Supporting Information

Nanoflowers like GaSe/β-Ga_2O_3 based heterostructure for highly efficient self-powered broadband photodetector

Urvashi Varshney[1,2], Anuj Sharma[1,2], Aditya Yadav[1,2], Preeti Goswami[1,2] and Govind Gupta[1,2]*

[1] *Academy of Scientific & Innovative Research (AcSIR), Ghaziabad-201002, India.*
[2]*CSIR-National Physical Laboratory, Dr. K.S. Krishnan Marg, New Delhi, 110012, India.*

**Corresponding Author Email:* govind@nplindia.org, govindnpl@gmail.com

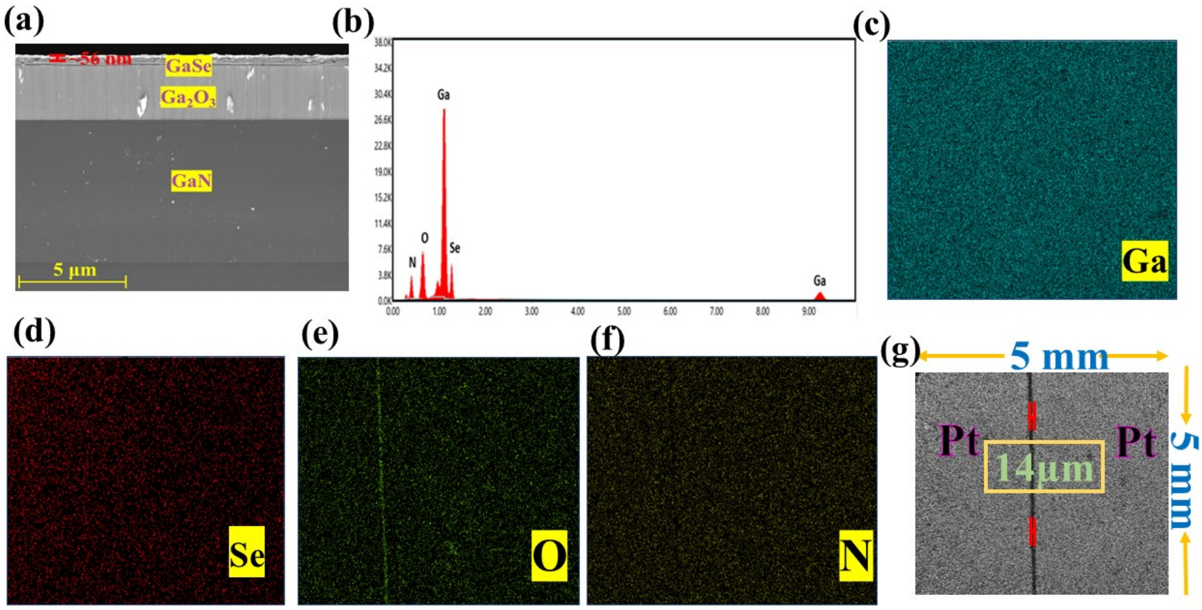

Figure S-1: (a) Cross-sectional FESEM image, (b) EDAX spectra, with individual elemental mapping of (c) Ga, (d) Se, (e) O and (f) N, and (g) top-view image of the GaSe/β-Ga_2O_3/GaN heterostructure.

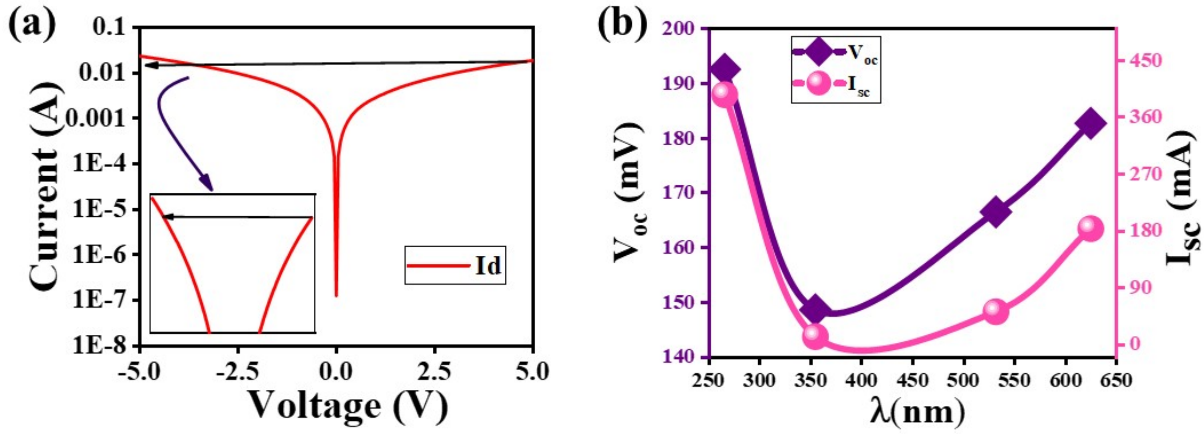

Figure S-2: (a) I–V semilog plots of the developed device, and the inset shows an enlarged display at 5 V and (b) V_{oc} (I_{sc}) values at 0V bias for illumination wavelength.

The values of open circuit voltage (V_{oc}), short circuit current (I_{sc}), responsivity (R), external quantum efficiency (EQE), detectivity (D), linear dynamic range (LDR), and power law are determined using the following equations.

$$V_{oc} = \frac{K_B T}{e} ln\left(\frac{I_l}{I_d} - 1\right) \quad (1)$$

$$I_{sc} = (I_l - I_d)\left[\left(exp\frac{eV_{oc}}{K_B T}\right) - 1\right] \quad (2)$$

$$R = \frac{I_{light} - I_{dark}}{P_d A} = \frac{I_P}{P} \quad (3)$$

$$E.Q.E. = \frac{R.hv}{e} \quad (4)$$

$$NEP = \frac{\{2eId\}1/2}{R} \quad (5)$$

$$D = \frac{(R\sqrt{A})}{\sqrt{2eI}}$$

where K_B is the Boltzmann constant, $\frac{K_BT}{e}$ is the thermal voltage, 25.69 mV at room temperature, I_{light} is the photocurrent under illumination, I_{dark} is the dark current, P_d is power density, P is incident optical power intensity, A is the effective illumination area of the device, e is the charge of an electron, I_p is the photocurrent, P_{max} and P_{min} represents the optical power maximum and minimum in a particular range of the device, h is the Planks constant, and α determines the photocurrent response w.r.t. optical power density.

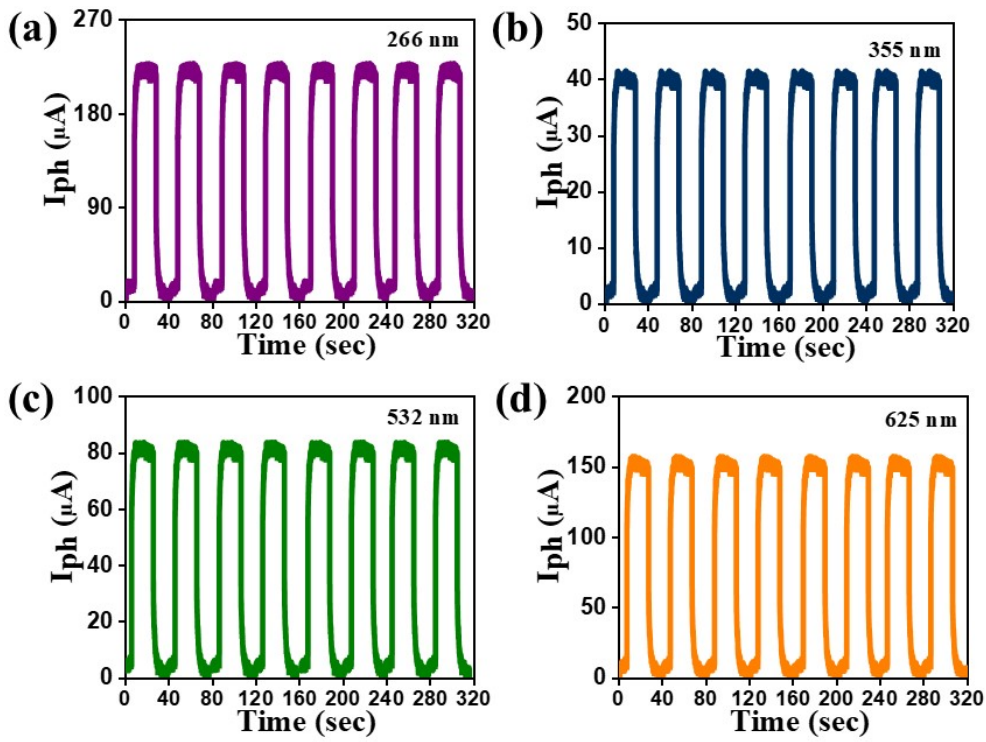

Figure S-3: Consistent, repeatable on/off multi-cycle at 0 V applied bias for all wavelengths, (a) 266 nm, (b) 355 nm, (c) 532 nm, and (d) 625 nm light illumination.

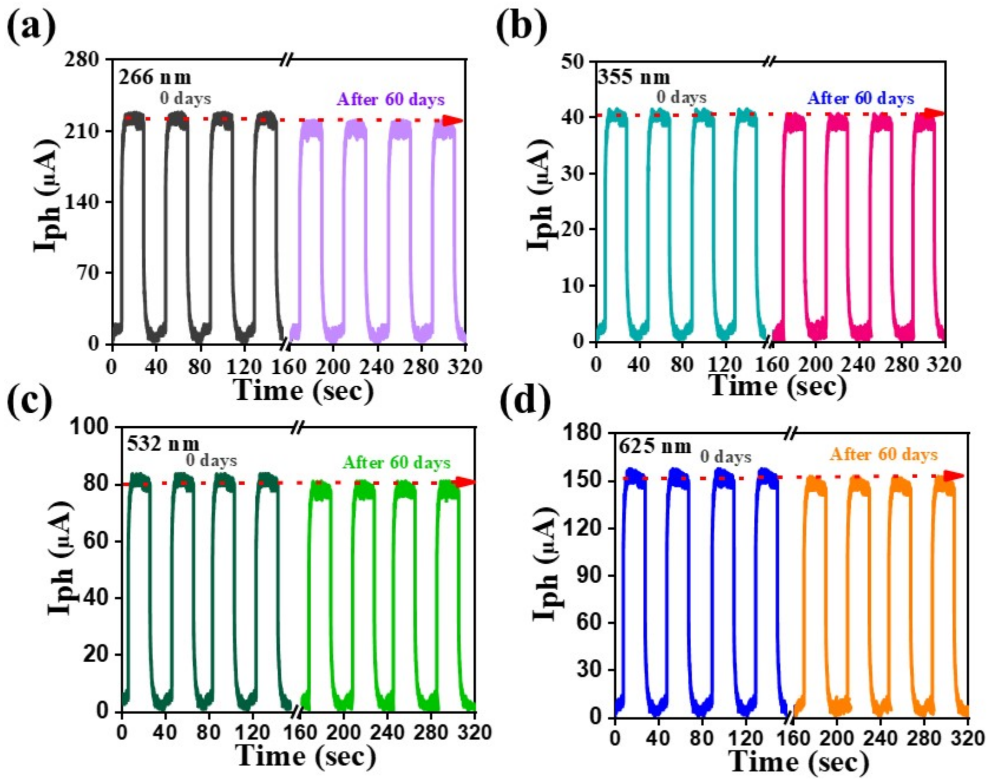

Figure S-4: The device performs at (a) 266 nm, (b) 355 nm, (c) 532 nm, and (d) 625 nm wavelengths after two months, demonstrating outstanding stability.

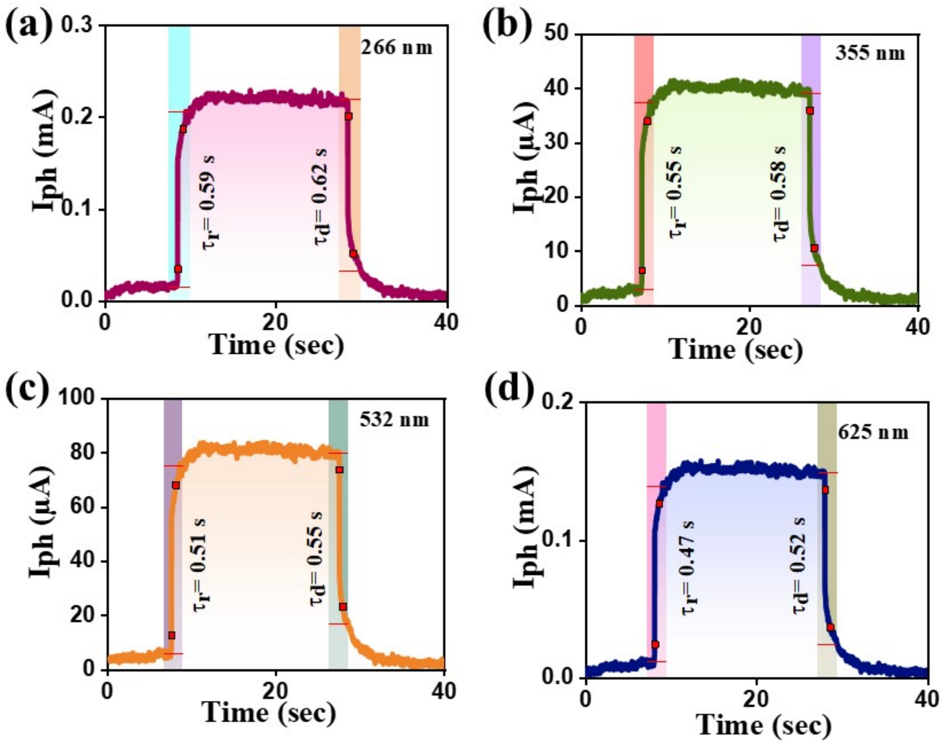

Figure S-5: The photoresponse curve to calculate the rise time and decay time (a) 266 nm, (b) 355 nm, (c) 532 nm, and (d) 625 nm.

Table S1: The bias-dependent performance parameters of the Ga_2O_3/GaN-NSS photodetection device for all wavelengths.

Wavelength (nm)	Bias (V)	R (AW^{-1})	D ($\times 10^9$ Jones)	EQE ($\times 10^3$%)	NEP ($\times 10^{-12}$ $WHz^{-1/2}$)
266 nm	0.5	5.48	3.31	2.56	3.91
	1	10.67	4.62	4.98	2.80
	3	37.40	8.67	17.47	1.49
	5	71.06	11.94	33.19	1.08
355 nm	0.5	1.43	0.83	0.50	14.94
	1	2.69	1.12	0.94	11.11
	3	9.51	2.13	3.32	5.87
	5	18.04	2.92	6.31	4.27
532 nm	0.5	2.29	1.44	0.53	9.36
	1	4.37	1.97	1.02	6.84
	3	15.52	3.74	3.62	3.60
	5	29.37	5.14	6.86	2.62
625 nm	0.5	5.01	3.14	1.75	4.29
	1	9.79	4.41	3.42	3.05
	3	34.17	8.24	11.95	1.63
	5	64.80	11.33	22.67	1.18

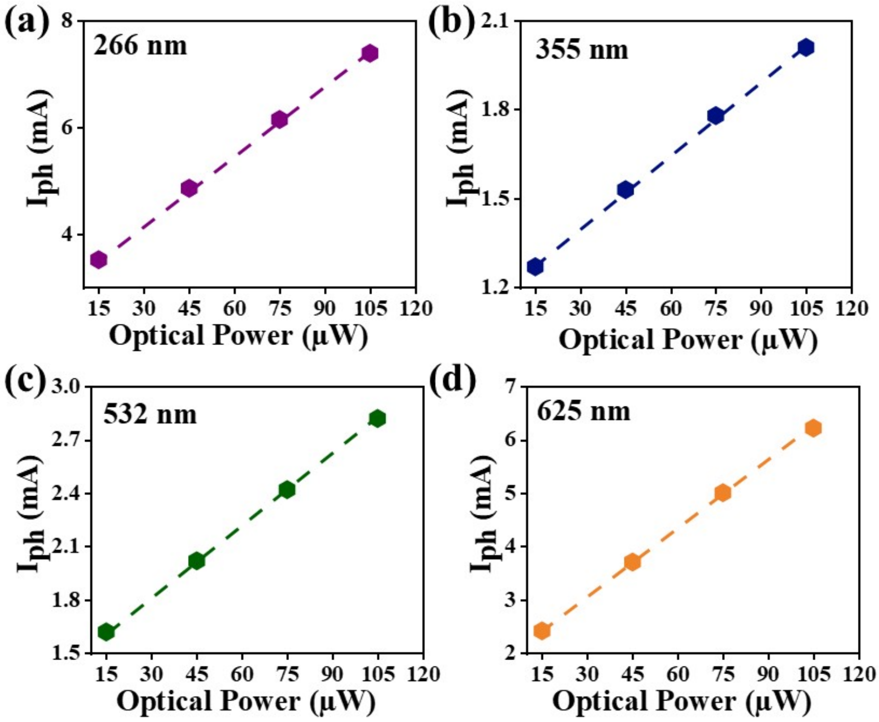

Figure S-6: Power–law curves for the developed device under the light illumination (a) 266 nm, (b) 355 nm, (c) 532 nm & (d) 625 nm.