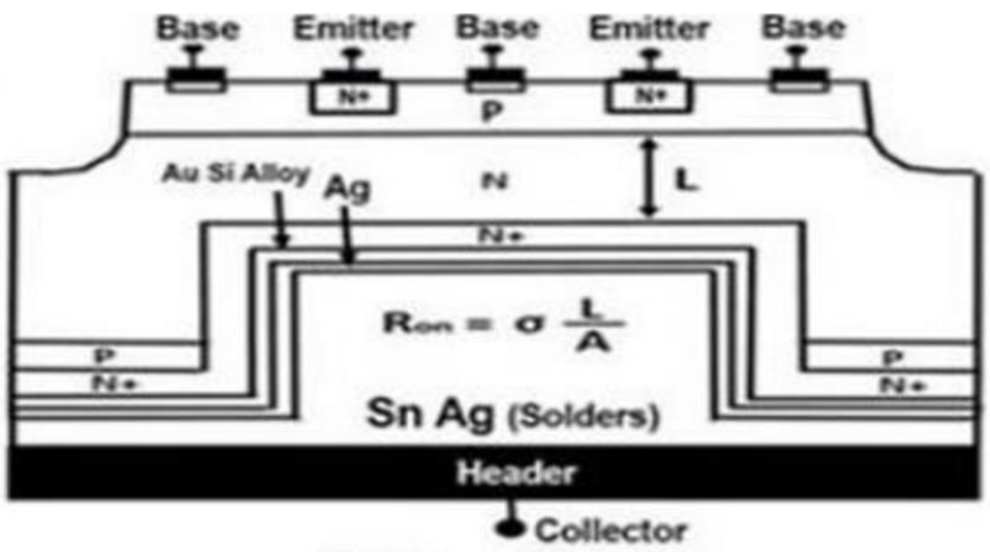
icks tary College Ave. enna.	Walter J. Ives Northern Electric Belleville Ontario, Canada
ill shington Washington	K. Iwama Tokyo Tele-Tec Inc. Tokyo, Japan
g o Electric s Ave. , Md.	A. Jacoby Australian Military Mission 12th & Constitution Ave. Washington, D. C.
obbs ectric	James R. Jaquet Westinghouse Elect. Corp.

Kazuo Iwama
Tokyo Tele-Tec Inc
Tokyo, Japan
Feb. 1954

12 Acknowledgment

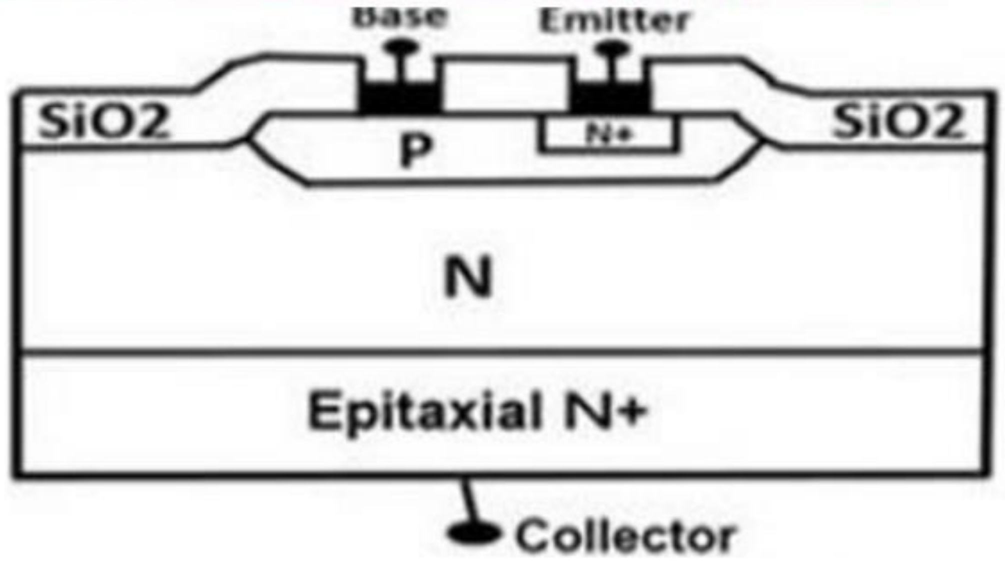
The author also express sincere gratitude to Yoshiyuki Kawana and Toshio Kato who guided Hagiwara In the Image Sensor R/D projects at Sony.

Kawana, Yoshiyuki at Sony invented the low collector On-Resistance N+PN junction type Bipolar transistor by thinning the back side of silicon wafer, a technique now used for the backside illumination CMOS image sensors widely to improve sensitivity.



(1) Low Collector Bipolar Tr invented by Yoshiyuki Kawana

Kato, Toshio at Sony invented the silicon surface light etching and new SiO2 Passivation technique for the N+PN junction type Bipolar transistor with the MESA like isolation, which is now known as the shallow trench isolation with the excellent side wall SiO2 formation to reduce the leakage current.



(2) New SiO2 Passivation Method invented by Kato Toshio

12 Acknowledgment

Hagiwara received many hints from the SONY bipolar process and device technology, which led Hagiwara to the original 1975 invention and 1978 development efforts for the P+PNP double junction type Pinned Photodiode

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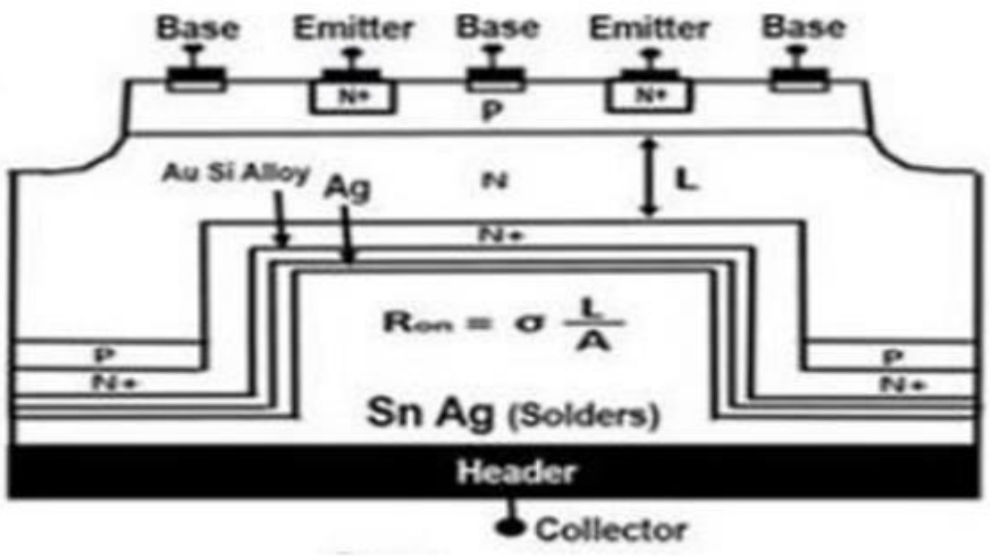

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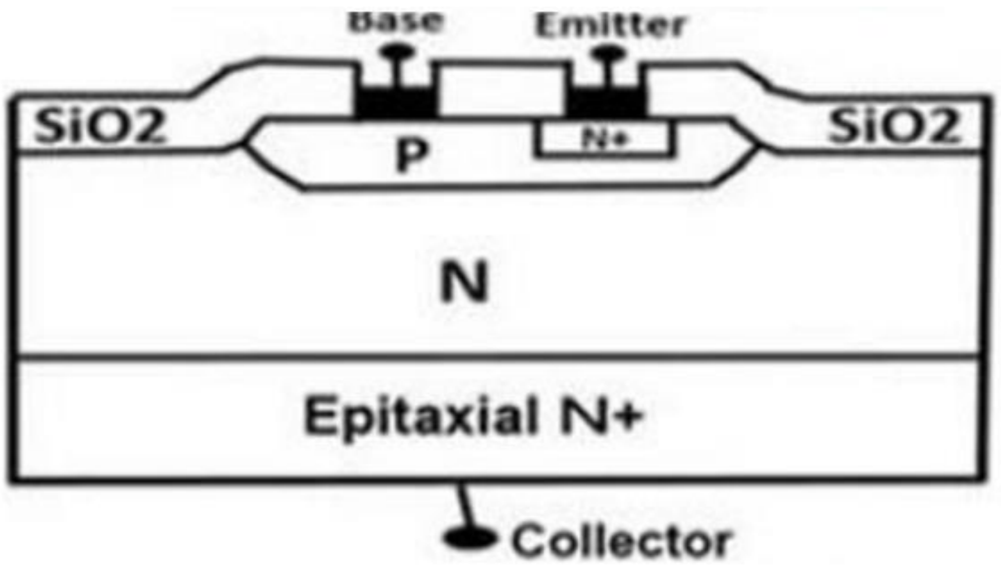

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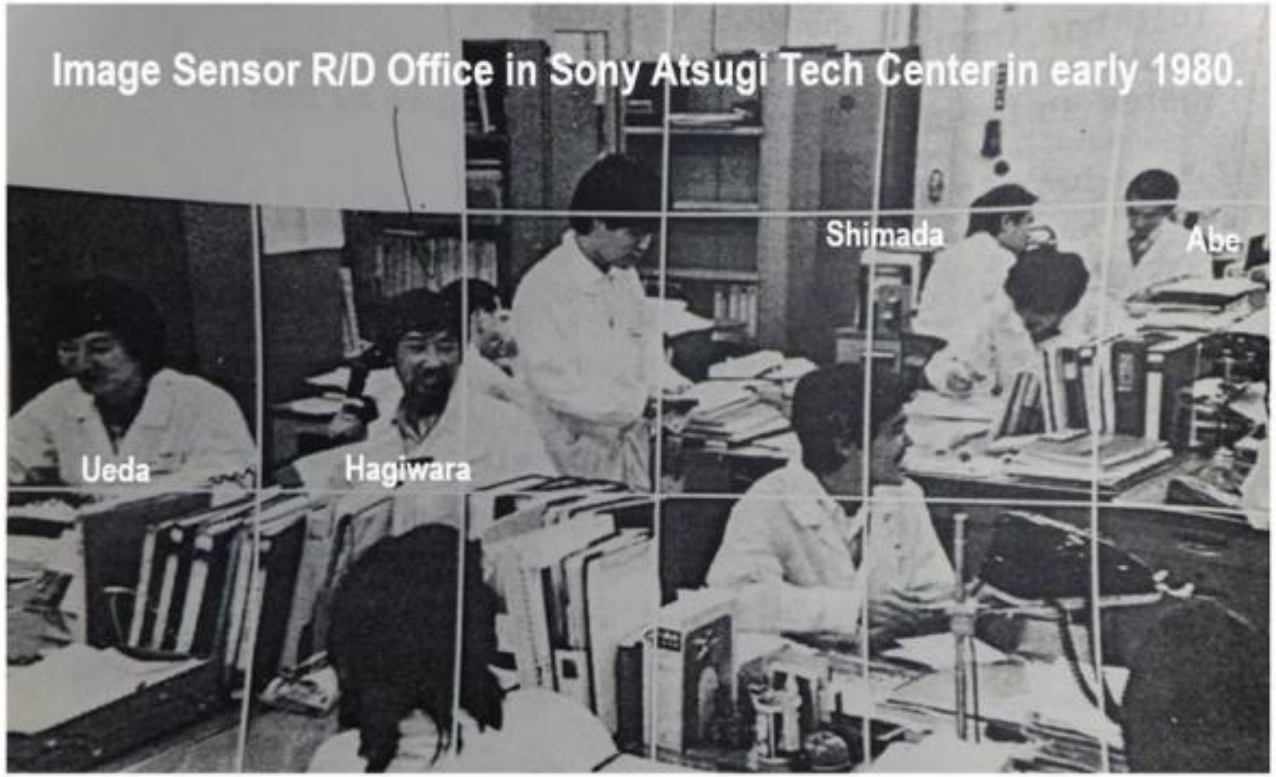
12 Acknowledgment

The author also received a lot of helps received from many coworkers at Sony including Motoaki Abe, Hiroshi Yamazaki, Terushi Shimizu, Yasuhiro Ueda, Tadakuni Narabu, Junya Suzuki and Tetsuo Kumezawa. Without their helps, this project was not possible. They are also dear friends and respectful mentors throughout private and public life at Sony.



12 Acknowledgment

Hagiwara explained why Sony is now so strong in the Image Sensor World.


1975-1982 Engineer in CCD Imagers and Camera System
1983-1989 Engineering Manager in SRAM/DRAM/ADC
1990-1998 General manager in Sony /NVM/MCU/PS1
1998-2008 Executive Staff Sony Semiconductor
Strategic Planning PS2/PS3
IEEE Computer Elemets Workshop
@ Vail, Colorado, 1995
Mitsuo Saito (Toshiba)
Bob Guensey (IBM)
Ken Kutaragi
Yoshiiaki Hagihara
06


Sony Chairman Ohga and Hagiwara
at Chairman Office in Sony Tokyo Headquarter, 1996

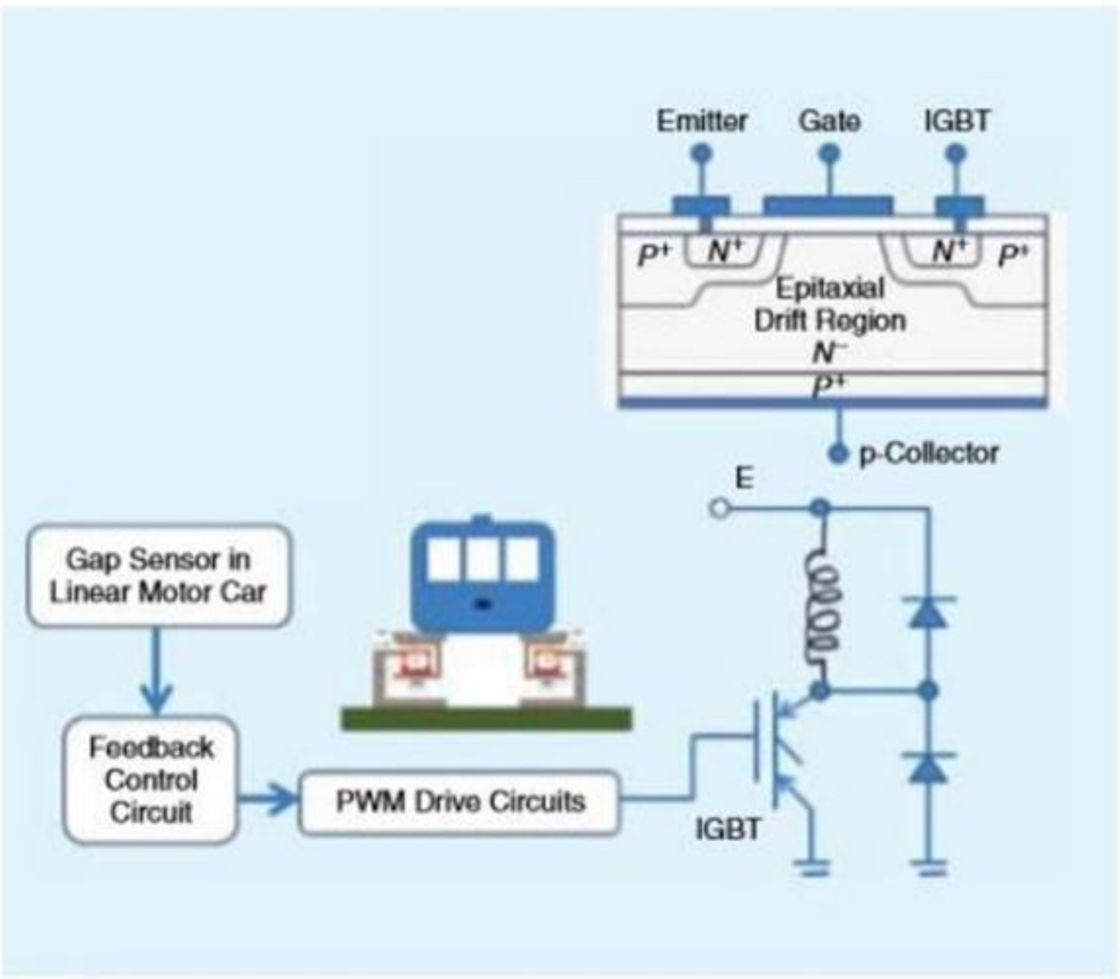

工学者100人が教える
自動車の最先端事情!!
崇城大学
情報学部情報学科
萩原良昭教授
YES
自動運転は可能
100人の学者が教えます
アカデミー
問.20年以内に全自動運転の車は日本で販売される?


ISSCC2013 San Francisco , Feb 18 2013

Yoshiaki Higihara: The p-n-p-n Diode in Future Linear Motor Cars and in Modern Imagers

John Louis Moll (1921–2011) was studying a p-n-p-n diode switch in his Ph.D. dissertation work when the first ISSCC was held in 1954. In a normal operation mode, this device works as a thyristor, which can drive a large current and is the key device structure of an IGBT applied for a linear motor car of the future (see Figure 9). In a dynamic operation mode, this device may work as a simple p-n-p-n dynamic capacitance that can detect and store one single electron, which is a key device structure of the modern image sensor (see Figure 10).

I recall, when I was taking his physics course at Caltech, that Feynman once said that an electron is always free, moving around rapidly in free space, even in solid, and it never stops. It is very hard to catch an electron because we do not know exactly where it is. Our civilization today is based on a technology that controls electrons, down to a single one.



GURE 9: The p-n-p-n switch diode for a modern linear motor car.

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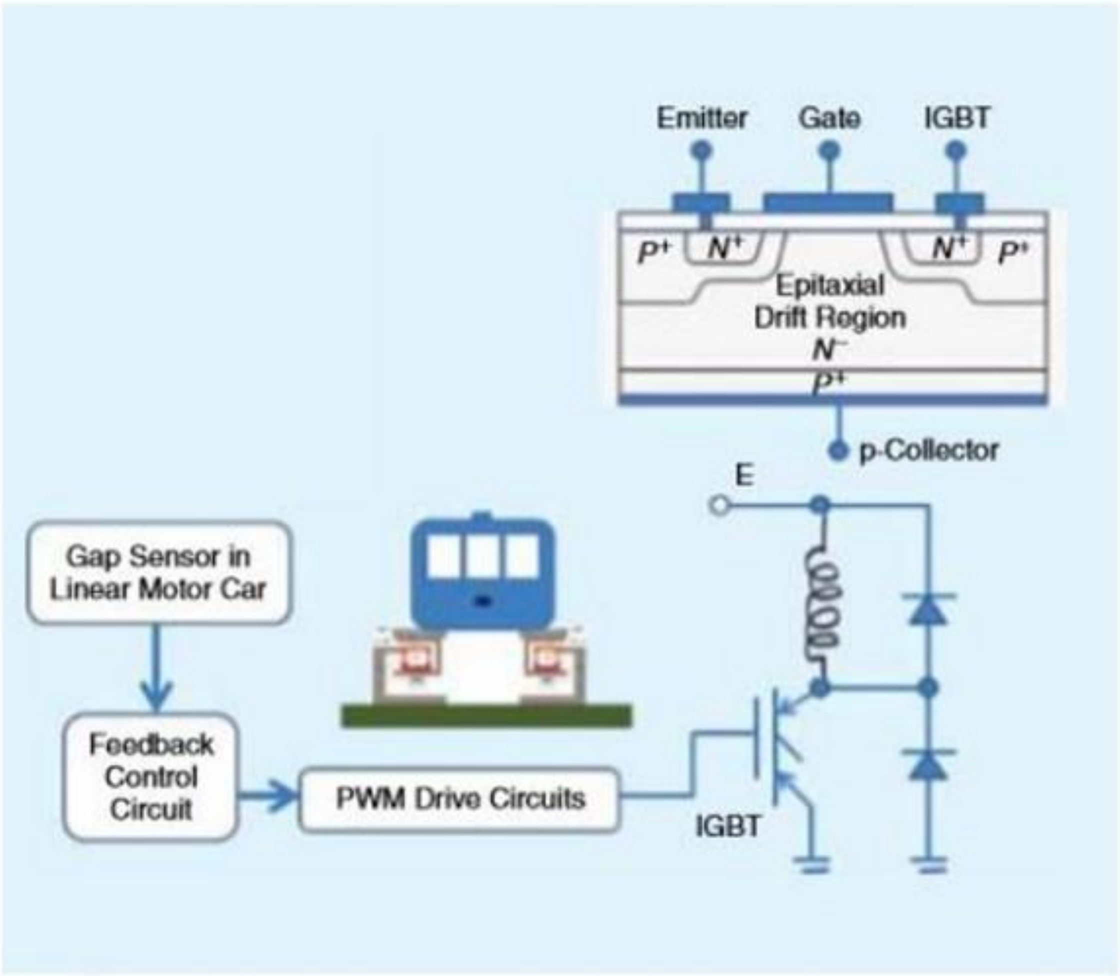


GURE 9: The p-n-p-n switch diode for a modern linear motor car.

Imagine a photon incident to a bipolar transistor base region. The photon energy creates an electron-hole pair. And the photo-electron can be stored in the base region as one single majority carrier. That is, a bipolar transistor can also function as a photon detector and/or a storage container. I thought that a room in a hotel must be empty and clean before the first hotel guest arrives. So must be this transistor base region empty and clean with no guest electrons at the beginning. This transistor in a dynamic p-n-p capacitor mode is useful since it can capture, confine, and control one single electron. But as a student, I did not know yet how to
student, I did not know yet how to
move that single photoelectron sitting in the base region to the outside world so that we can make use of it as a signal. I had no way yet to know whether the hotel guest has arrived and is resting in the hotel room or not. We had no way yet to ask the hotel guest to come up to the hotel lobby to meet me. I had to wait a few more years (until 1970 in my senior year in college) to find the answer. We all know now it is the CCD structure that can store and transfer one single electron. With a precharge reset set gate and
With a precharge reset set gate and
a source-follower circuit, a scheme invented by Walter Kosonocky. We could finally meet our hotel guest at the hotel lobby.

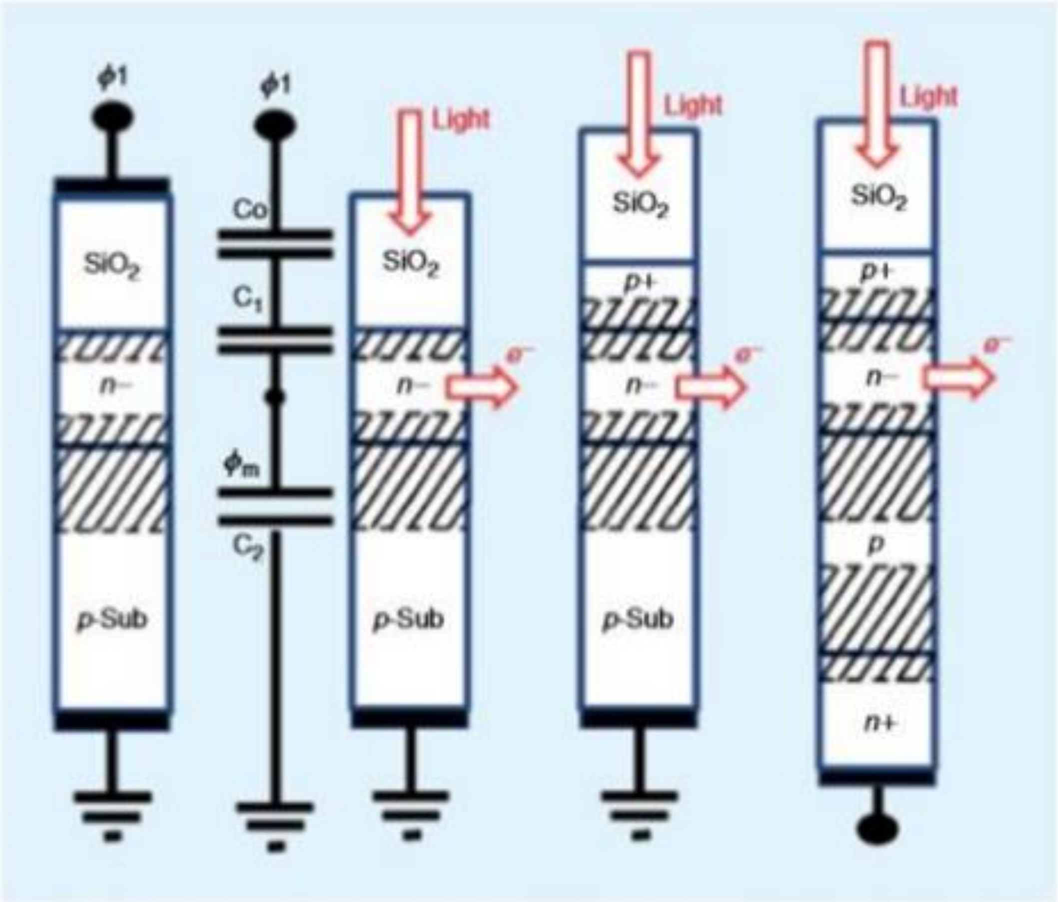
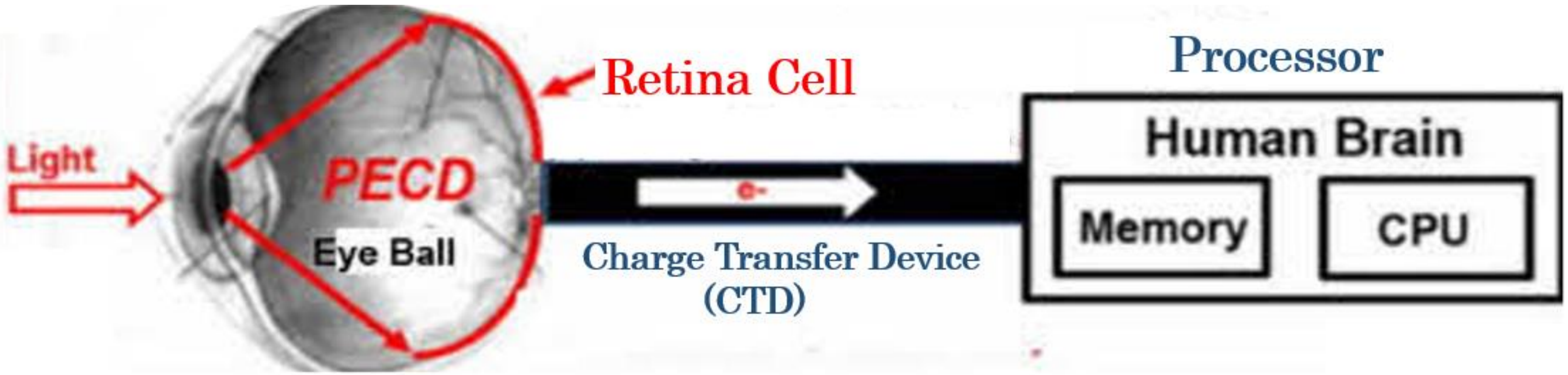
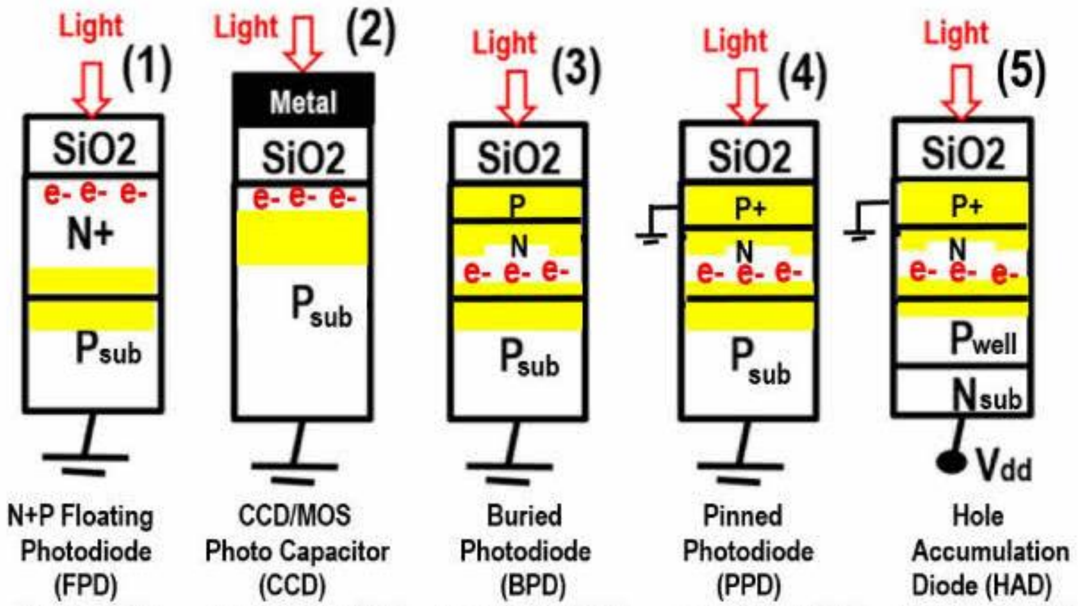


FIGURE 10: From CCD to the dynamic p-n-p-n diode capacitors.





Different kinds of Photon Detecting Device (PDD)

Yoshiaki. Hagiwara, Japanese Patent Applications JPA 1975-127647, JPA 1975-127647 and JPA 1975-134985.