# Back-Illuminated Non-Isolated Single-Photon Avalanche Diode in Foundry CMOS Technology

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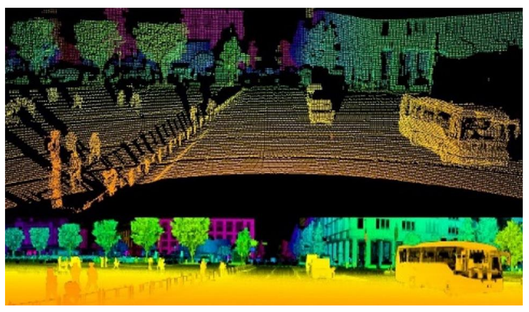
## SPAD Applications



*Source : Sony*

[Autonomous vehicles]

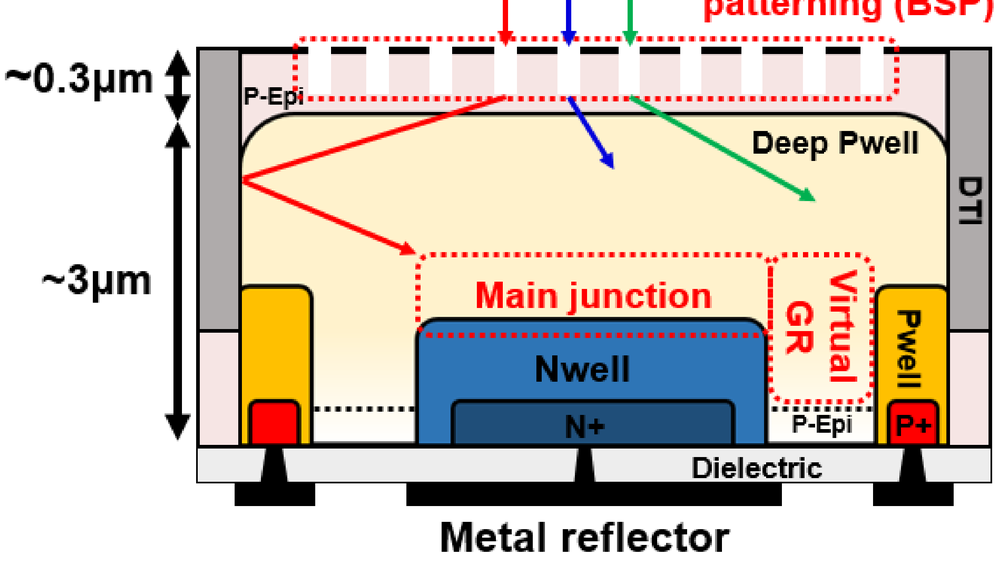
*Source : GE HealthCare*

[ToF PET]

- **Single-photon avalanche diodes (SPADs) are widely used in several applications such as autonomous vehicles and time-of-flight positron emission tomography (ToF PET).**

## Device Structure and Simulation

**[Back-illuminated (BI) non-isolated SPAD]**



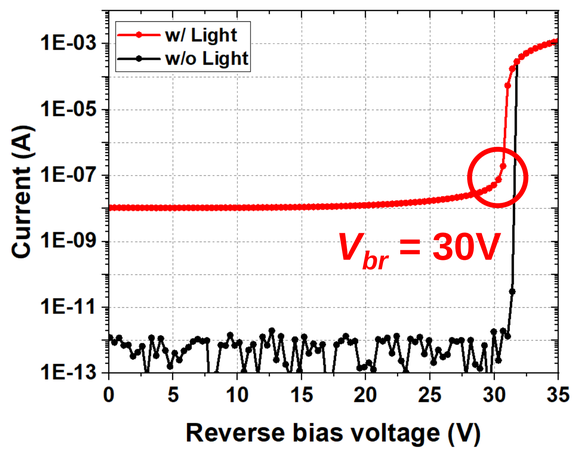

- **Device features**
  - **Main junction : Nwell / Deep Pwell**
  - **Guard-ring : Virtual GR**
  - **Backside partterning (BSP)**
  - **Deep trench isolation (DTI)**
  - **Metal reflector**

## Conclusion

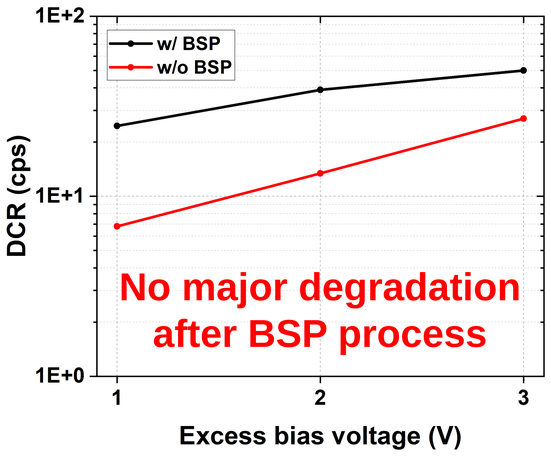
- **The proposed BI non-isolated SPAD with backside patterning achieves a ~50% higher PDP at 940nm than the default SPAD while it shows a comparable DCR.**
- **The PDP will be improved by increasing the thickness of the P-Epi.**
- **It is expected to play an important role in biomedical and LiDAR applications.**

## Results

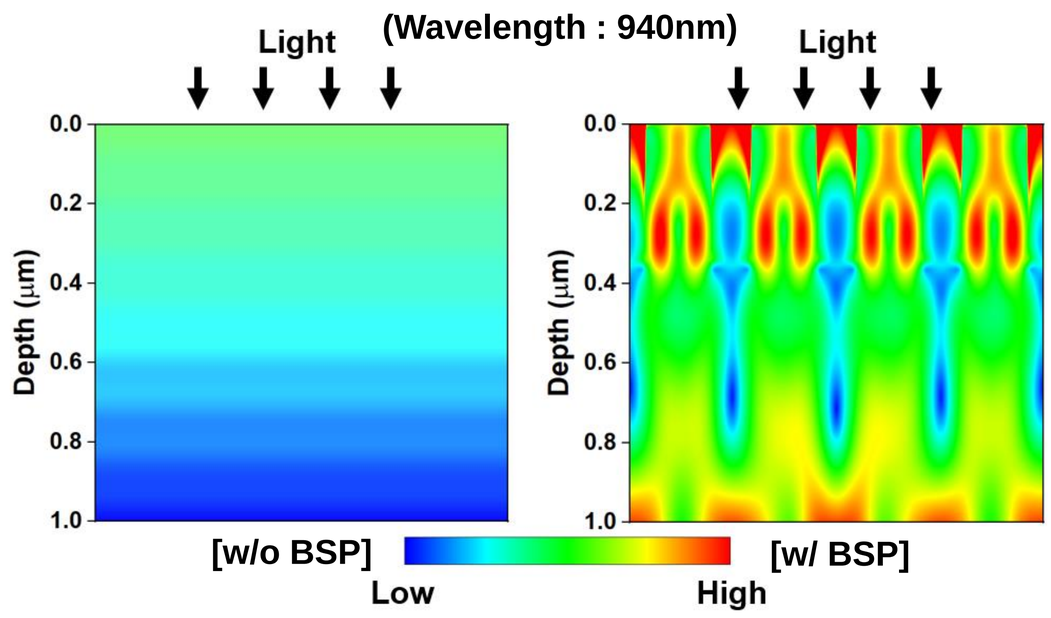
- **I-V characteristics**




- **Dark count rate (DCR) comparison**

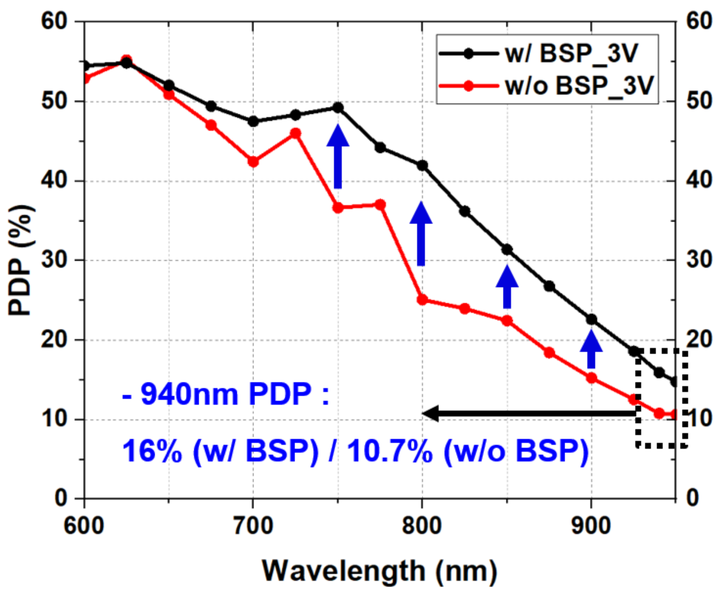



- **Finite-difference time-domain (FDTD) simulation**




- **Backside patterning (BSP) effectively enhanced the incident light through diffraction.**

- **Photon detection probability (PDP) comparison**




- **Thanks to BSP, the PDP improved at long-wavelengths.**

- **Performance summary**

| | w/o BSP | w/ BSP |
|---|---|---|
| Active area | 10μm | |
| Breakdown voltage | 30V | |
| Excess voltage | 3V | |
| DCR (cps / μm$^2$) | 0.34 | 0.64 |
| 940nm PDP | 10.7% | 16% |