

Applications



(Source: Willis Knighton Health)



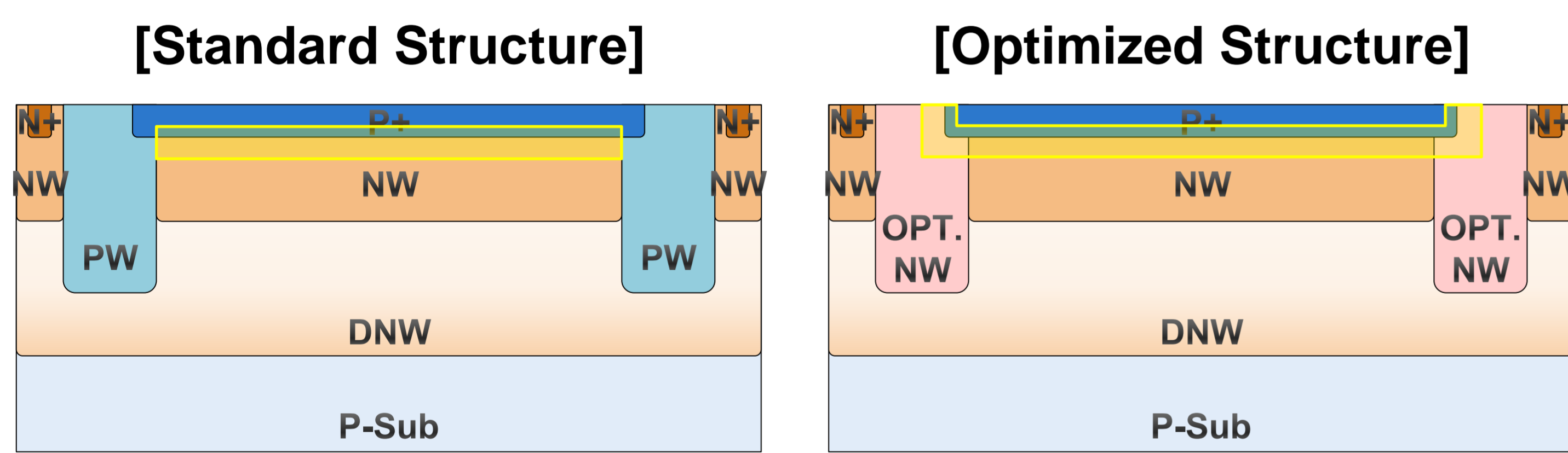
(B. Park, ISSCC 24)

[Positron Emission Tomography]

[X-ray Detector]

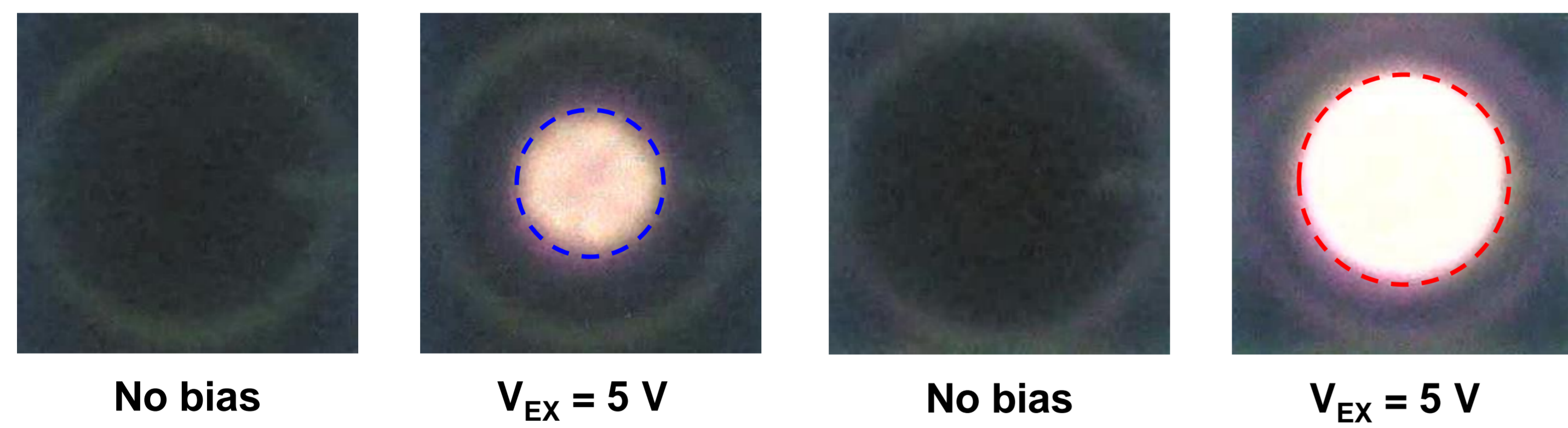
- Single-photon avalanche diodes (SPADs) are widely used for bio-applications such as positron emission tomography (PET) and X-ray detectors.

Structure and Fill Factor



	Standard Structure	Optimized Structure
Junction	P+/NW	
Guard Ring	PW	Optimized NW
Active Area (μm)	9	
Guard-Ring Width (μm)	1.8	

[Light Emission Tests]



- Even though the drawn active area of the two structures are identical, the effective active area of the optimized structure has extended from the horizontal active area of the junction to the vertical area between the anode and the guard ring.
- This fill factor improvement of the optimized structure is clearly shown in the light emission test (LET).

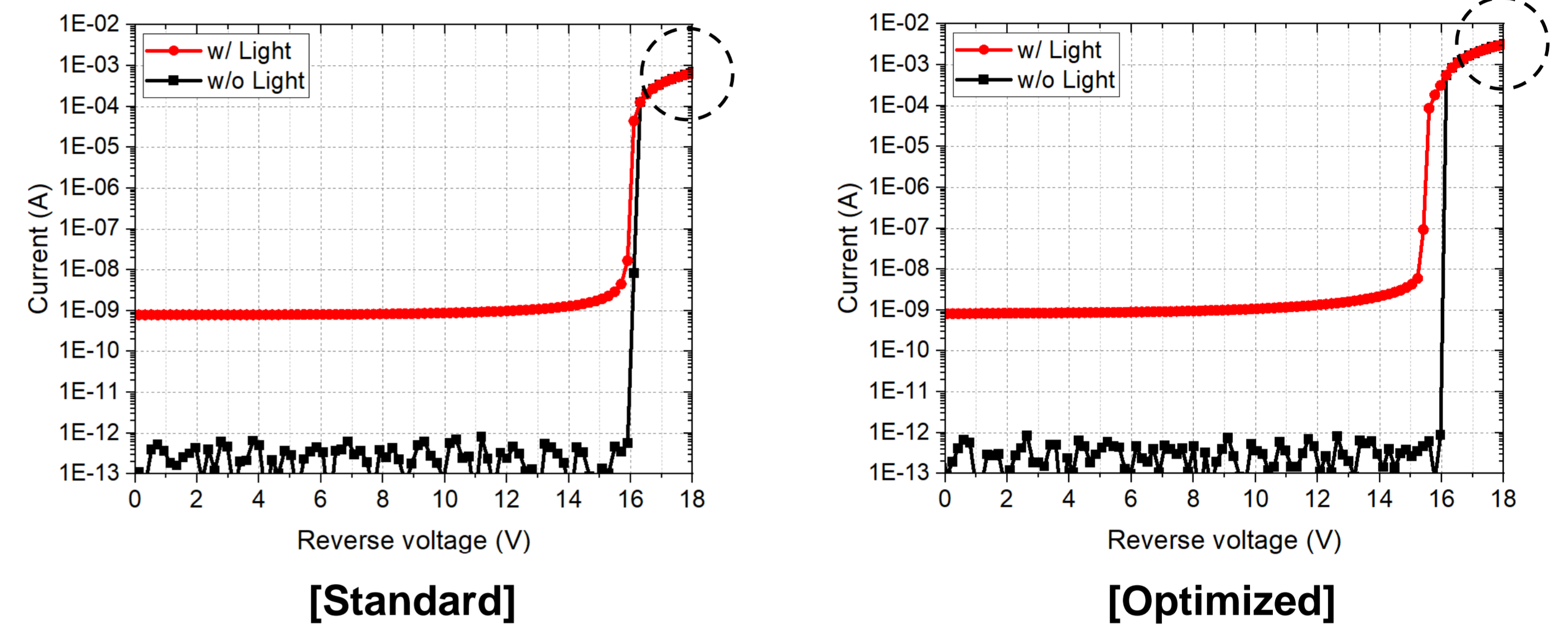
Conclusion

Summary

- Guard ring is optimized for better efficiency.
- Fill factor and avalanche triggering probability are enhanced which are confirmed by IV and LET characteristics.
- PDP has been greatly increased especially in shorter wavelengths.
- Excellent timing jitter performance is measured at near 420 nm.

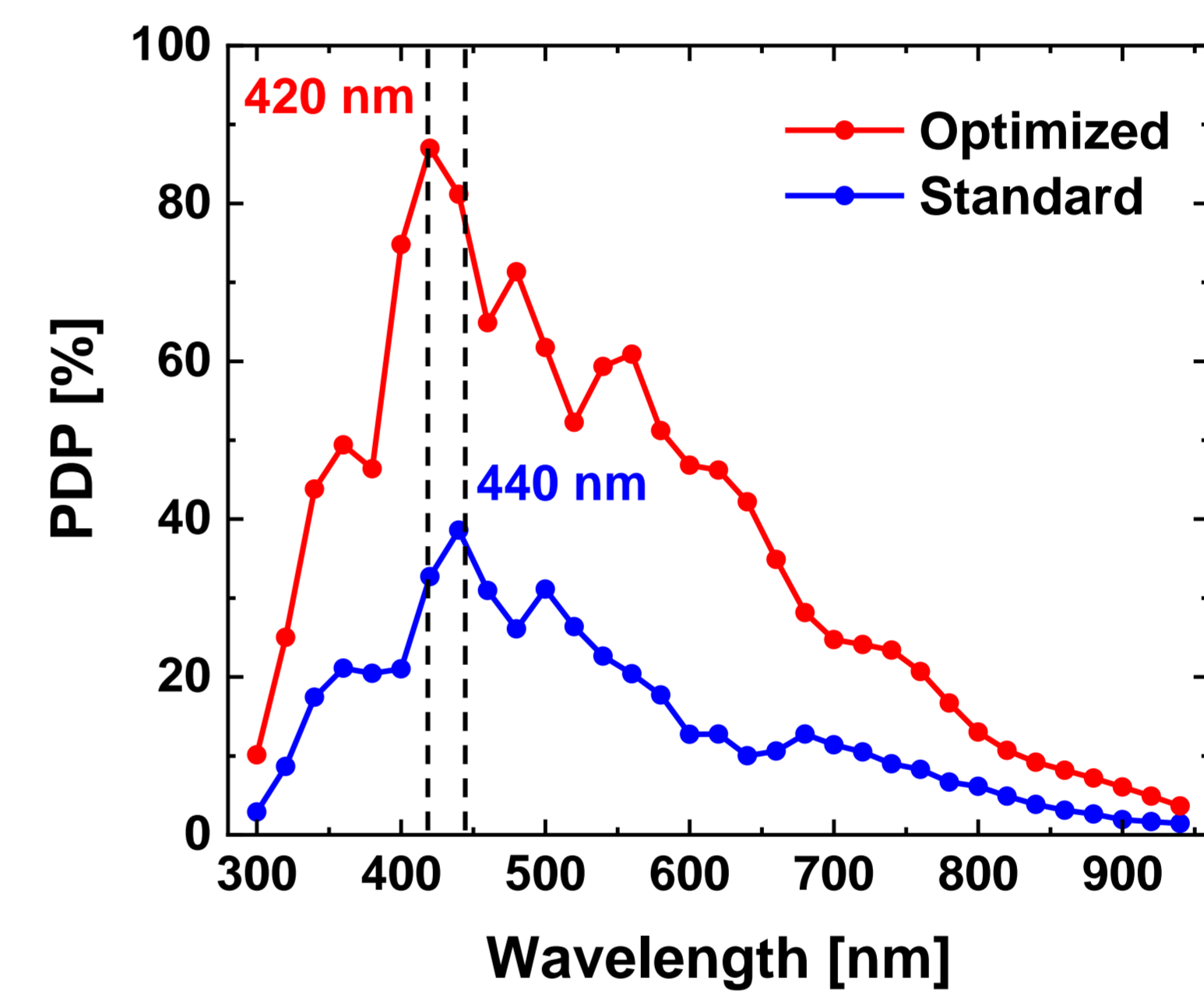
Measurements

Current-Voltage (IV) Characteristics



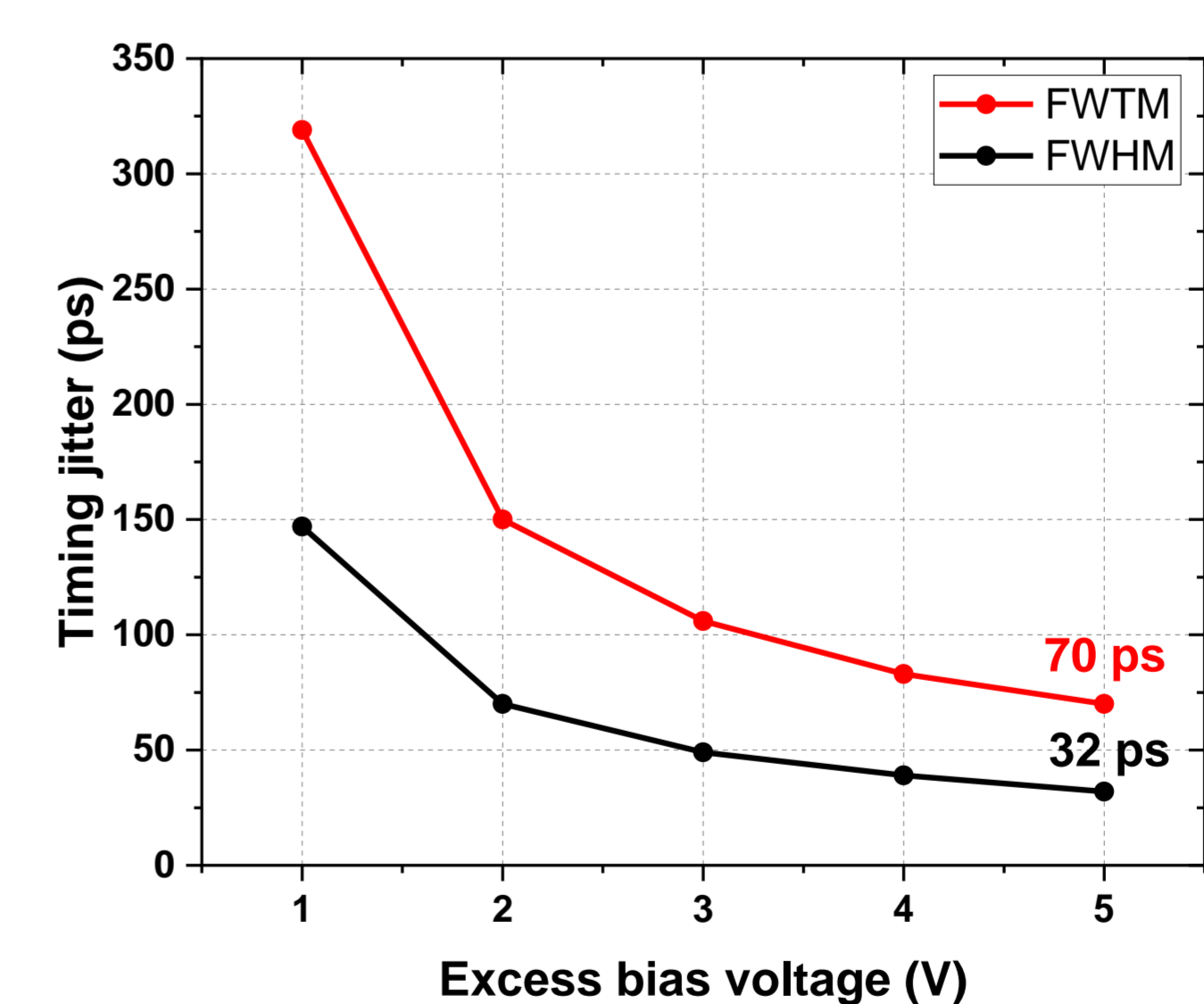
- Breakdown Voltage: Standard (16.15 V) > Optimized (15.55 V)
- Saturation Current: Standard (~1.1 mA) < Optimized (~3.2 mA)
- Higher avalanche triggering probability for optimized structure

Photon Detection Probability (PDP) Characteristics



- Excess bias voltage (V_{EX}) = 5 V
- Peak PDP (Wavelength) for drawn area (active area diameter = 9 μm)
 - Standard Structure: 38.6% (440 nm)
 - Optimized Structure: 87% (420 nm)

Timing Jitter Characteristics (for Optimized Structure)



- Excess bias voltage \uparrow \rightarrow Electric field \uparrow \rightarrow Better jitter performance
- Full width at tenth maximum (FWTM) has improved up to 70 ps.
- Full width at half maximum (FWHM) has improved up to 32 ps.

Research Plans (in progress)

- Verification of accurate fill factor improvement of the optimized structure (e.g., by using laser scanning microscopy (LSM) measurement)
- Investigation on the improvement of the avalanche triggering probability with the optimized guard ring.