

Hagiwara_in_1975_invented_NEC_1982_Buried_Photodiode_KODAK_1984_Pinned_Photodiode_and_Sony_1987_HAD

The first Pinned Photodiode was developed by Hagiwara Team and reported in Tokyo at the SSDM Conference on Sep 1978. It was in the form of the P+N_{sub} double junction type photodiode with the pinned P+ surface hole accumulation region, which is pinned and fixed at the P substrate grounded potential by the adjacent heavily doped P+ channel stops.

NEC developed in 1982 also a double junction photodiode and named it as Buried Photodiode.

Kodak also developed in 1984 a double junction photodiode and named it as Pinned Photodiode.

In 1987, Sony produced a triple junction photodiode and named it as Hole Accumulation Diode (HAD) and used it the portable and digital video cameras.

However, they are all similar to the double and triple junction photodiodes invented in 1975 by Hagiwara at Sony. Evidence is given by JPA1975-127646, JPA1975-127647 and JPA1975-134985.

Hagiwara reported the Pinned Windows and Pinning Surface Potential in 1978 based on his 1975 invention of the P+N_{sub} junction type Pinned Photo diode.

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The Hole Role in Solid-State Imagers

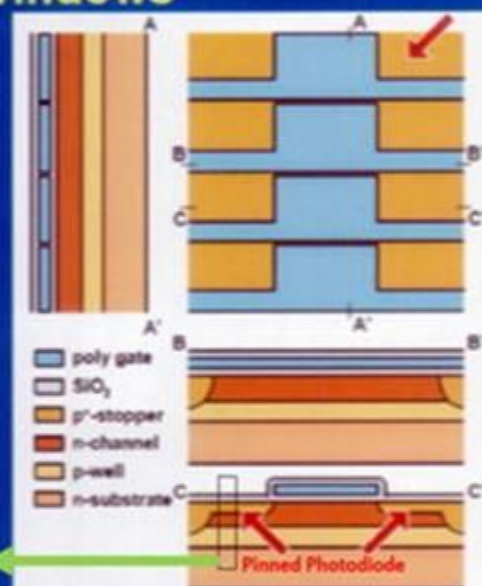
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Despite these advantages, notice that parts of the depleted n-type CCD channels are not covered by gate material. In this way, their electrostatic potential is not defined! Such a structure will suffer from serious charge transport issues during its operation, because charge can and will be trapped in local potential pockets. The effect can simply be solved by defining the potential in the open areas through an extension of the p⁺-channel stopper. A simple self-aligned p-implant of $2 \cdot 10^{13}/\text{cm}^2$ B-ions after the gate construction is sufficient to extend the channel stop area to the gate edge and, consequently, fix the potential in the open areas. The result after this self-aligned implant is shown in Fig. 4. The presence of enough holes plays a crucial role in fixing the potential for the regions normally "beyond control" of the gates. [Is this structure the mother of the PPD or buried diode or hole-accumulation device (HAD)?]

CCD with Pinned Windows

Pinning surface potential by:

- self-aligned, shallow B implant,
- e.g. $2 \cdot 10^{13}/\text{cm}^2$,
- 1978 : Hagiwara (Sony),
- 1982 : Beck (Philips).



Albert Theuwissen quoted Hagiwara 1978 paper and explained the importance of hole role in image sensors @ Workshop on CMOS Imaging, Duisburg May 16, 2006

Direct Quotation

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