牧本塾_近況報告2022_01_16_萩原良昭

SONYのHADセンサーの特許が盗まれていていることを２０１９年の６月に知りました。
実は、ＮＥＣがＩＥＤＭ１９８２で開発報告した　Buried Photodiodeも、
KODAKがＩＥＤＭ１９８４で開発報告した　Pinned Photodiode も、
実は１９７５年に　萩原が発明したものです。Double とTriple 接合型の
フォトトランジスタ構造で、ベース領域が完全空乏化し、完全電荷転送が
可能な受光素子で、残像がなく、かつVOD機能を持ち、電子シャッター機能
が可能で、メカフリーの、FILMが不要な、カメラを実現するために不可欠な
受光素子です。また、同時に萩原はＣＭＯＳ　イメージセンサーに必要な
GLOBAL SHUTTER機能を可能にする、　in-pixel MOS容量のBuffer Memory
を装備した受光素子も１９７５年に発明しています。この基本構造が今回、
４５年後、SONYは　裏面照射型のCMOS　Image　Sensorに採用して現在
世界をリードしています。萩原はそのことを２０１９年の仙台でのIEEEの
学会で発表し、その後合計で、今まで８件の論文に挑戦し、５件が受理され
発表されました。最後は２０２１年１２月９日に開催の　IEEE主催の国際学会
ICECET2021で２件発表できました。
SONY（萩原）がPinned Photodiode の発明者であると論説することができました。
SONYの現役技術者、SONYのOBの皆様、牧本次生さん、渡邊誠一さん、若林整さん、
奈良部忠邦さん、亡き川名喜之さん（昨年６月２１日死去、享年８９歳）、加藤俊夫
さんや渡邊誠一さん、先輩の鈴木俊治さん達の激励を受けて実現しました。

SONＹがどうして今強いか？それは、SONYが社会が必要とする製品を提供し続けているからです。
井深さんが小型トランジスタラジオを、盛田さんがWALKMANを、岩間さんが小型ビデオカメラを、
久多良氏さんがゲームをやりたいと言い出し、社会に必要なものを社会に提供しようとしたからです。

井深さんや盛田さんのTOPは、自らが製品を試し、WALKMANの普及のために、山手線の電車の中で
SONYの社員にWALKMANで音楽を聴かせ、一般人への普及に努力し新しい生活様式を創造しました。

一般の人も、私もなにかあると、Wikipedia で、それが何かを調べます。 Wikipediaは非常に便利です。
また、誰でも登録すれば編集が可能です。また、変更や追加が可能です。大賀さんはお客様の琴線に
触れる製品を社会に提供し、どういうものかを理解していただくことが重要だといつもお話していました。

https://en.wikipedia.org/wiki/Photodiode

Pinned photodiode [edit]

The First Pinned Photodiode was invented on March 5, 1975 by Yoshiaki Hagiwara. The Evidence was given in his application form to the IP department of Sony Corporation. Hagiwara filed three Japanese patents JPA1975-127646, JPA1975-127647 and JPA1975-134985 in 1975. Unfortunate the documentations were all written only in Japanese and never have been disclosed in the English speaking community till recently. See http:/www.aiplab.com/ in details. There is a big difference between the buried photodiode and the pinned photodiode. There are two kinds of buried photodiode, one is a buried photodiode with a floating P+ surface region and the other is a buried photodiode with the pinned P+ surface region, which is also called as Sony Hole Accumulation Diode (HAD). The floating surface is due to the RC delay caused by the undesired finite resistance. IEEE IEDM1982 NEC paper by Teranishi which did not show the adjacent P+ channel stops to make the zero resistance needed to pin the P+ heavily doped P+ surface hole accumulation region. Any small finite resistance value causes the RC delay time which invites the serious image lag problem. Hagiwara 1975 three Japanese patent figures show the Pinned connection to the surface region and also the empty potential well profile for the first time in the world which is the evidence of the no-image-lag feature.

The pinned photodiode (PPD) has a shallow P+ implant in N type diffusion layer over a P-type epitaxial substrate layer with no RC delay to the external controlled pinning voltage. It is not to be confused with the PIN photodiode. The PPD is used in CMOS active-pixel sensors.[21] which explained that Hagiwara at Sony invented in 1975 and developed First Pinned Photodiode in 1978.

SONＹは発明と発見をする科学者や開発者が大勢いました。パワートランジスタを発明した亡き川名喜之さんの功績は大きいですが、その名前はあまり社会には知られていません。SONYはHADセンサーという名称を考案してイメージセンサーの独自性をPRしました。世の中は、それに対抗して　Pinned Photodiode　という名前を選び、ここでもSONYは孤独なビジネスを強いられましたが、今、SONYはイメージセンサーで独走しています。今ではSONYは、公式HPに、Pinned Photodiode = HAD は　SONYオリジナルの発明だとPRしました。

https://en.wikipedia.org/wiki/Photodiode

Early image sensor used the CCD type charge transfer device with the N+P single junction photodiode with the floating N+ surface which has the serious image lag problem and suffered from shutter lag . This was largely resolved with the invention of the pinned photodiode (PPD) by Hagiwara in 1975 , evidenced by three Japanese patents by Hagiwara JPA1975-134985, JPA1975-127646 and JPA1975-127646 which can be used in the interline transfer CCD type charge transfer devices and CMOS type low power digital signal type charge transfer device (CMOS imager). Hagiwara team at Sony developed the first Pinned Photodiode in SSDM1978 paper. Fossum in his 2014 paper did not quote properly and ignored the 1975 Hagiwara three basic patents on double and triple junction type photodiodes with the pinned surface and with the complete charge transfer capability with no image lag feature, and also with the anti-blooming control feature with the vertical overflow drain (VOD) function, which realize the electrical shutter function replacing completely the film and machanical shutter parts. Hagiwara in his JPA 1975-127646 and JPA 1975-127647 patents also invented the Global Shutter function with the MOS capacitor type buffer memory to avoid the rotary shutter effect. These works by Hagiwara and Sony were ignored and not quoted properly in Fossum 2014. [22] Fossum claimed incorrectly that Nobukazu Teranishi, Hiromitsu Shiraki and Yasuo Ishihara at NEC in 1980.[22][23] They developed and reported the results years later after Hagiwara 1975 invention and 1978 first development efforts. Hagiwara 1975 patents showed that the lag can be eliminated since the signal carriers can be transferred from the double and triple junction type photodiode to the CC type charge transfer devid. Hagiwara 1975 reports, led to their invention of the pinned photodiode, a photodetector structure with low lag, low noise, high quantum efficiency and low dark current. Forsum 2014 was misleading and did not explained these facts clearly. [22] It was first invented by Hagiwara at Sony in the 1975 patents and Hagiwara team at Sony developed in 1978 and reported at SSDM1978, in Tokyo Japan for the first time in the world in public. The second runner is the NEC Teranish team in 1982. Teranishi and Ishihara with A. Kohono, E. Oda and K. Arai in 1982, with the addition of an anti-blooming structure.[22][24] The new photodetector structure invented at Sony and later called in 1987 also as Hole Accmulation diode (HAD) was originally given the name "pinned photodiode" (PPD) by B.C. Burkey at Kodak in 1984. In 1987, the PPD began to be incorporated into most CCD sensors, becoming a fixture in consumer electronic video cameras Peter Noble invented the in-pixel Active pixel image sensor with the three-transistor type source follower current amplifier circuits in 1969. But we had to wait the CMOS scaling advancement till 2000. Meanwhile the CCD type charge transfer device was widely used with the double and triple junction type photodiode originally invented by Hagiwara in 1975.

もうHADを使わず、Pinned Photodiode が、SONYオリジナルの発明だとPRしました。

https://en.wikipedia.org/wiki/Photodiode

In 1994, Eric Fossum, while working at NASA's Jet Propulsion Laboratory (JPL), proposed an improvement to the CMOS sensor: the integration of the pinned photodiode. A CMOS sensor with PPD technology was first fabricated in 1995 by a joint JPL and Kodak team that included Fossum along with P.P.K. Lee, R.C. Gee, R.M. Guidash and T.H. Lee. Since then, the PPD has been used in nearly all CMOS sensors. The CMOS sensor with PPD technology was further advanced and refined by R.M. Guidash in 1997, K. Yonemoto and H. Sumi in 2000, and I. Inoue in 2003. This led to CMOS sensors achieve imaging performance on par with CCD sensors, and later exceeding CCD sensors.[22] Recently Sony developed the backlight CMOS image sensor which used the Hagiwara 1975 pinned buried photodiode originally developed by Hagiwara at Sony. Sony now has announced that Hagiwara was the true inventor of Pinned Photodiode. See https://www.sony.com/en/SonyInfo/News/notice/20200626/

Photodiode array [edit]

A one-dimensional array of hundreds or thousands of photodiodes can be used as a position sensor, for example as part of an angle sensor.[25]

A 2 x 2 cm photodiode array chip with more than 200 diodes

In recent years, one advantage of modern photodiode arrays (PDAs) is that they may allow for high speed parallel readout since the driving electronics may not be built in like a charge-coupled device (CCD) or CMOS sensor.

Passive-pixel sensor [edit]

The passive-pixel sensor (PPS) is a type of photodiode array. It was the precursor to the active-pixel sensor (APS).[22] A passive-pixel sensor consists of passive pixels which are read out without amplification, with each pixel consisting of a photodiode and a MOSFET switch.[26] In a photodiode array, pixels contain a p–n junction, integrated capacitor, and MOSFETs as selection transistors. A photodiode array was proposed by G. Weckler in 1968, predating the CCD.[27] This was the basis for the PPS.[22]

Early photodiode arrays were complex and impractical, requiring selection transistors to be fabricated within each pixel, along with on-chip multiplexer circuits. The noise of photodiode arrays was also a limitation to performance, as the photodiode readout bus capacitance resulted in increased noise level. Correlated double sampling (CDS) could also not be used with a photodiode array without external memory. It was not possible to fabricate active pixel sensors with a practical pixel size in the 1970s, due to limited microlithography technology at the time.[27]

もうHADを使わず、Pinned Photodiode が、SONYオリジナルの萩原の１９７５年の発明だとPRしました。

https://www.sony.com/en/SonyInfo/News/notice/20200626/

Sony's Representative Inventions Supporting Stacked Multi-Functional CMOS Image Sensors

Sony Corporation
Sony Semiconductor Solutions Corporation

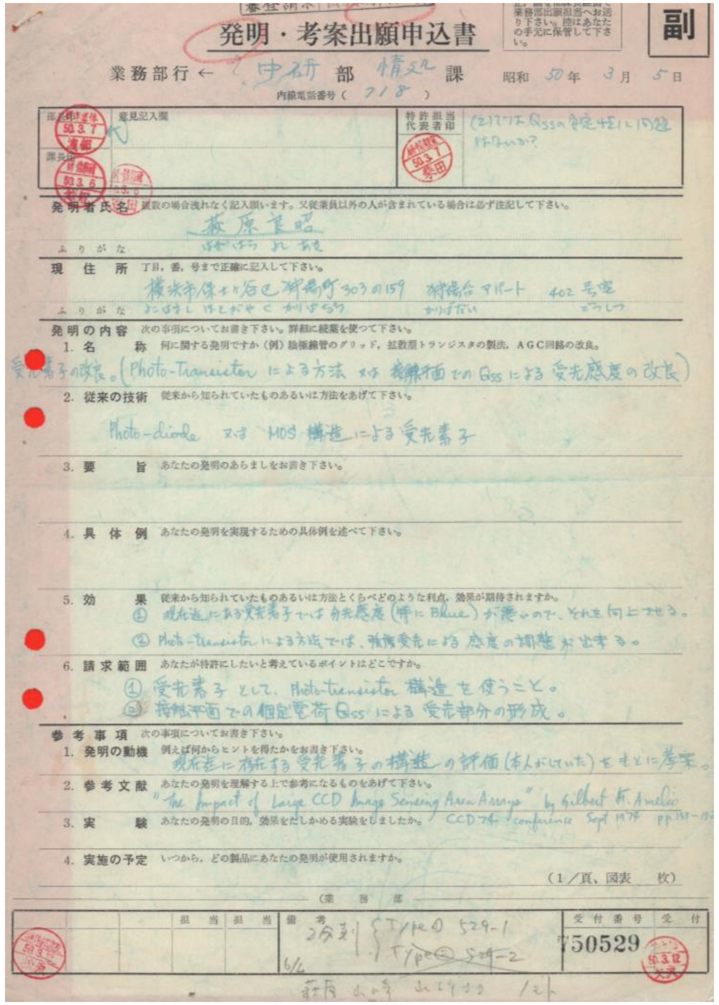
Pinned Photodiode Adopted for Back-Illuminated CMOS Image Sensors

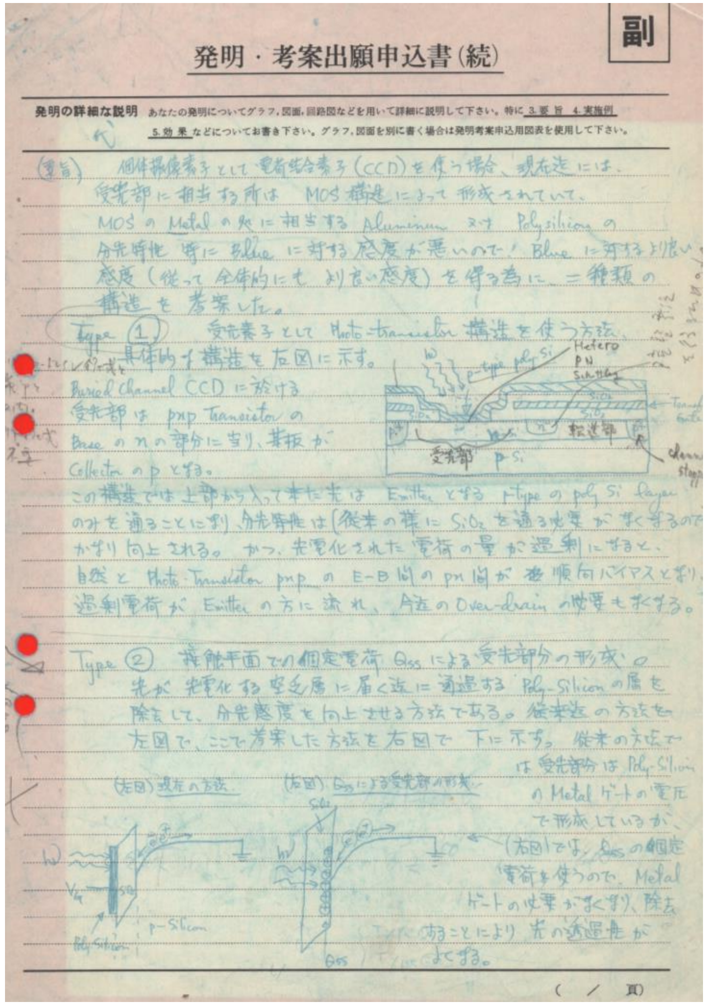
The history of Sony's inventions of image sensors goes back to the CCD era. Above all, Pinned Photodiode is a technology that contributes to improving the performance of back-illuminated CMOS image sensors, and the history of inventions and product development are as below.

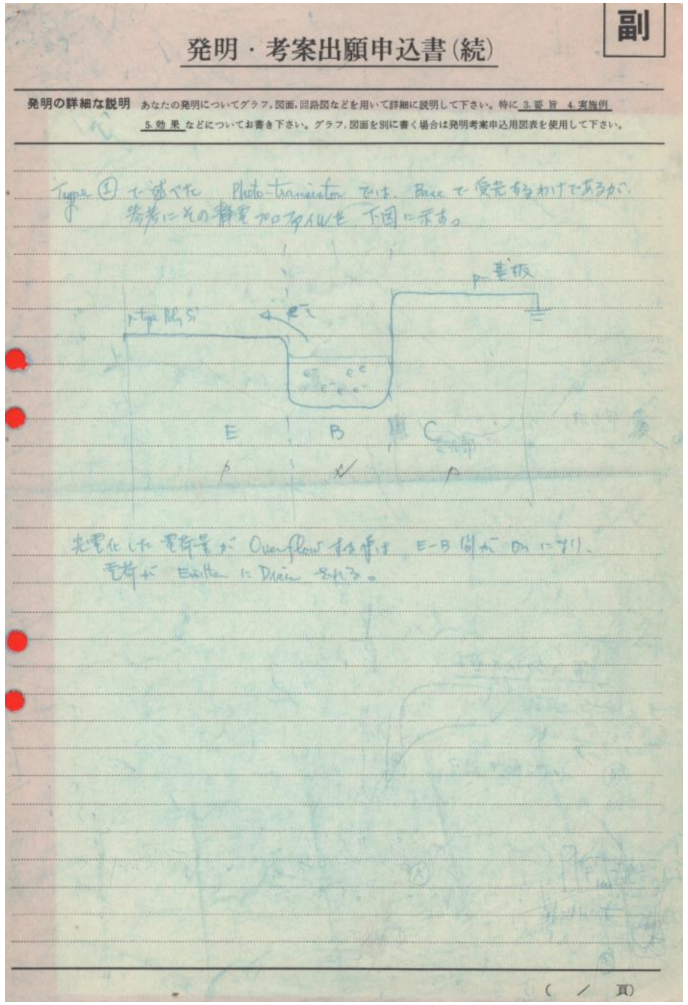
In 1975, Sony invented a CCD image sensor that adopted a back-illuminated N+NP+N junction type and an N+NP+NP junction type Pinned Photodiode (PPD) (Japanese patent application number 1975-127646, 1975-127647 Yoshiaki Hagiwara). In the same year, inspired by such structure, Sony invented a PNP junction type PPD with VOD (vertical overflow drain) function (Japanese Patent No. 1215101 Yoshiaki Hagiwara). After that, Sony succeeded in making a principle prototype of a frame transfer CCD image sensor that adopted the PNP junction type PPD technology, having a high-impurity-concentration P+ channel stop region formed near a light receiving section by ion implantation technology for the first time in the world, and its technical paper was presented at the academic conference, SSDM 1978 (Y. Hagiwara, M. Abe, and C. Okada, "A 380H x 488V CCD imager with narrow channel transfer gates", Proc. The 10th Conference on Solid State Devices, Tokyo, (1978)). In 1980, Sony succeeded in making a camera integrated VTR which incorporated a one-chip frame transfer CCD image sensor that adopted the PNP junction type PPD. President Iwama in Tokyo, Chairperson Morita in New York, at the time held a press conference respectively on the same day, which surprised the world. In 1987, Sony succeeded in developing a 8 mm video camcorder that adopted, for the first time in the world, the interline transfer CCD image sensor, which incorporated "PPD having a high-impurity-concentration P+ channel stop region formed near the light receiving section by ion implantation technology" with VOD function, and became the pioneer of the video camera market. The PPD technology that has been nurtured through such a long history is still used in back-illuminated CMOS image sensors.

もうHADを使わず、Pinned Photodiode が、SONYオリジナルの萩原の１９７５年の発明だとPRしました。

１９７５年３月５日にSONYの横浜中央研究所で２６歳の萩原が出願したものです。垂直OFD（ＶＯＤ）機能付きのDouble 接合型のＰＮＰフォトトランジスタ型受光素子の発明です。これがＳＯＮＹが1987年に開発したＨＡＤです。ＫＯＤＡＫが　Pinned Photodiodeと呼び、IEDM1984 で開発発表したものです。NECがIEDM1982 で開発発表したBuried　Photodiodeもこの構造に含みます。萩原は既にこのPinned PhotodiodeをSSDM1978で開発発表しました。







もうHADを使わず、Pinned Photodiode が、SONYオリジナルの萩原の１９７５年の発明だとPRしました。

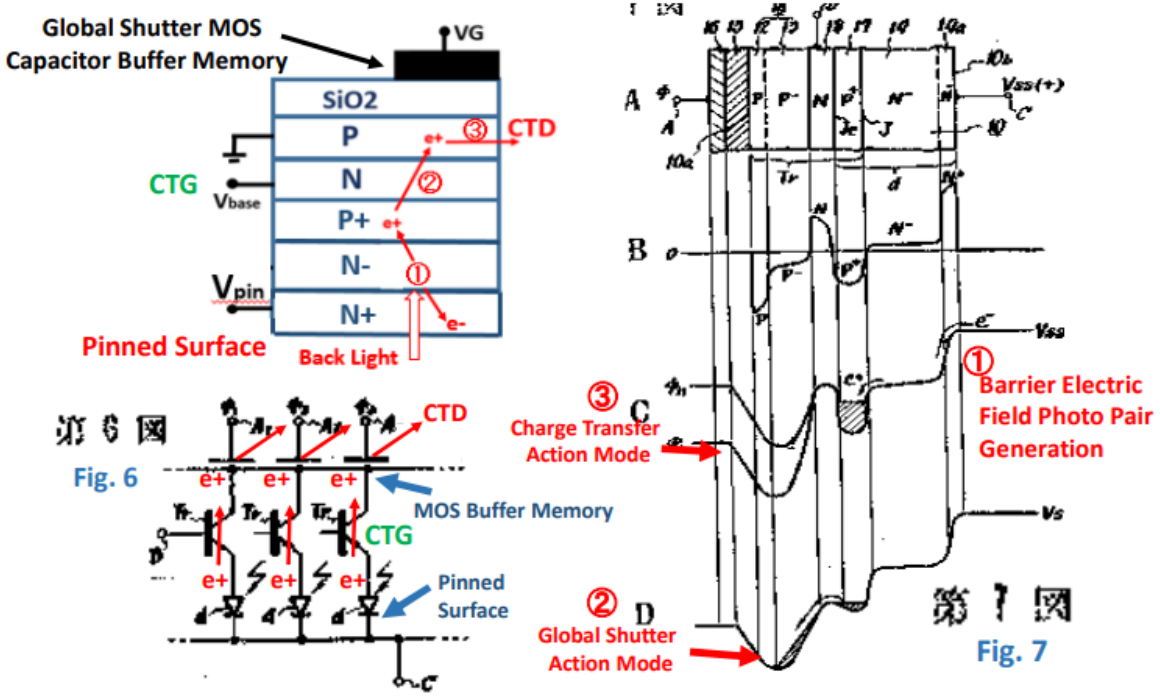
Who Invented Pinned Photodiode ？

https://www.sony.com/en/SonyInfo/News/notice/20200626/

（1）JPA 1975-127646 on October 13, 1975

Japanese Patent 1975-127646

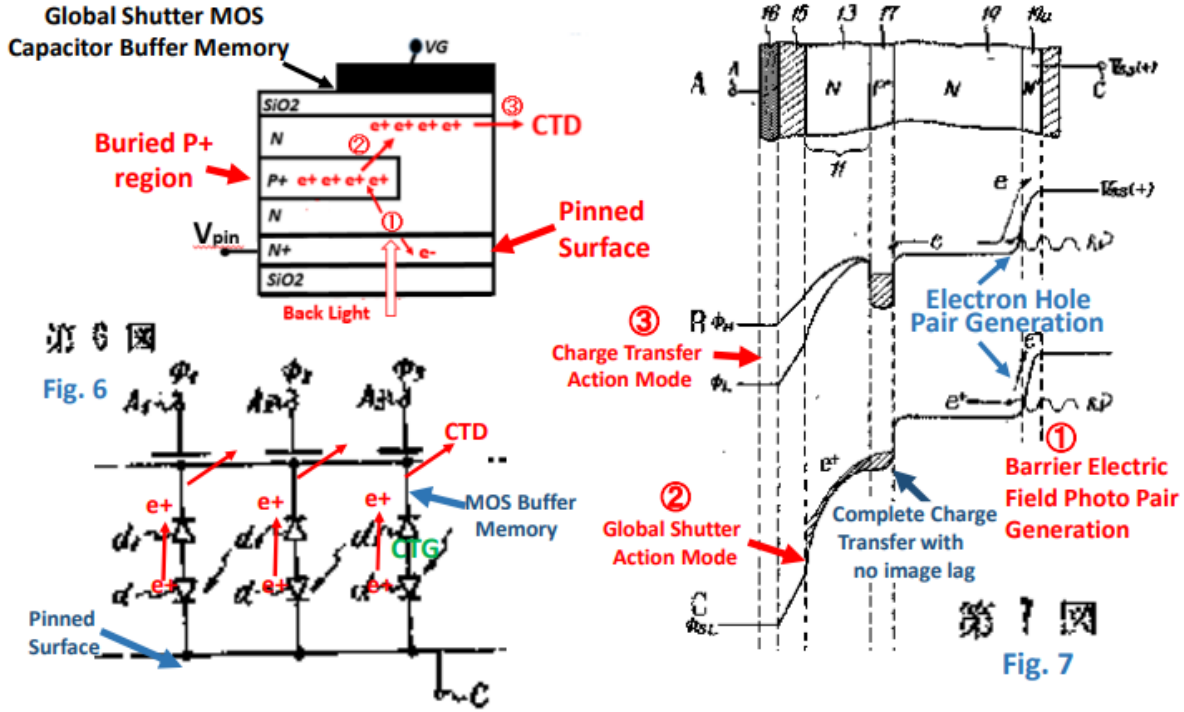
N+NP+NP junction type Buried Pinned Photodiode
with Built-in MOS Capacitor Buffer Memory Global Shutter Function
and the surface N+N doping slope Barrier Electric Field Photo Pair Generation



（2）JPA 1975-127647 on October 13, 1975 .

Japanese Patent 1975-127647

N+NP+N junction Dynamic Photo Transistor type Buried Pinned Photodiode
with Built-in MOS Capacitor Buffer Memory Global Shutter Function
and the surface N+N doping slope Barrier Electric Filed Photo Pair Generation



もうHADを使わず、Pinned Photodiode が、SONYオリジナルの萩原の１９７５年の発明だとPRしました。

Who Invented Pinned Photodiode ？

https://www.sony.com/en/SonyInfo/News/notice/20200626/

(3) Hagiwara applied JPA 1975-134985 on November 10, 1975 .

Hagiwara at Sony invented Pinned Photodiode with VOD function.

PNPN junction Transistor type Pinned Photodiode

Visit https://www.j-platpat.inpit.go.jp/ and put the patent number 1975-134985

File	1975-134985	Filed	1975/11/10
Public	1975-058414	Public	1977/05/13
		Grant	1983/10/19

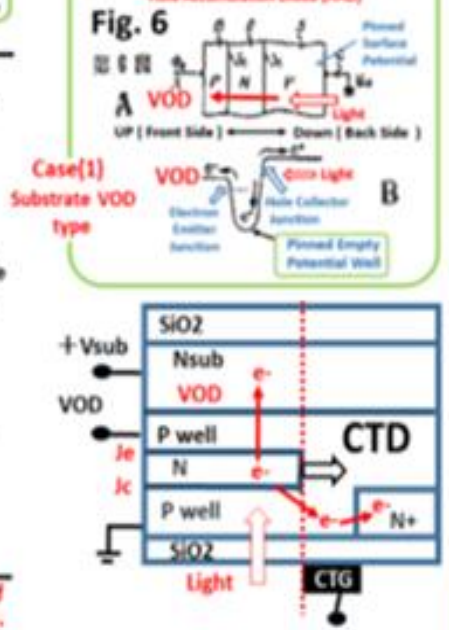
Patent Claim in English Translation

(1) In the semiconductor substrate (Nsub), the first region(P well) of the first impurity type is formed, (2) on which, the second region (N) of the second impurity type is formed. (3) The charge (e-) from the light collecting part (N) is is transferred to the adjacent charge transfer device (CTD). (4) Both are placed along the main surface of the semiconductor substrate. (5) In the solid stare image sensor so defined, a rectifying Emitter junction (Je) is formed on the second region (N) of the light collecting part (N) . And (6) Collector junction (Jc) is formed by the second region (N) and the first region (P well), forming a (PNP) transistor structure, (7) Photo charge is stored in the Base (N) according to illuminated light intensity and transferred to the adjacent CTD. The solid state image sensor so defined is in the scope of this patent claim.

Fig.6 shows that this is also the invention of the in pixel VOD (vertical overflow drain).

Japanese Patent 1975-134985

Hole Accumulation Diode (HAD)



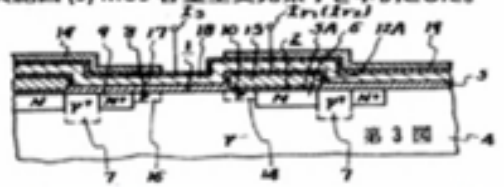
(4) Hagiwara applied JPA 1977-126885 on September 29, 1977 .

Hagiwara at Sony invented also the Electric Shutter Function with the complete image lag free feature by the punch-thru mode.

JPA 1977-126885

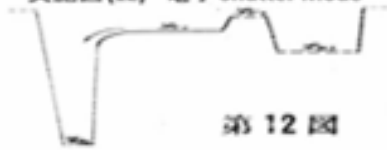
㊧公開特許公報 (A) 昭54—51318
㊧特 願 昭52—126885
㊧出 願 昭52(1977) 9 月29日
㊧出 願 人 ソニー株式会社
㊧発 明 者 萩原良昭
㊧発 明 者 越智成之
同 橋本武夫

実施図 (3) MOS 容量型受光素子を事例とした。



実施図 (9) ガンマ補正 Mode

実施図 (12) 電子 Shutter Mode



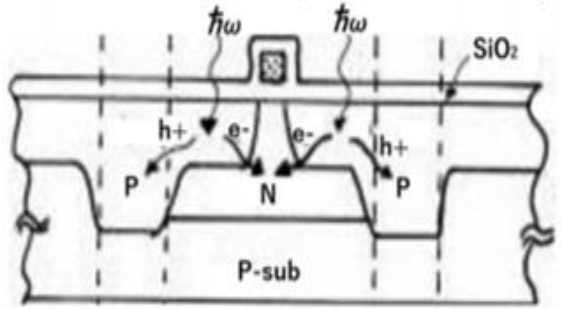
VOD 電極電子の電圧を極端に深くして Punch thru を利用して残像のない状態を実現し、電子 shutter 機能を可能にした。

もうHADを使わず、Pinned Photodiode が、SONYオリジナルの萩原の１９７５年の発明だとPRしました。

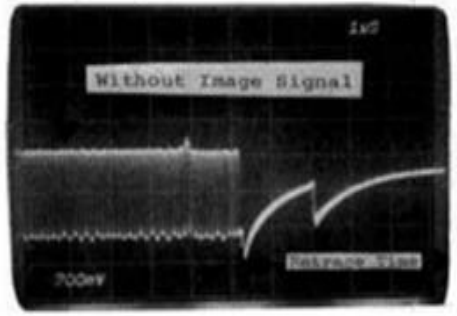
Who Invented Pinned Photodiode ？

https://www.sony.com/en/SonyInfo/News/notice/20200626/

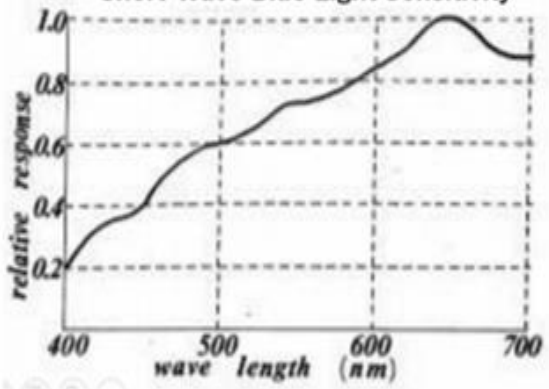
(A) Pinned-Surface and Buried-Storage PNP Photodiode with Adjacent Channel Stops



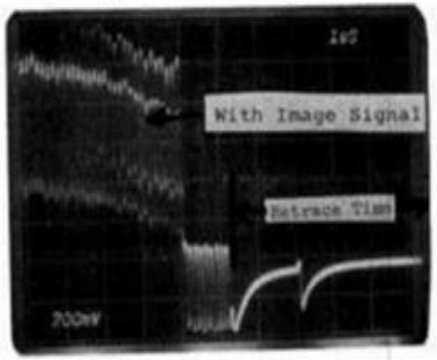
(C) Signal Output with No Light showing Very Low Dark Current Feature



(B) Spectral Response with Very High Short-Wave Blue Light Sensitivity



(D) Signal Output with Input Light showing No Image Lag Feature



Yoshiaki Hagiwara, Motoaki Abe and Chikara Okada, " A 380H x 488V CCD Imager with Narrow Channel Transfer Gates", Proceeding of 10th Conference on Solid State Devices, Tokyo 1978, Japanese Journal of Applied Physics, Volume 18 Sup 18-1, pp. 367-369.

SONY- Fairchild Patent War (1991-2000) on Pinned Photo Diode with Vertical OFD


CCD特許侵害訴訟

ソニー、逆転勝訴

NY東部地裁

From Japanese News Paper, July 16, 1996.

1996 年 7 月　日刊工業新聞記事から

(2000 年 1 月米国最高裁で最終決着ソニー勝訴)

In January 2000, the US supreme court made the final judgement favoring Sony claims. And the long SONY-Fairchild Patent War on the PDD with the built-in vertical overflow drain (VOD) ended.


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