GaN/ $Al_{1-x}Ga_xN$ Ultraviolet Photodetectors Grown by Metalorganic Chemical Vapor Deposition

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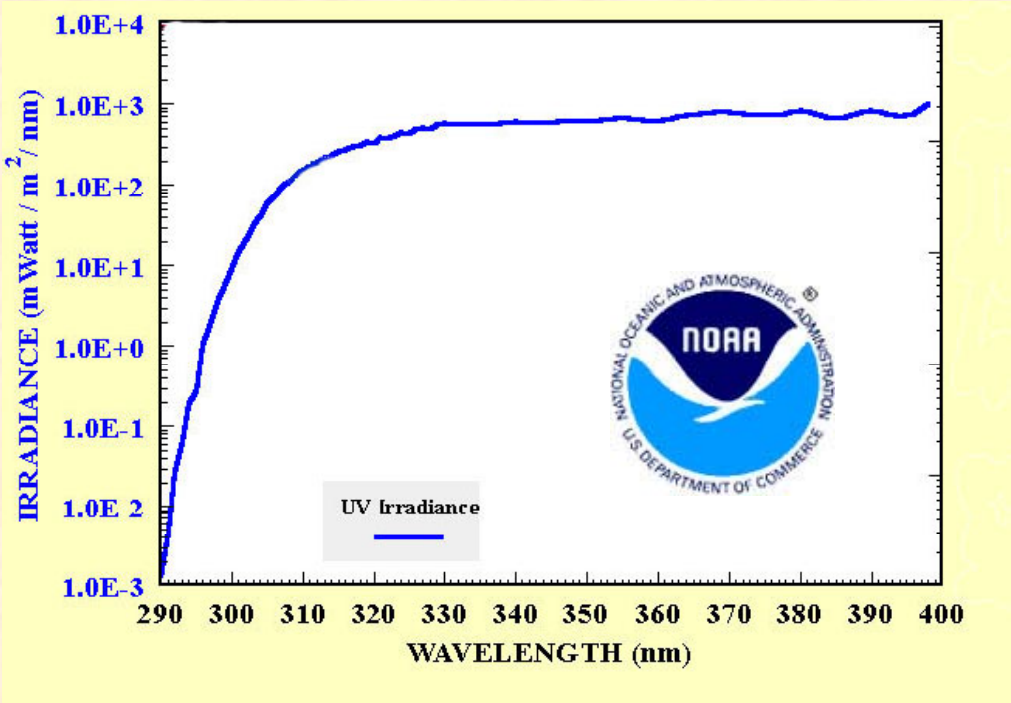
$Al_xGa_{1-x}N$/GaN Photodetectors

- Solar-blind $Al_xGa_{1-x}N$ PINs
- Solar-blind $Al_xGa_{1-x}N$ MSMs
- GaN PIN APDs

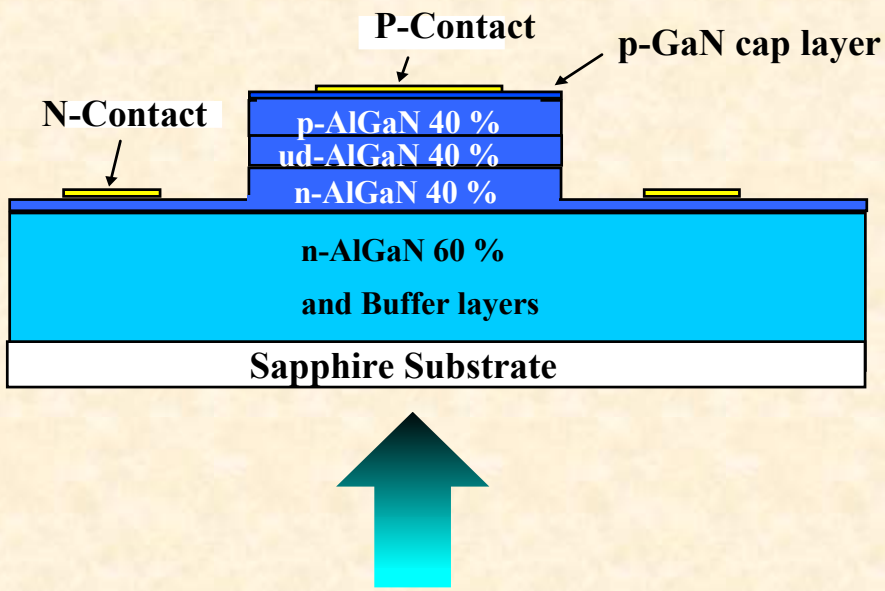
Atmospheric solar UV spectral irradiance



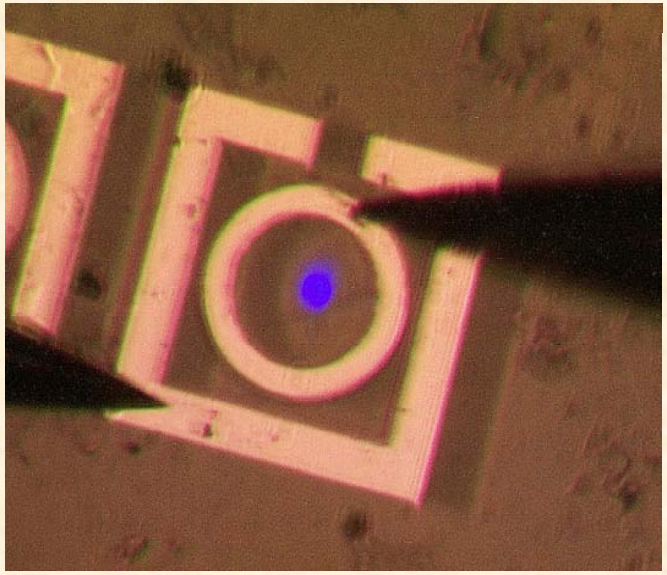
Measured at the surface June 22 at solar noon.

Back illumination SB PIN photodiodes

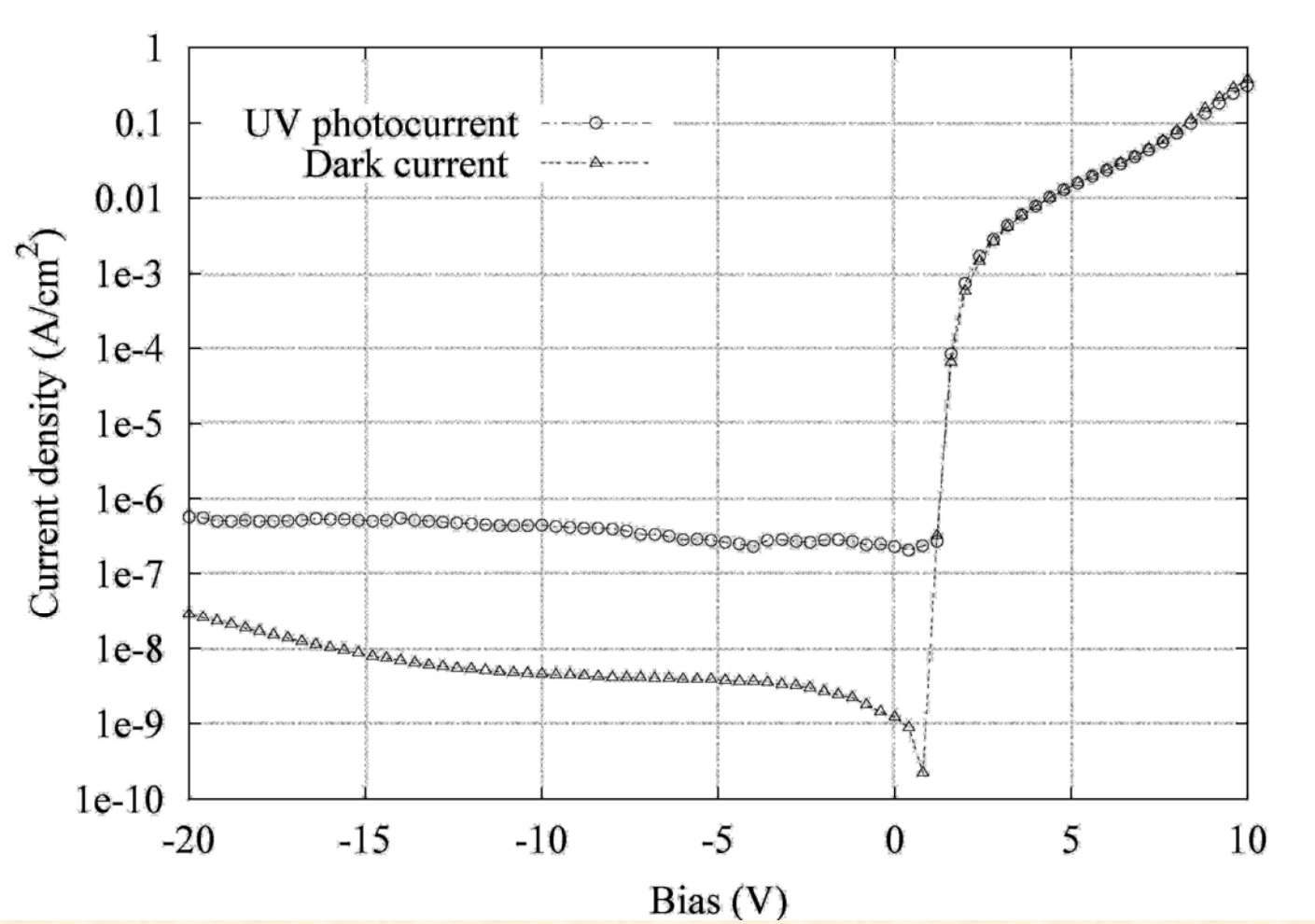
Device cross section



Back illumination QE device test

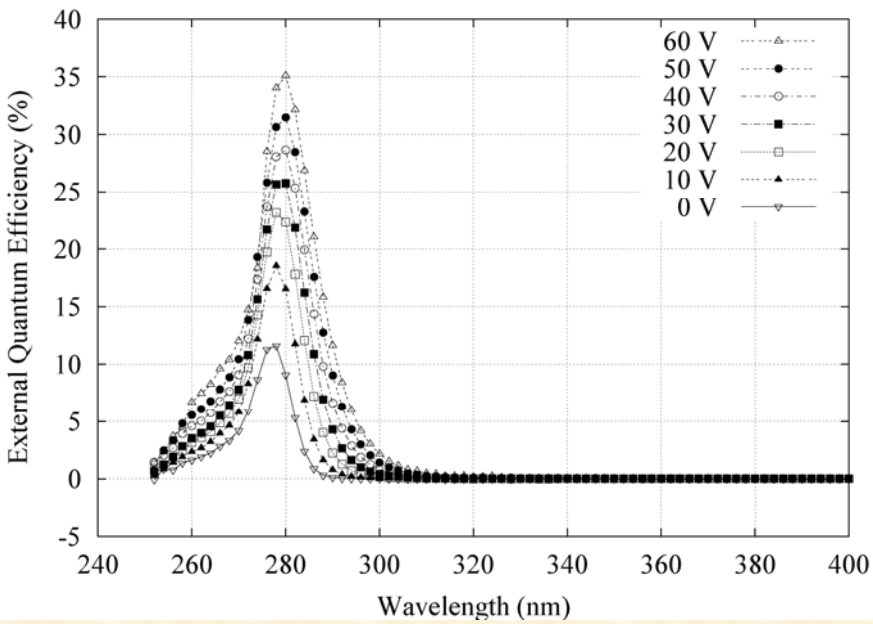


Current-Voltage Characteristic

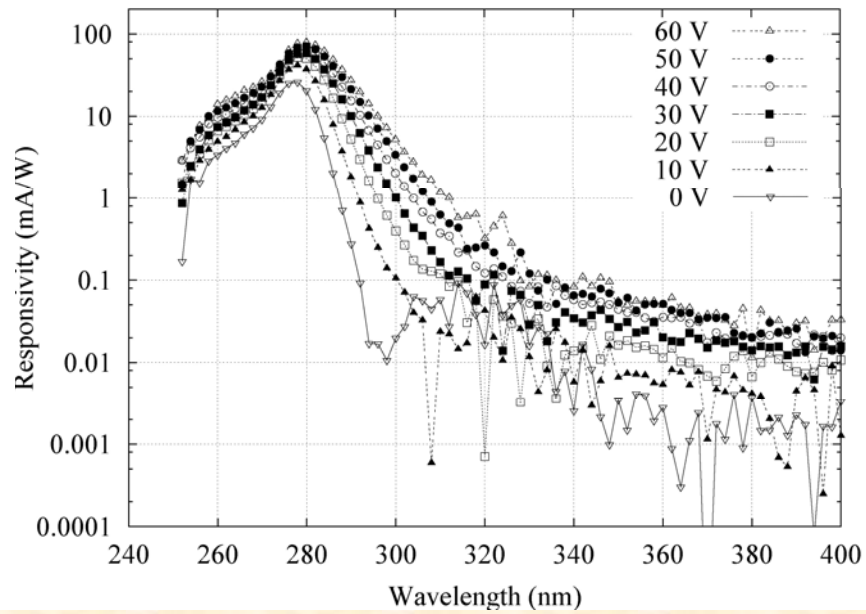


Quantum Efficiency and Spectral Response

External quantum efficiency



Spectral responsivity



PIN Low Frequency Noise Data

Lower bound **$D^* = 4.2\text{x}10^{11}$ cm·Hz$^{1/2}$·W^{-1}**

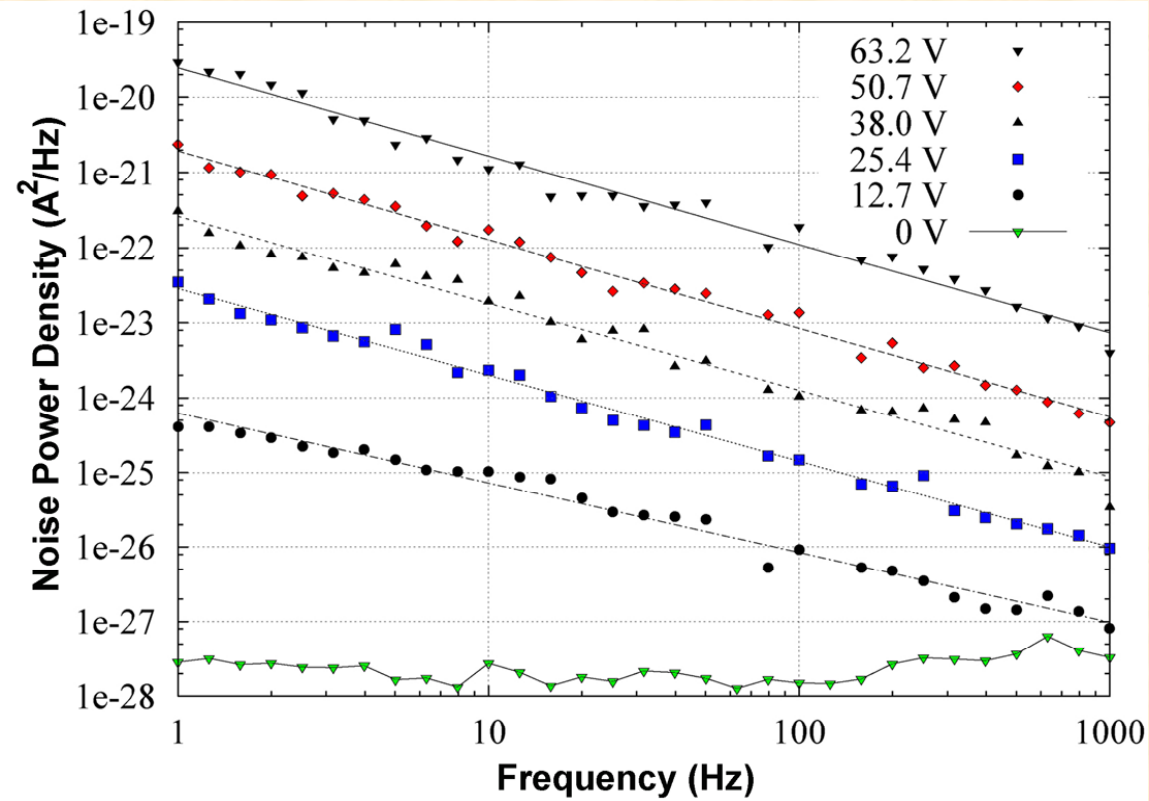
$$NEP = \sqrt{i_n^2} \Big/ \Re$$

$\Re =$ Responsivity

$$D^* = \frac{\sqrt{A_D B}}{NEP}$$

$A_D =$ Cross-sectional area

$B =$ Bandwidth



PIN R_0A Extraction

Upper bound **$D^* = 5.3\text{x}10^{13}$ cm·Hz$^{1/2}$·W^{-1}**

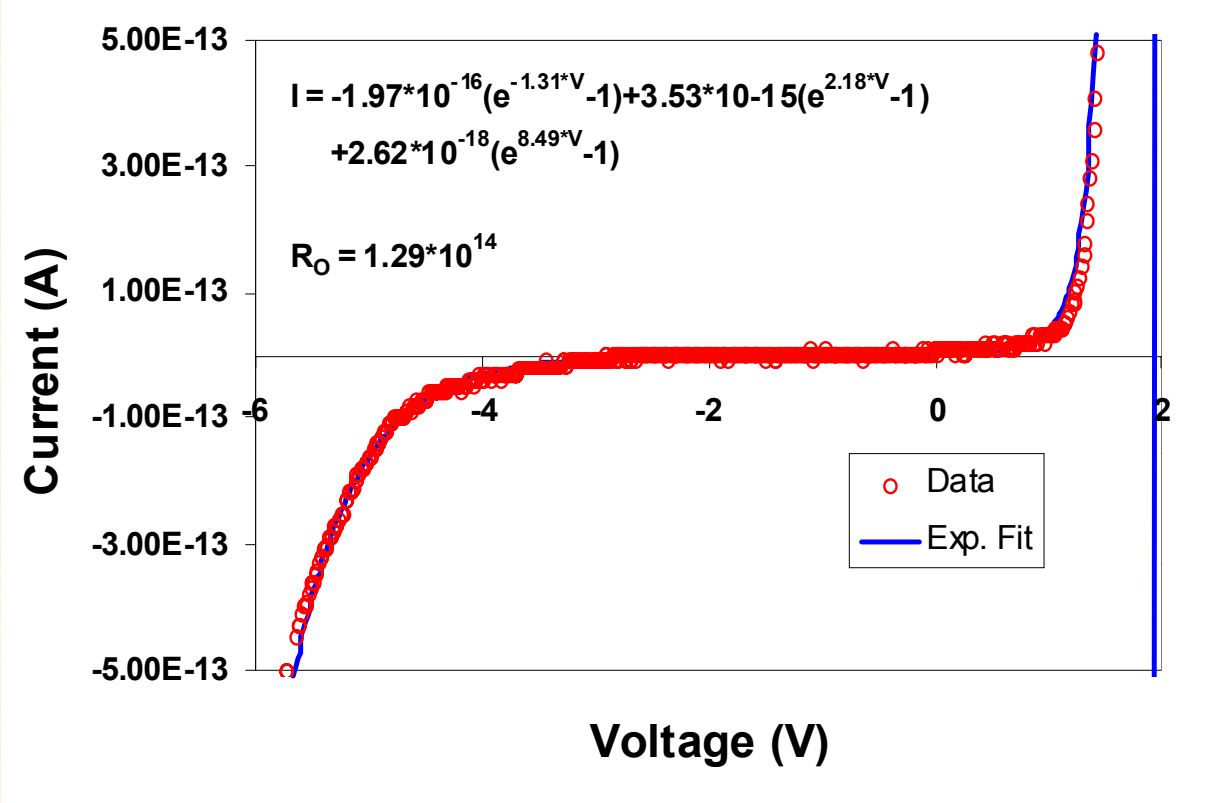
$$\frac{1}{R_0} = \left.\frac{dI}{dV}\right|_{V=0}$$

$R_0 =$ Differential resistance

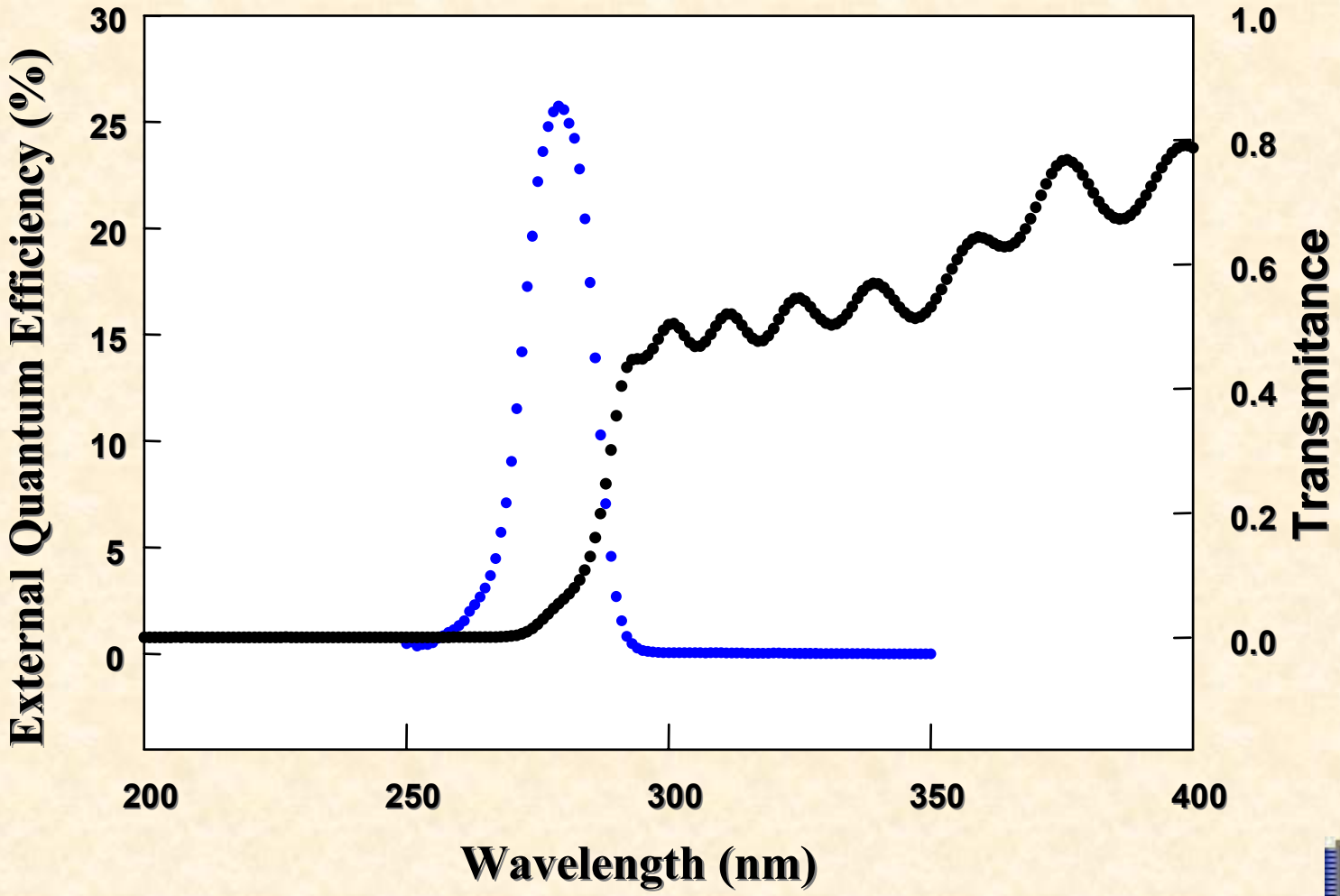
$$D^* = R_\lambda \left(\frac{R_0 A}{4kT}\right)^{1/2}$$

$R_\lambda =$ Responsivity at zero bias

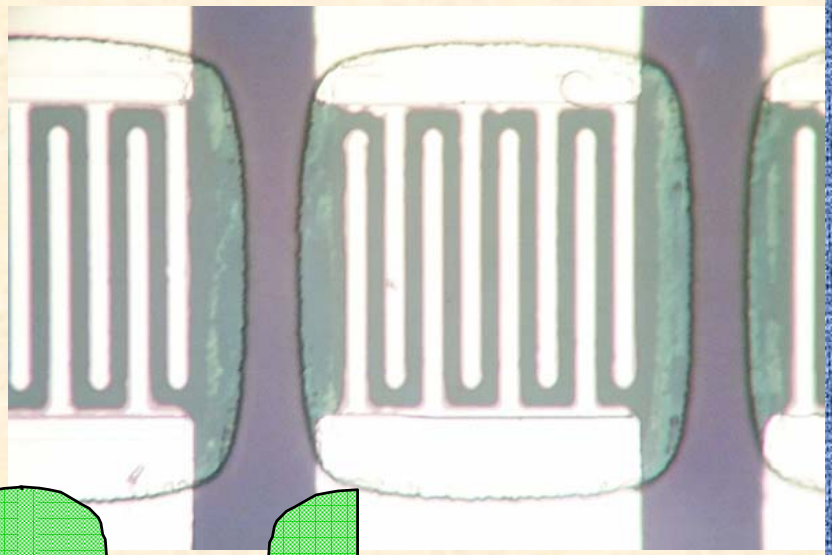
$A =$ Cross-sectional area

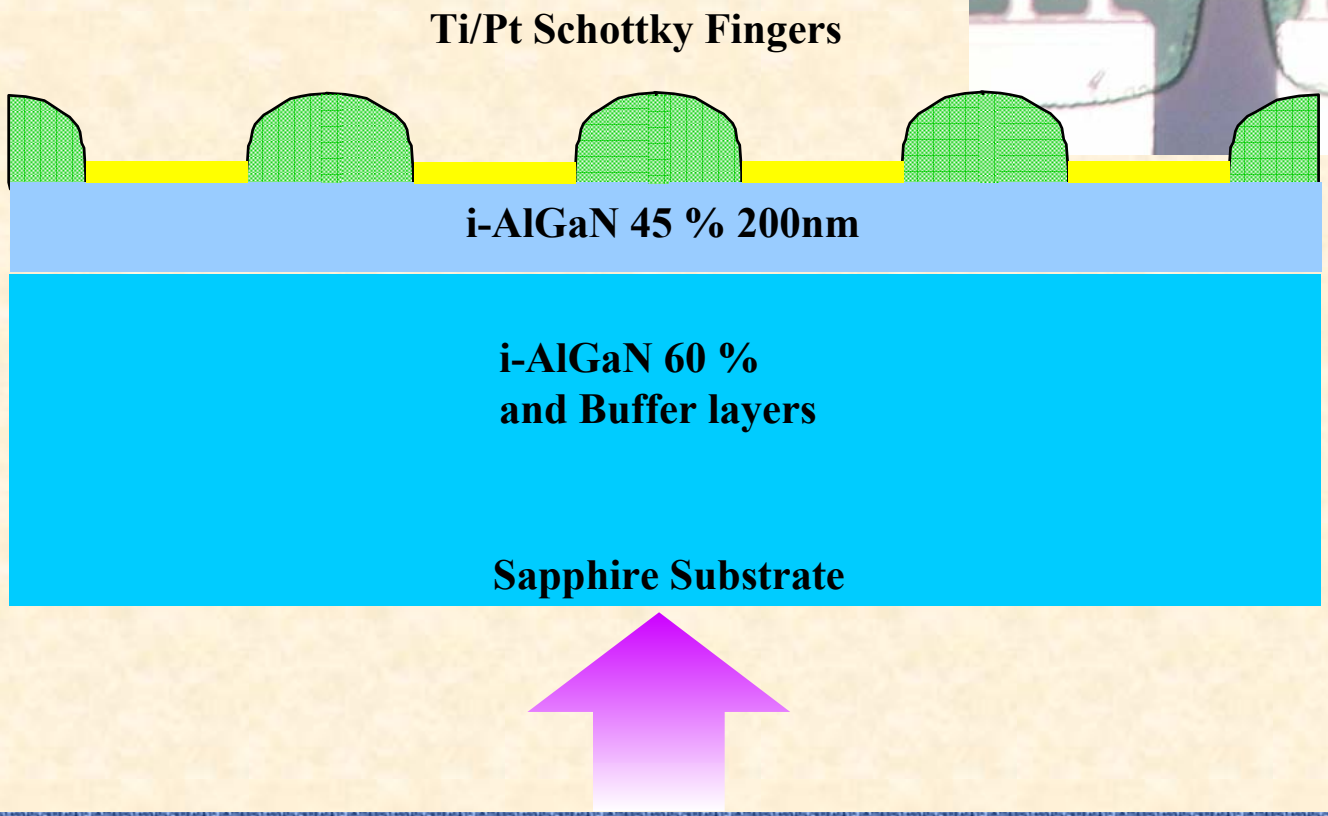


Solar-Blind $Al_xGa_{1-x}N$ PINs

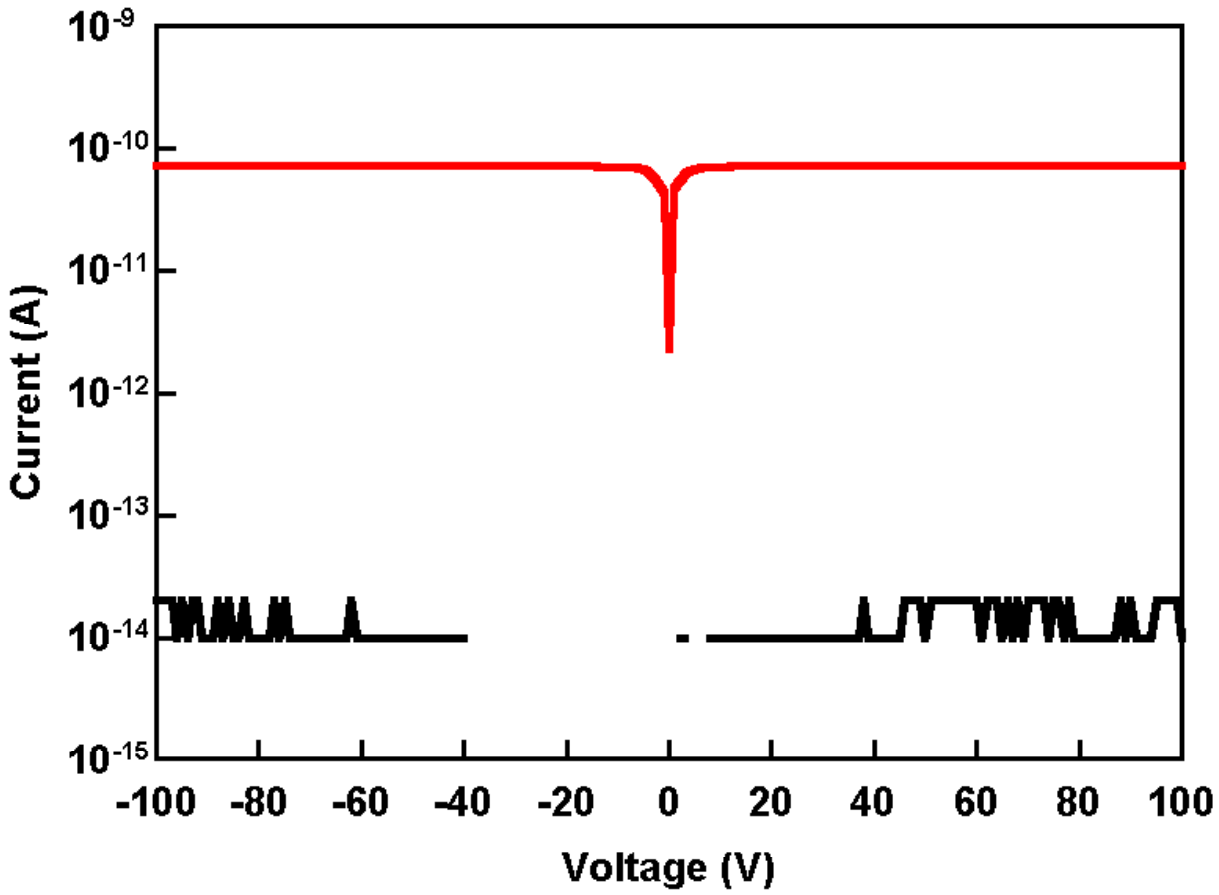


Solar-blind $Al_xGa_{1-x}N$ MSMs

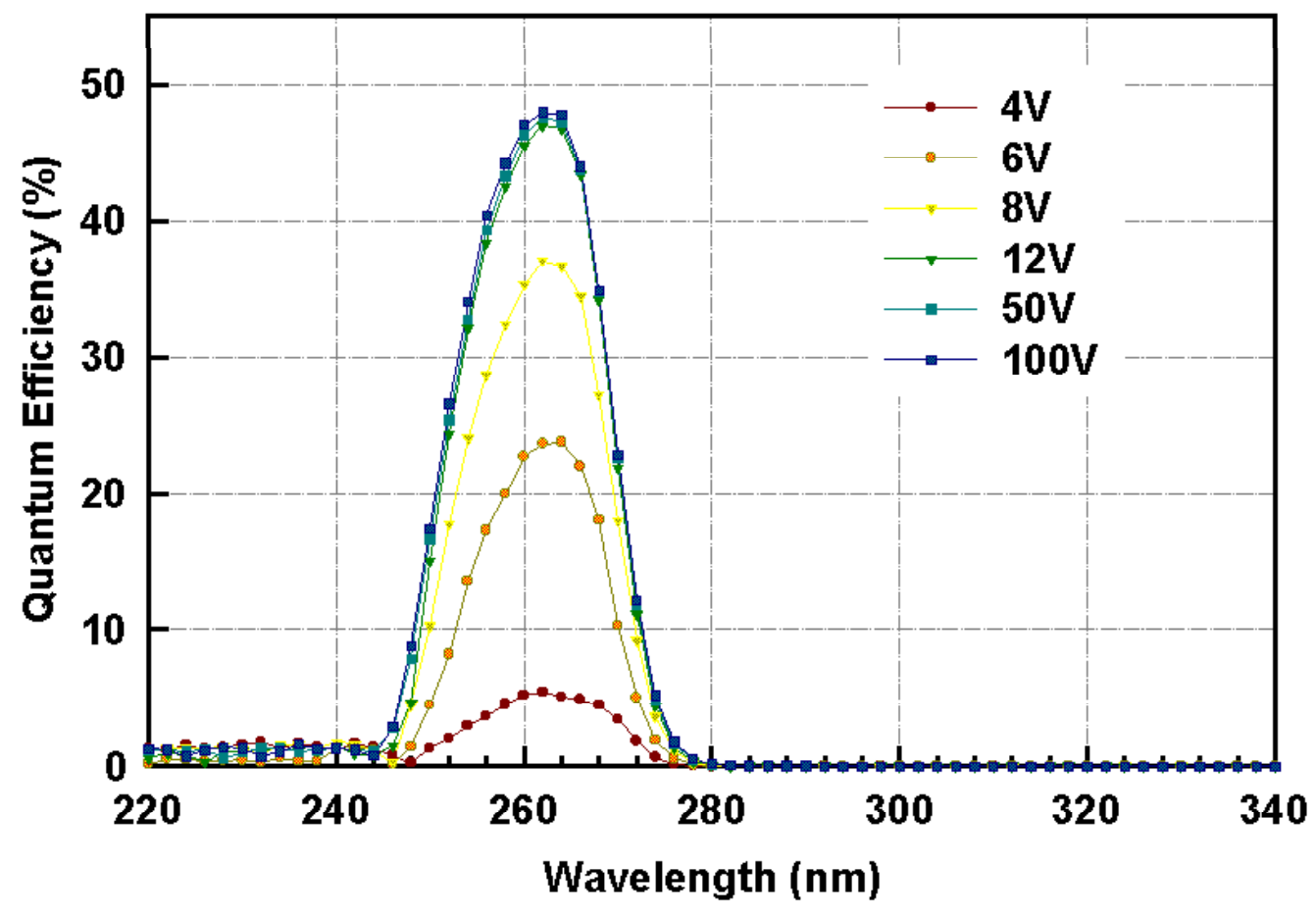




Solar-blind $Al_xGa_{1-x}N$ MSMs:
Current voltage characteristic



Solar-blind $Al_xGa_{1-x}N$ MSMs: External Quantum Efficiency

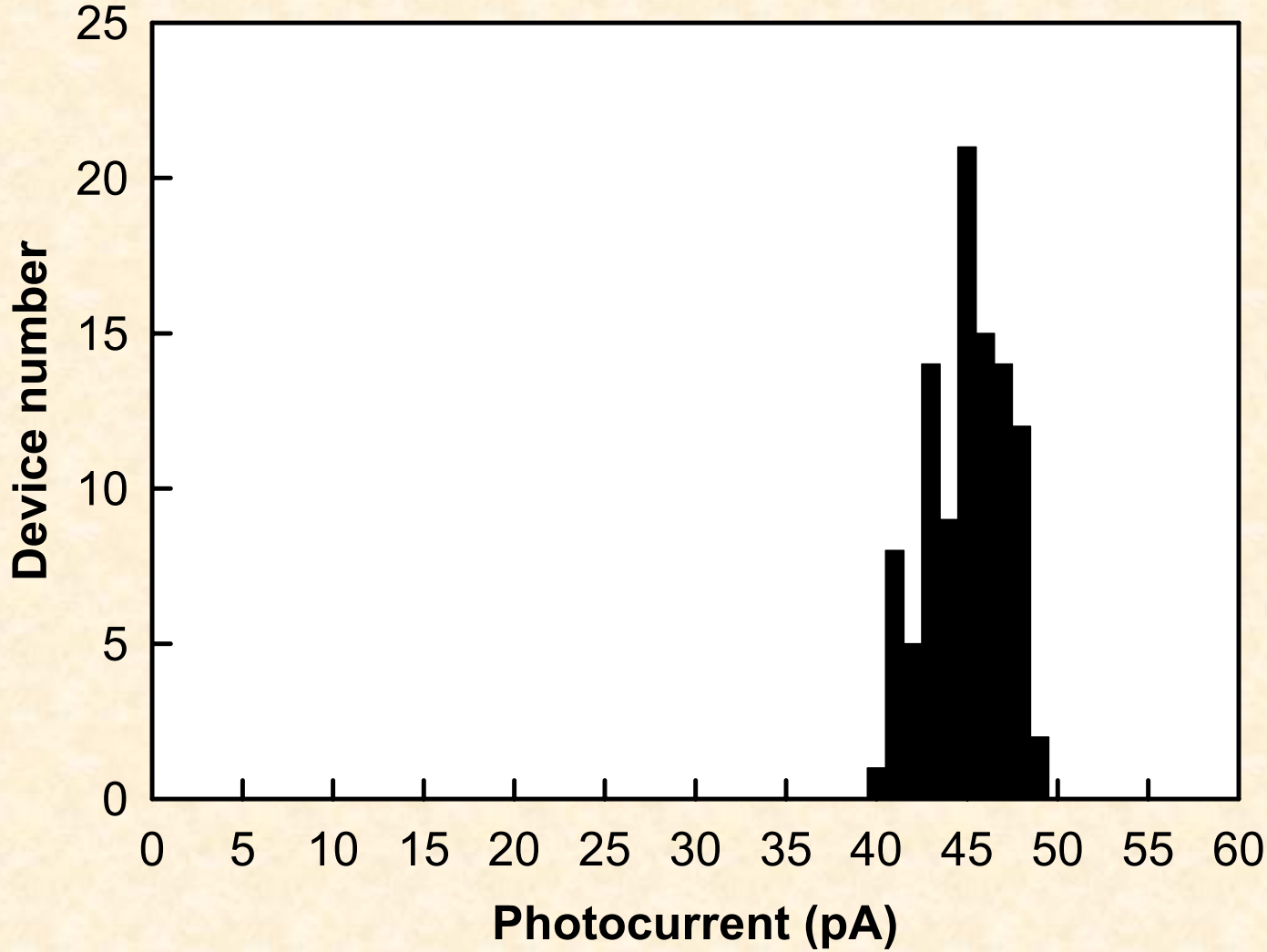


Peak Q.E. of ~47% at 15V, λ=262 nm.

Q.E. constant V > 15V

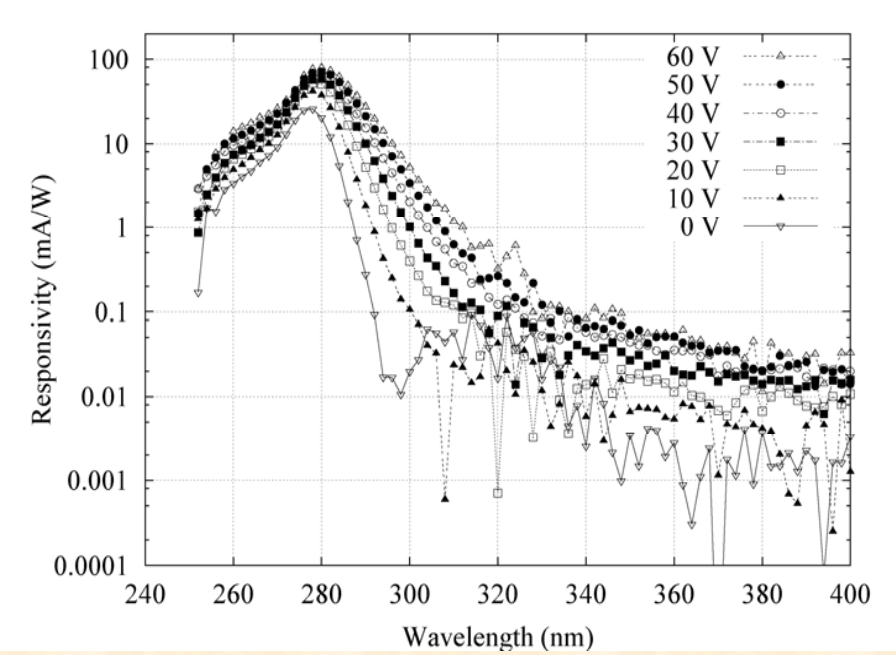
MSM Device Uniformity

10×10 SB array photocurrent histogram

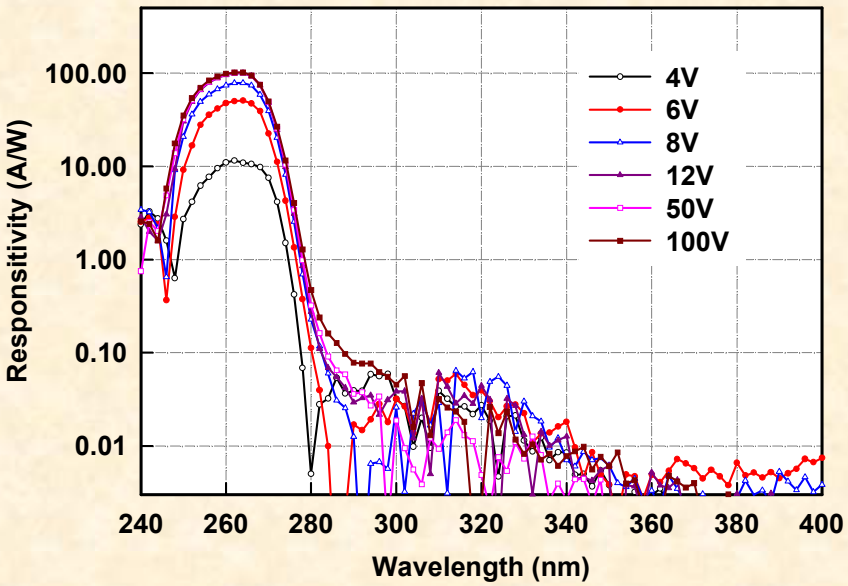


Device Responsitivity Comparison

PIN spectral responsitivity



MSM spectral responsitivity

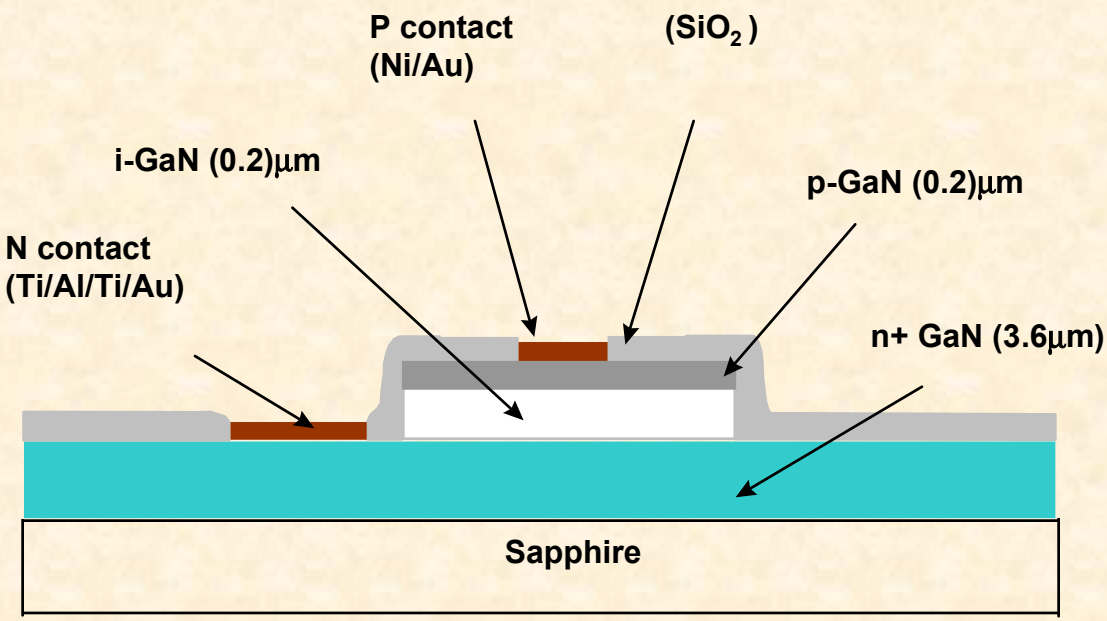


GaN Avalanche Photodiodes

Avalanche internal gain can improve the sensitivity

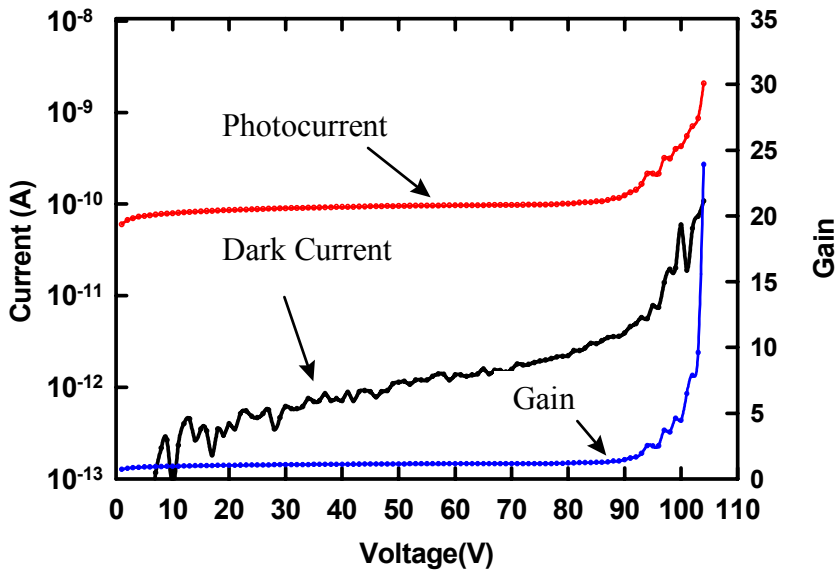
$$NEP_{PIN} = \frac{h\nu}{q\eta}\left[2q(i_{ph} + i_d)B + 4kTB/R\right]^{1/2} (\mathrm{W.Hz}^{-1/2})$$

$$NEP_{APD} = \frac{1}{M} NEP_{PIN}$$

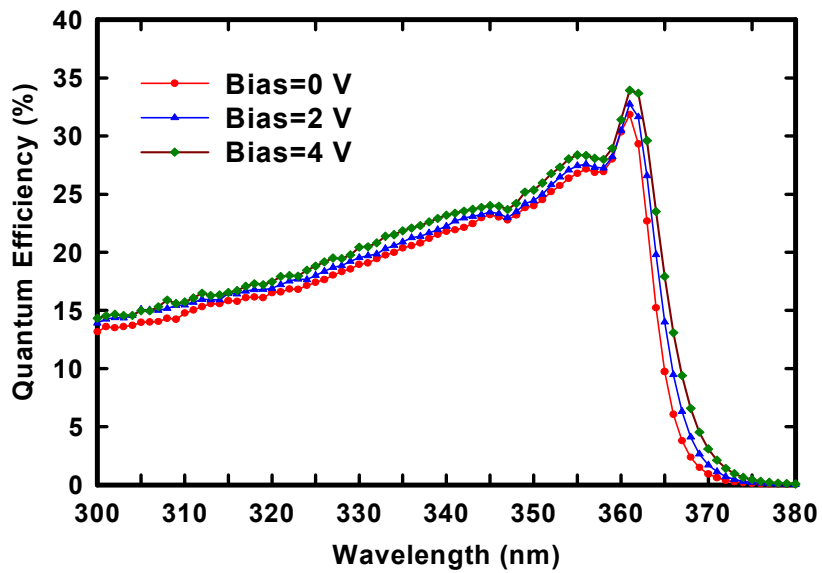


GaN Avalanche Photodiodes

Current voltage characteristic

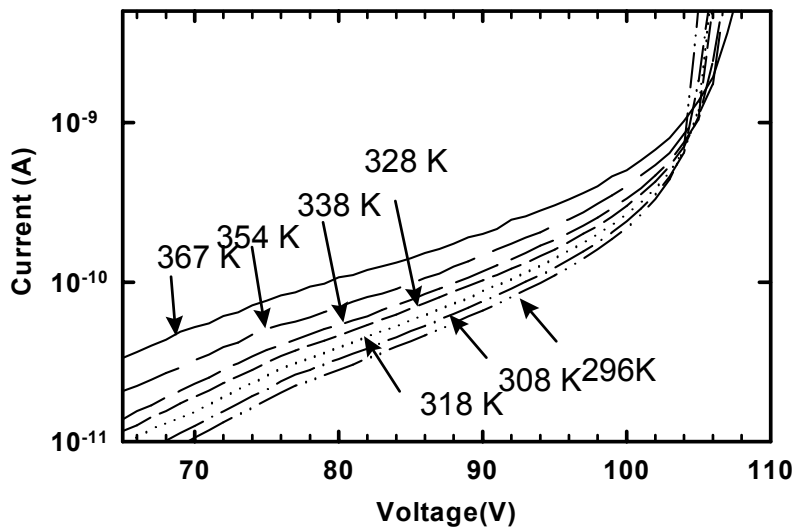
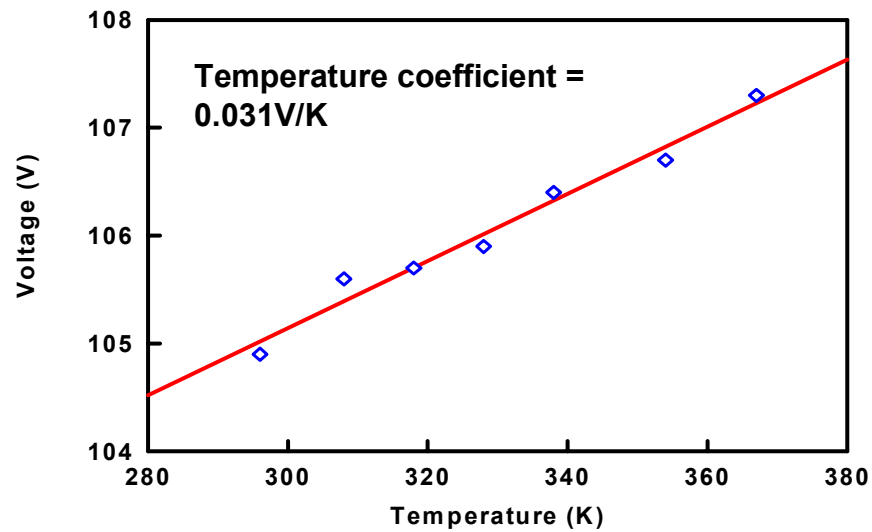


Spectral response



GaN Avalanche Photodiodes:
Ionization Temperature Dependence

I-V curves at different temperatures



Extracted temperature coefficient