SUPPORTING INFORMATION

High-performances "fueled" photodetector based on few-layered 2D ternary chalcogenide $NiGa_2S_4$

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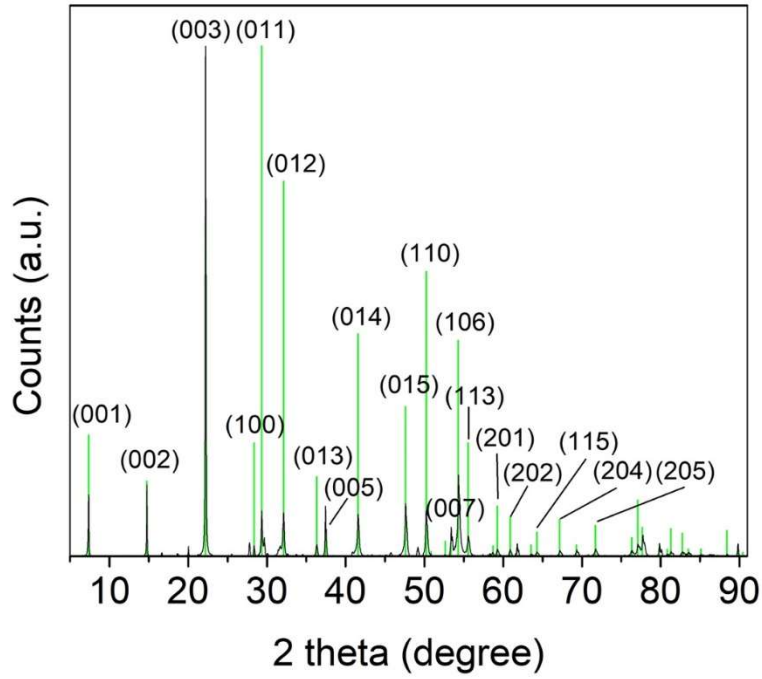


Figure S1. Indexed XRD pattern of the $NiGa_2S_4$ crystalline powder.

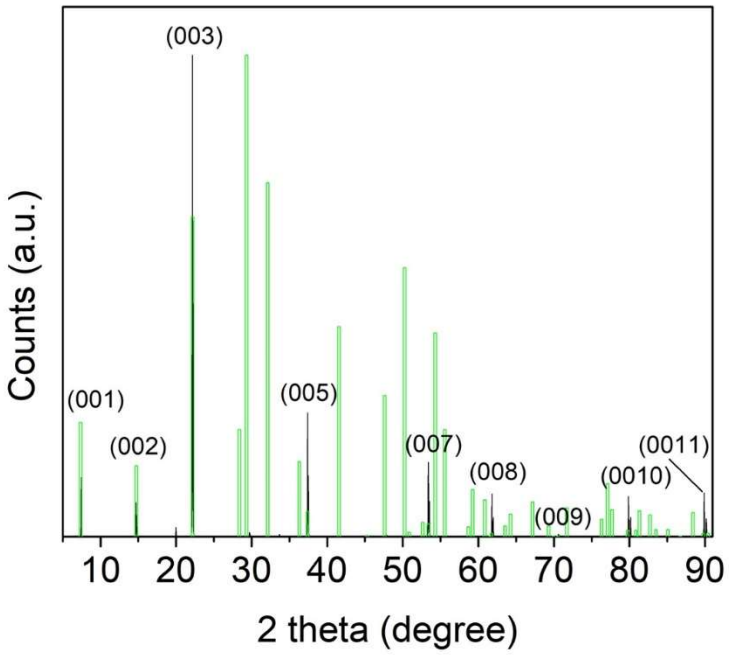


Figure S2. Indexed XRD pattern of a bulk $NiGa_2S_4$ crystal.

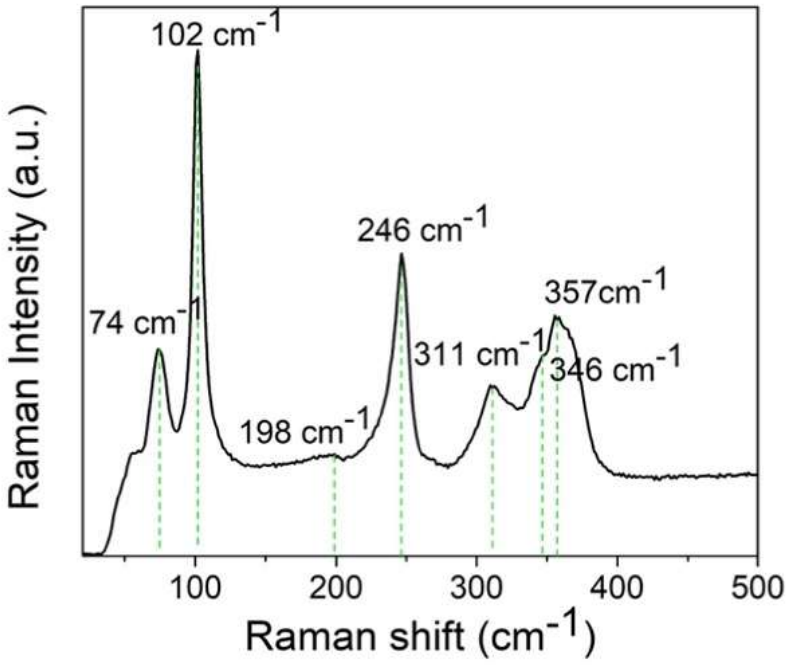


Figure S3. Raman spectra of $NiGa_2S_4$ crystal prepared by CVT technique.

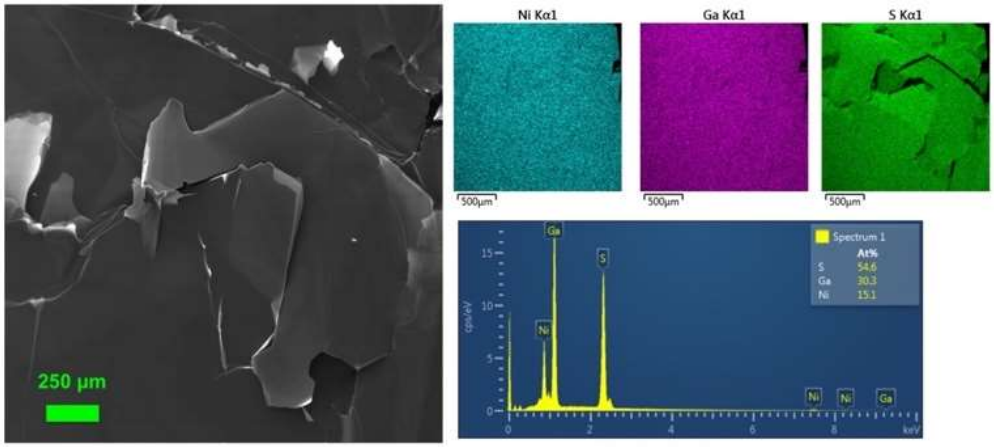


Figure S4. SEM image of a scotch tape exfoliated $NiGa_2S_4$ crystal prepared via CVT technique and the corresponding EDS elemental mapping, spectrum, and semi-quantitative analysis.

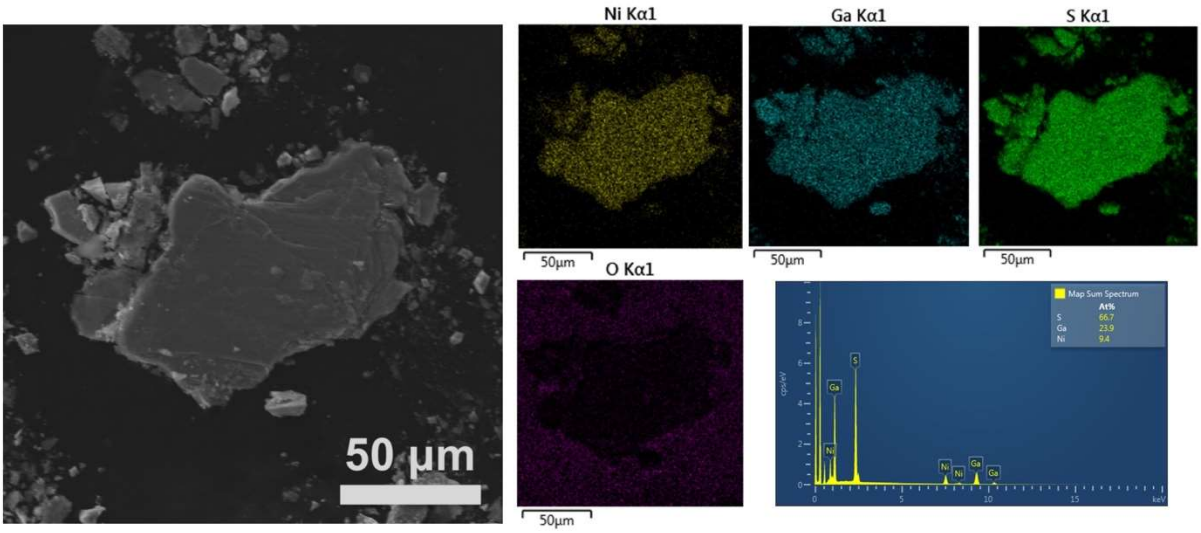


Figure S5. SEM image of a powder obtained grinding $NiGa_2S_4$ crystal exposed to air for a period of 3 months and the corresponding EDS elemental mapping, spectrum, and semi-quantitative analysis.

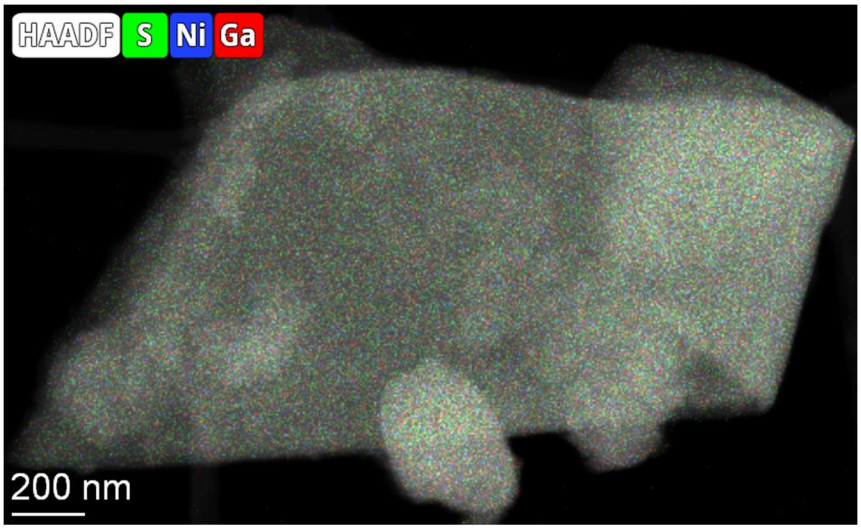


Figure S6. - EDS Map of a typical $NiGa_2S_4$ crystalline flake.

Table S1. Elemental composition obtained from STEM-EDS analysis.

Element	**Atomic Fraction (%)**	**Atomic Error (%)**
S	58.2	2.4
Ni	13.4	1.8
Ga	28.4	2.7

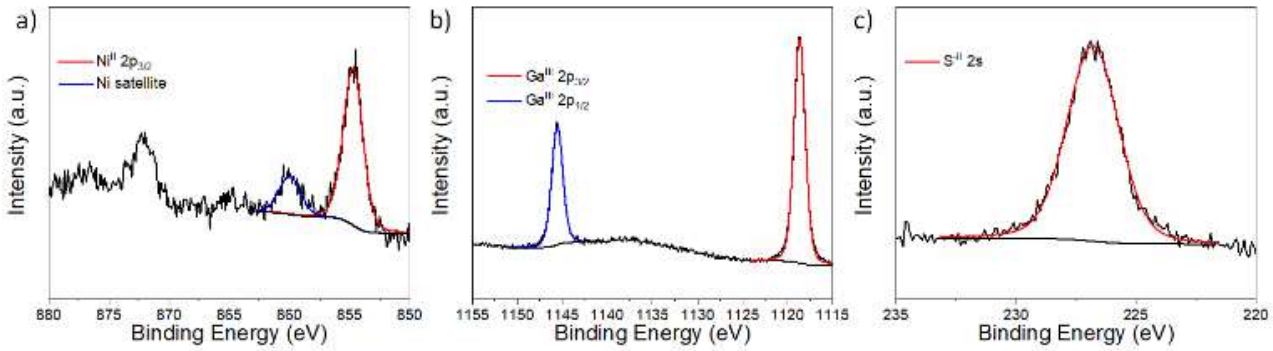


Figure S7. High-resolution core-level spectra of **a)** Ni 2p region; **b)** Ga 2p region and **c)** S 2s region.

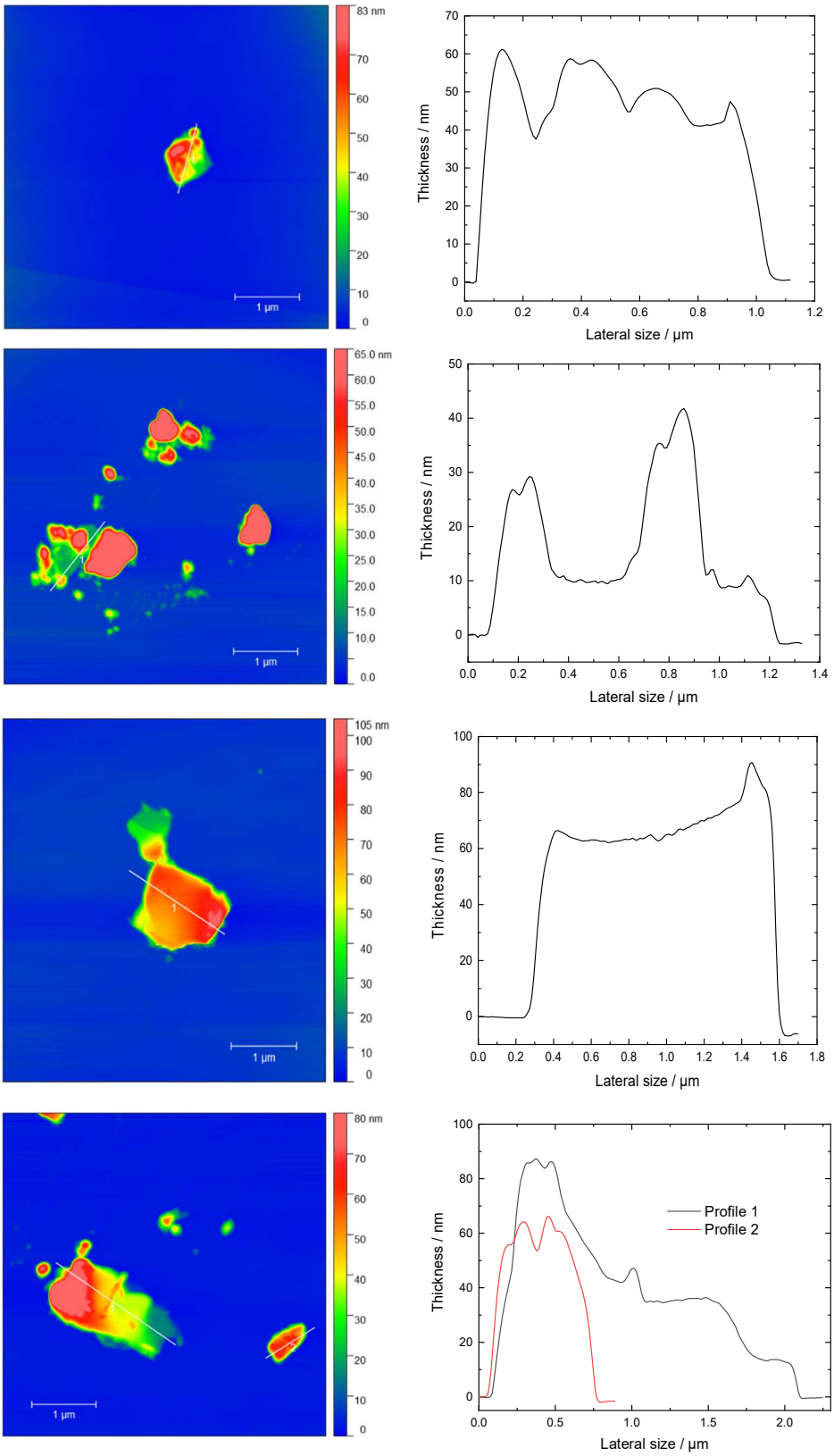


Figure S8. – Various AFM images of 2D-$NiGa_2S_4$ with their corresponding height profile. These flakes were deposited on ITO that were employed as the photodetector.

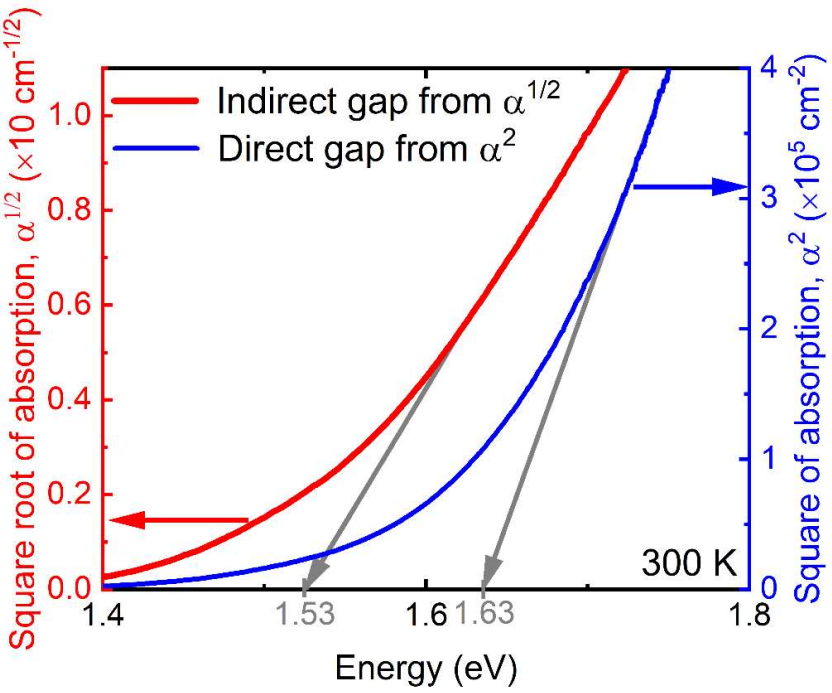


Figure S9. An exemplary analysis of room temperature optical absorption spectrum: square root of absorption (red line) typical for indirect absorption and square of absorption (blue line) typical for direct absorption.

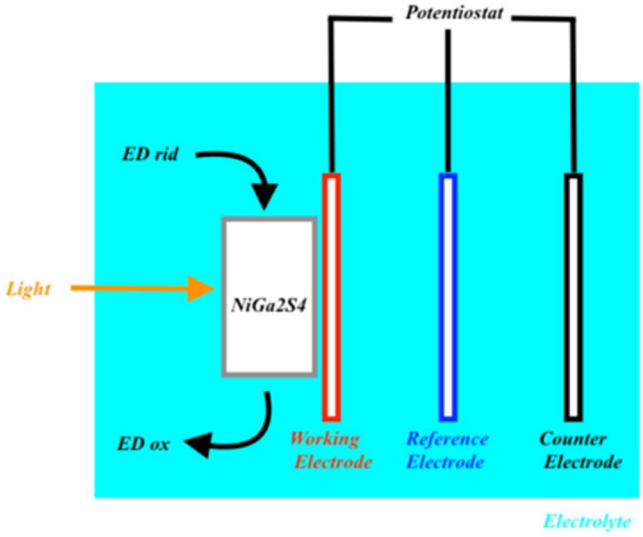
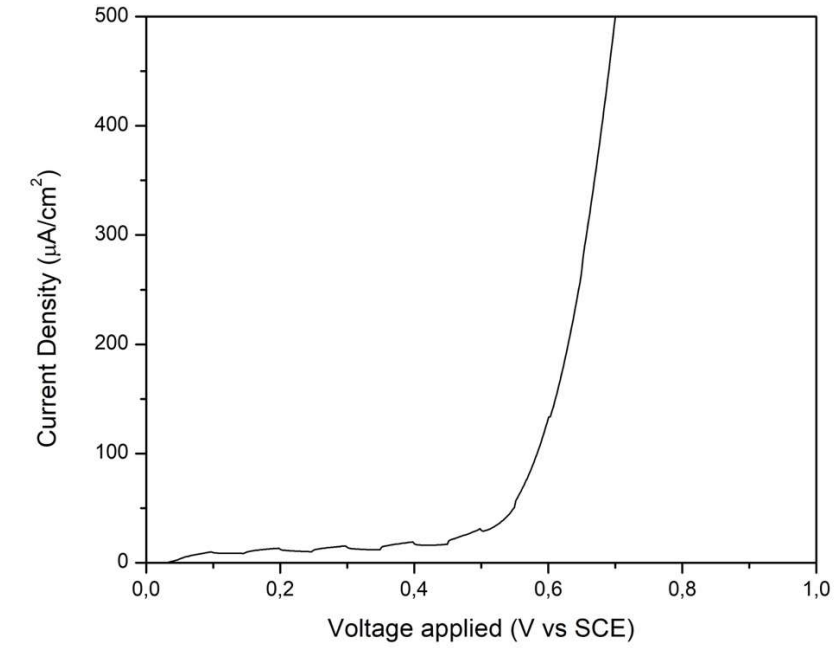


Figure **S10**. Scheme of the cell employed for the PEC tests.



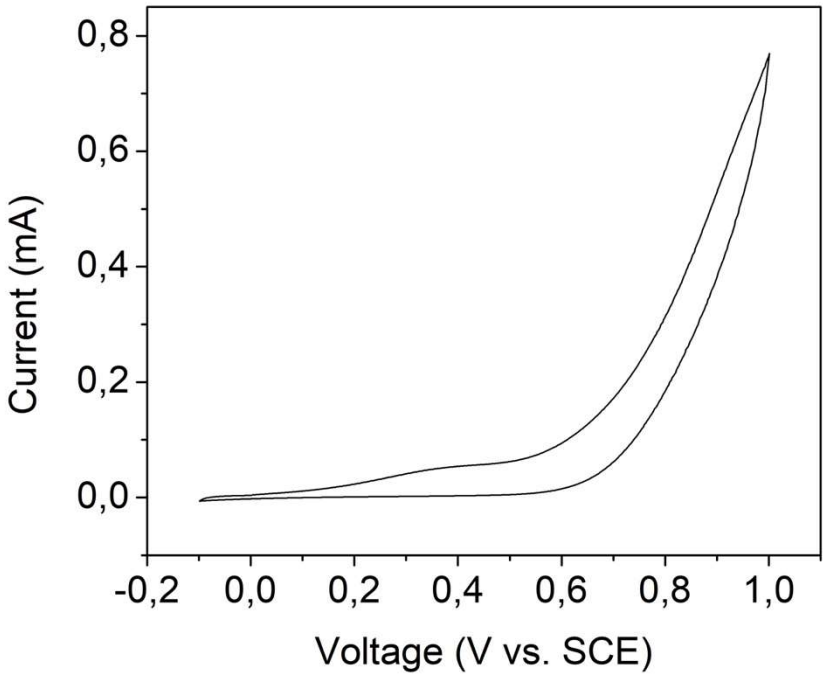


Figure S11. Linear Sweep Voltammetry (**top**) and Cyclic voltamperometric curve (**bottom**) of $NiGa_2S_4$/ITO. A 420 nm LED light source has been employed to investigate the photocurrent induced upon irradiation.

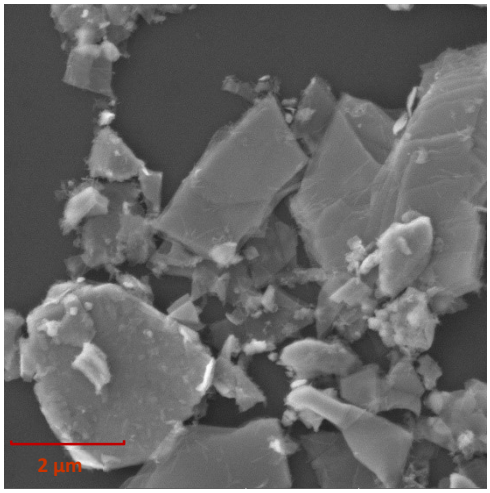


Figure S12. SEM image of 2D-$NiGa_2S_4$ flakes which were employed for the fabrication of the photodetector.

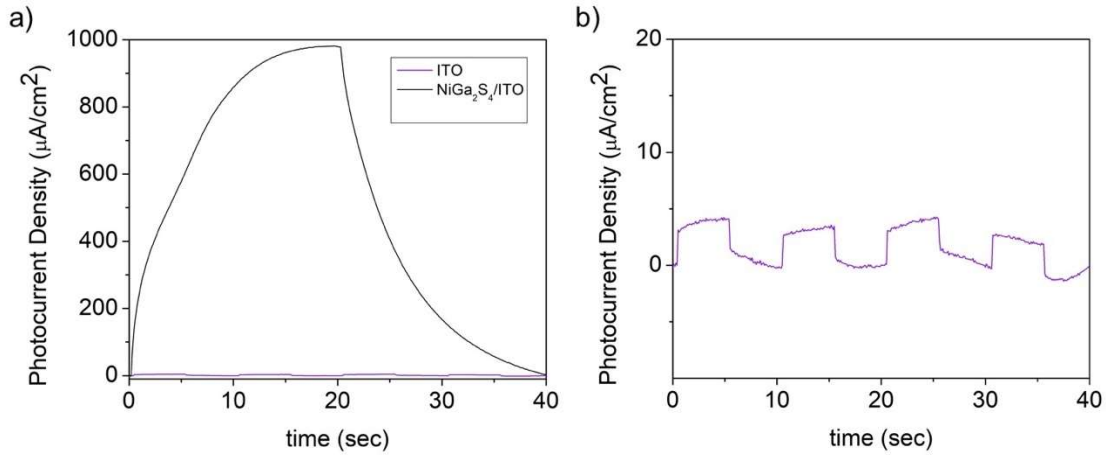


Figure S13. a) Comparison of the photocurrent density obtained using an ITO glass and a $NiGa_2S_4$/ITO photodetector in the presence of a 1 M KOH ethanol (25% v/v) water solution as electrolyte under irradiation with purple light (power = 1000 mW). **b)** Magnification of the photocurrent density using bare ITO glass as photodetector.

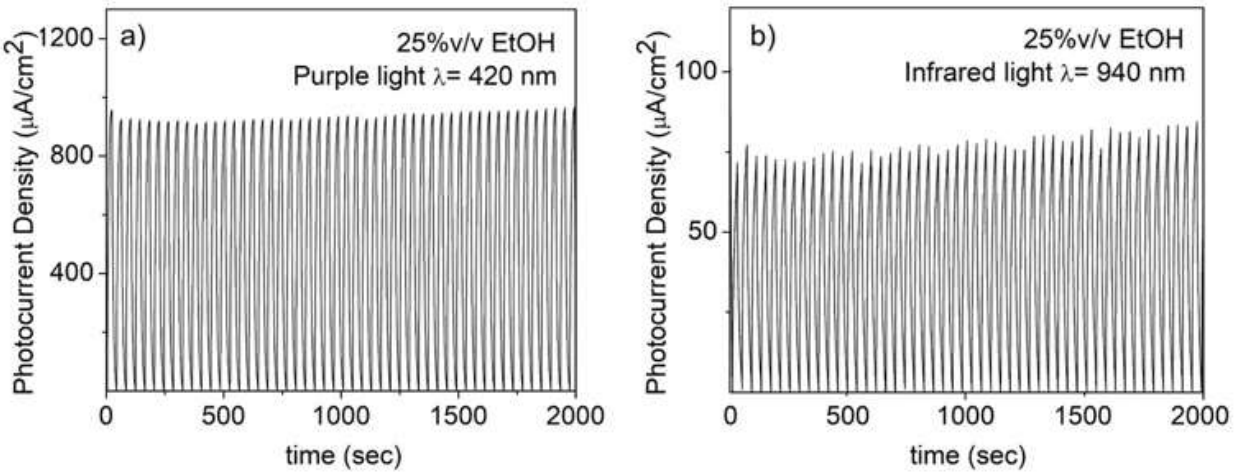


Figure S14. Long term cycle stability test of $NiGa_2S_4$-based photodetector in 1 M KOH ethanol (25% v/v) water solution at 0.5 V vs SCE under purple and infrared light, with irradiance power of 800 and 300 mW respectively.

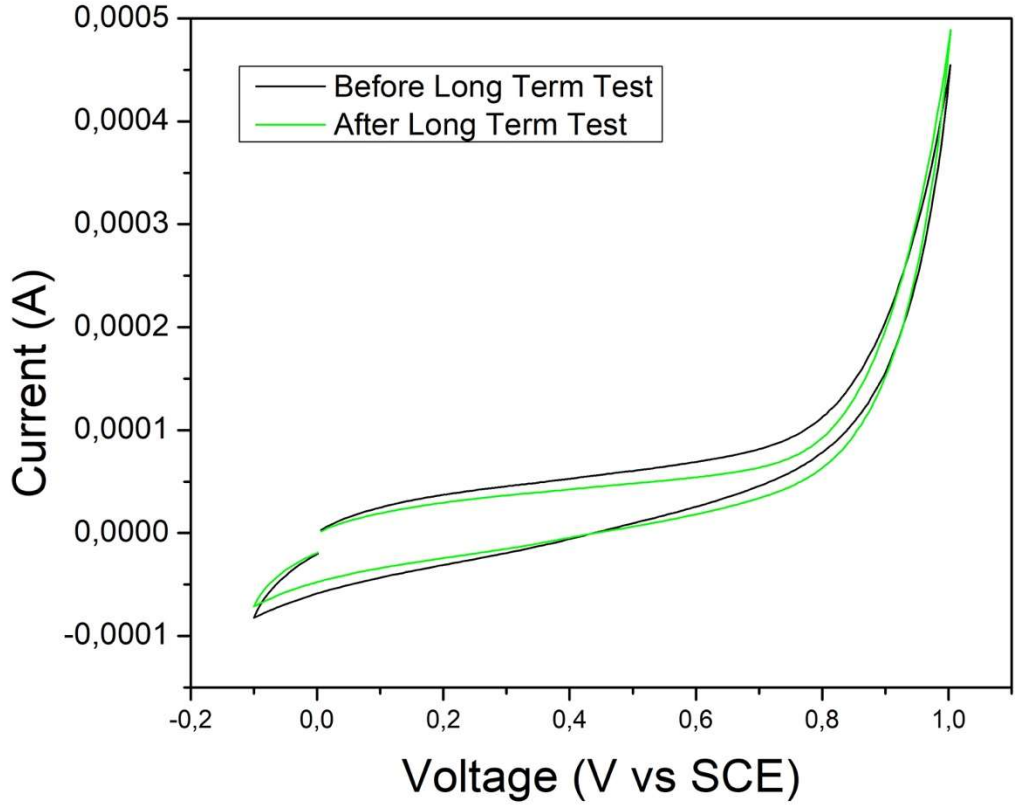


Figure S15. Cyclic voltammetry diagram of the $NiGa_2S_4$/ITO electrode before and after the long-term ON-OFF tests.