Advanced Photodetector Quantum Efficiency System: APD-QE

The Cutting-edge tool for the cutting-edge photodetectors.

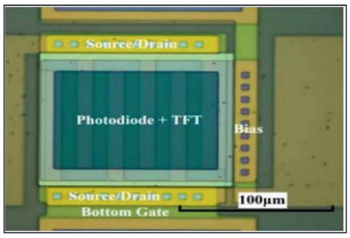
Introduction

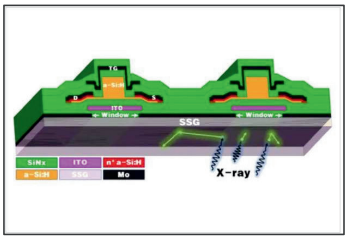
With the rise of 5G technology and popularization mobile devices, more and more advanced photoelectric sensors are used in our daily lives. In order to be better applied to mobile devices, the photosensitive area of these advanced photodetector is getting smaller and smaller. However, these applications place higher and higher requirements on the light sensing performance of advanced photodetectors. In the process of shrinking the photosensitive area, it also brings the challenge of accurate measurement of quantum efficiency. For example, under different wavelengths of the traditional focused beam spot, the focal shift caused by the dispersion of different wavelength can reach mm-level. It is difficult to focus all photons into the micrometer-level active area. Therefore, it is hard to accurately measure the full-spectrum quantum efficiency curve.

APD-QE adopts the spatial light homogenizing technology and follows the ASTM standard “Irradiance Mode” test method. It’s proven that APD-QE can accurately perform quantum efficiency and other key parameter measurements of advanced photodetectors. APD-QE can combine with various advanced probe stations to deliver a complete testing solution for many advanced photodetectors, such as iPhone LiDAR and a its variety of light sensors, Apple Watch blood oxygen light sensor, TFT image sensor, active active pixel sensor (APS), high-sensitivity indirect conversion X-ray sensor, etc.

Application

- Optical sensor in LiDAR
- InGaAs Photodiode/ SPAD
- Photosensor of APPLE Watch
- Photodiode-gated Transistor for high gain sensing and imaging
- High Photoconductivity Gain and Fill-Factor Optical Sensor
- Highly-sensitive indirect-conversion X-ray Detector characterization
- Silicon Photonics
  InGaAs APD





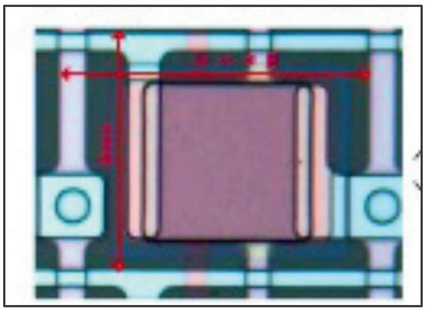
Specification / Product Selection Guide

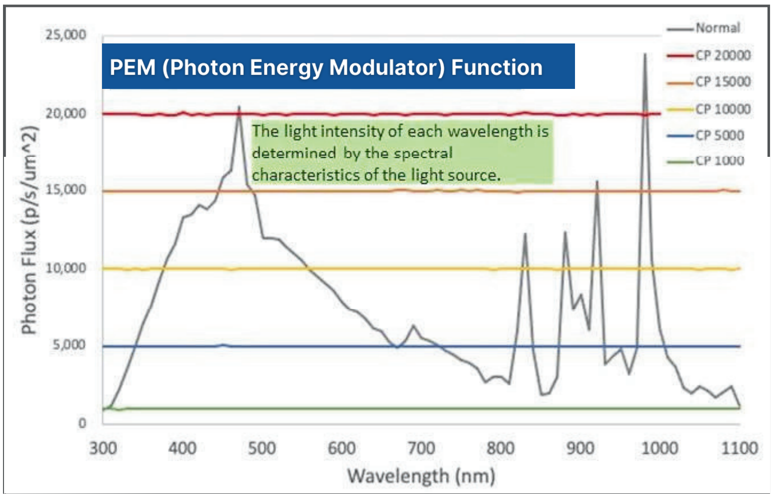
Item	Specification
Quantum Efficiency Measuring System	300 nm ~ 1100 nm 2500 nm extendable
Software	PDSW software Upgradable to FETOS-SW (3T or 4T device)
Probe station system (option)	4” standard probe station (MPS-4-S)
Customized integration solution	Probe stage and shielding dark box

Testing Results / Publications

1. Advanced light sensor research tool for nonlinear effects

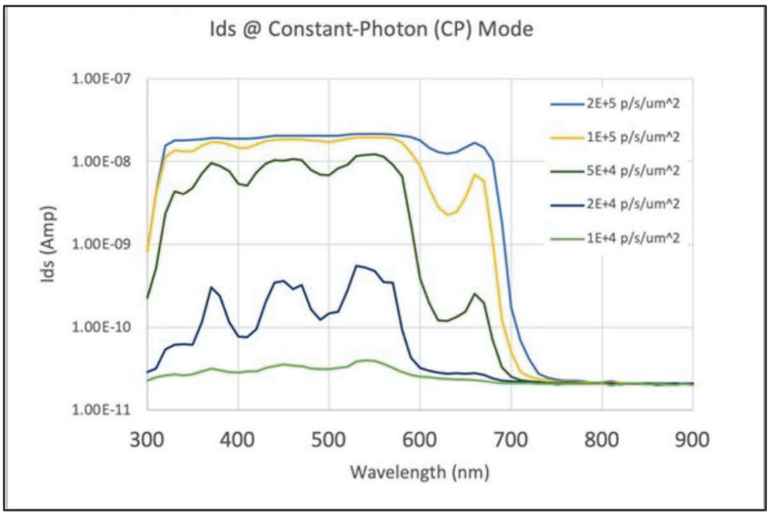
The light-intensity response characteristics of new-type light sensors are not linear (such as amorphous silicon TFTs sensor, X-ray sensor, etc.). That is to say, under the conditions of different incident photons, the response spectral characteristics will be significantly different. The determination of the spectral response of the working mode is a very important research topic.





PEM™ (Photon Energy Modulator)

PEM (Photon-Energy Modulator) is a photon number-light energy regulator that can control monochromatic light of different wavelengths to output a constant photon number. This allows the device under test to receive the same number of incident photons at different wavelengths. It can be used for the spectral response of photodetectors to the nonlinearity of light intensity. This unique tool provides precise control of photon number and energy, ensuring accurate and reliable results across various wavelengths.

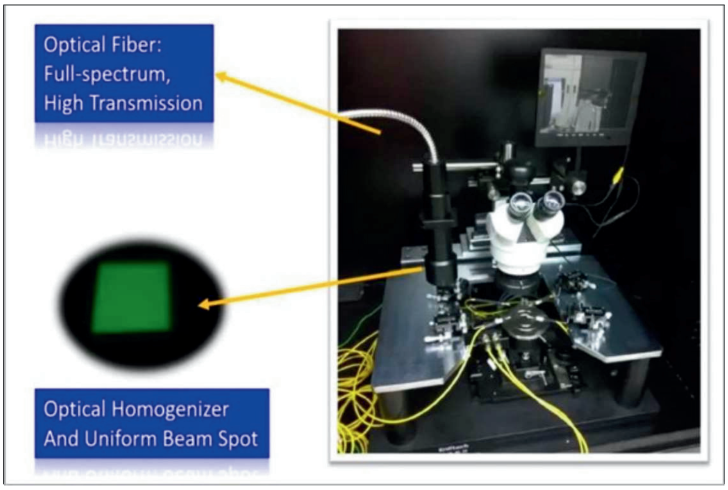


PEM™ Mode for a-Si TFT Photosensor

The CP mode was used for the photocurrent response spectroscopy (QE) study of a-Si TFT photosensors. The test results show that the photocurrent response (QE) spectrum of the a-Si TFT photosensor changes greatly under different irradiation conditions of constant photon number, indicating the nonlinear effect of this sensor.

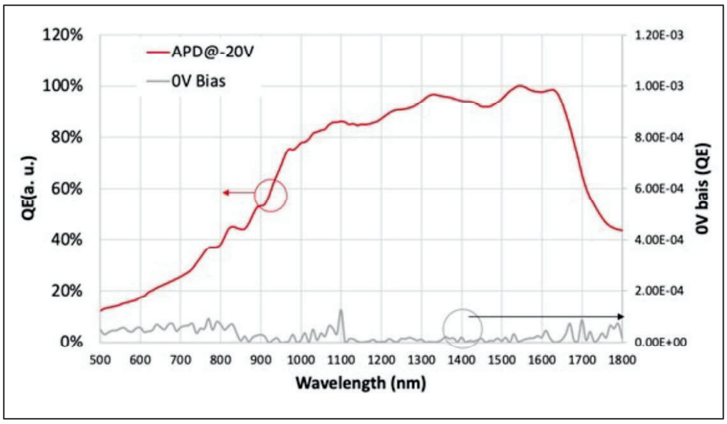
2. InGaAs Avalanche Diode Spectrum Response Test

Avalanche diodes need to work at high voltages (generally >15V), which has exceeded the voltage (Max 12V) that all lock-in amplifiers on the market can withstand. Avalanche diodes with advanced technology have a small light receiving area (<50um) and cannot be tested in "power mode". APD-QE can be integrated with the probe station and provide "amplitude illumination" mode, which can overcome the dispersion problem of small spot to accurately test advanced PD devices <100um.



APD-QE probe station integration & the “irradiance mode”

APD-QE can be integrated with a variety of probe stations. At the same time, the "irradiance mode" with uniform light spot is adopted. The monochromatic light spot with high uniformity is irradiated on the device with a diameter of <100um. The quantum efficiency test of the full spectrum is performed, which can overcome the serious test error caused by the dispersion phenomenon of traditional small light spots at different wavelengths.



EQE Tests of InGaAs Avalanche Diode

APD-QE tests the quantum efficiency spectra of avalanche diode devices in the infrared band at 0V and -20V bias voltages. The results show that the device hardly works when the bias is not applied. When the bias voltage reaches -20 V, the remarkable quantum efficiency spectrum shows the excellent photoelectric conversion performance of the device, and the highest conversion efficiency is reached at 1600 nm.

3.Low Temperature Polysilicon TFT Sensor Array (LTPS-TFT)

As full-screen fingerprint recognition and more light sensors are integrated on displays using TFT technology, it appears an important part of technological evolution including the spectral response/ quantum efficiency of these light sensors, transfer curves under different incident light intensities, light intensity response dynamic range and response to time, etc. APD-QE integrates multi-channel SMU, which can perform dark state transfer curve test of up to 4-terminal devices, current transfer curve test under variable light intensity, light intensity dynamic range test up to 120dB (6-orders), and photocurrent time response picture. APD-QE provides all the test capabilities required for all optoelectronic characterization.

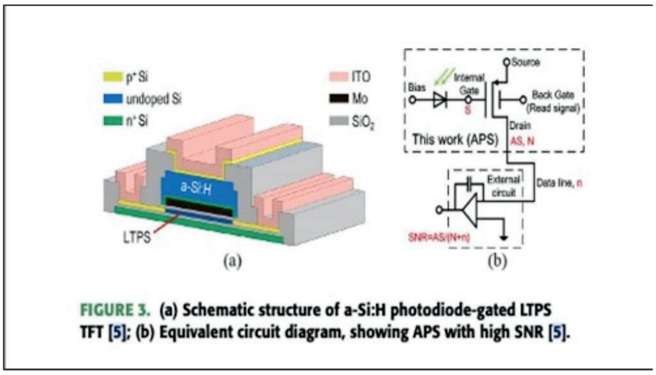
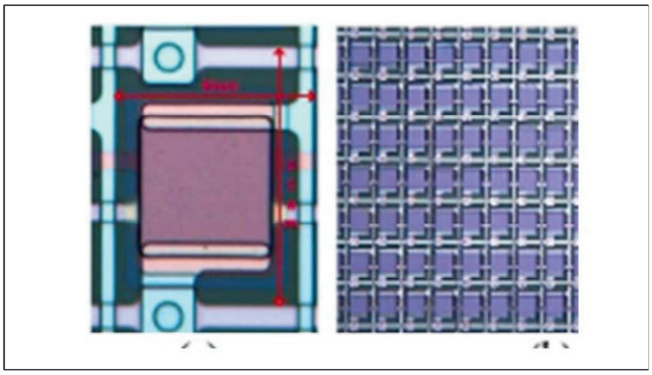
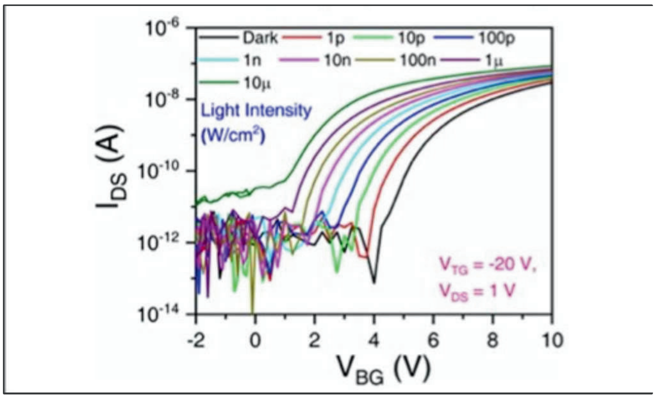


FIGURE 3. (a) Schematic structure of a-Si:H photodiode-gated LTPS TFT [5]; (b) Equivalent circuit diagram, showing APS with high SNR [5].

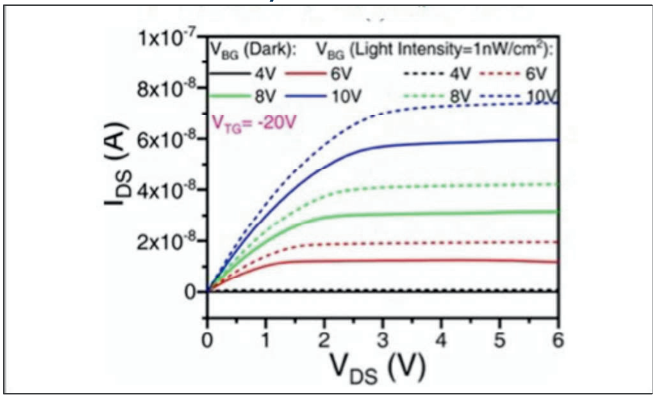
Amorphous silicon photodiode structure



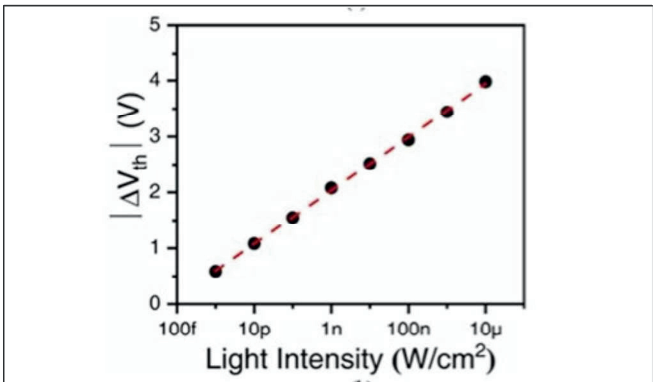
Low Temperature Polysilicon TFT Sensor Array (LTPS-TFT)



Current transfer curves at different constant light intensities (CE)



Transfer curves at different voltages



LDR, 6-order light intensity dynamic testing range

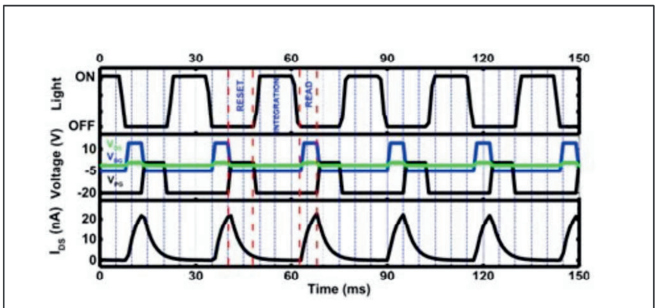


Fig. 14. Photoresponse of π-shaped TFT mimicking operations of reset, integration, and read in an imaging pixel.

Photocurrent Time Response Plot of TFT Sensor