

## **Supporting Information:**

### *I) Photogeneration theory details: non-uniform absorption and transient solution*

ZnO and SnO<sub>2</sub> are n-type semiconductors [I, II] due to the donor character of their intrinsic defects [III, IV]. Photo-current  $I_{ph}$  generated by incident light can be theoretically modelled with the help of the continuity equation describing the photo-generated excess of minority carriers  $\Delta p_{ph}(\vec{r}, t)$  in the low injection regime [12]. That is to say,

$$\frac{\partial \Delta p_{ph}}{\partial t} = g_{ph} - \frac{\Delta p_{ph}}{\tau_p} + D_p \nabla^2 \Delta p_{ph} \quad (i)$$

where  $g_{ph}$  is the pair generation rate per volume unit,  $\tau_p$  is the hole lifetime and  $D_p$  the hole diffusion constant. If the  $x$  – axis and  $z$  – axis are considered to be parallel and perpendicular to the longitudinal direction of the nanowire ( $L$  and  $T$  dimensions in figure 1 of the main text) and the illumination is assumed to be uniform and parallel to the  $z$  – axis, the following simplifications can be introduced in equation (i),

$$\nabla^2 \Delta p_{ph} = \frac{\partial^2 \Delta p_{ph}}{\partial z^2} \quad (ii)$$

$$g_{ph} \equiv g_{ph}(z) \quad (iii)$$

$$\Delta p_{ph}(\vec{r}, t) = \Delta p_{ph}(z, t) \quad (iv)$$

In general, photo-generation across the section of the nanowire will be non – uniform. In this case,  $g_{ph}(z)$  is generally described as,

$$g_{ph}(z) = \alpha \eta \beta \Phi_{ph} e^{-\alpha z} \quad (v)$$

where  $\alpha$  is the light absorption coefficient of the metal oxide at the incident wavelength,  $\eta$  is the quantum efficiency of pairs generation by one photon,  $\beta$  is the fraction of photons not reflected by the surface and  $\Phi_{ph}$  is the flux of incident photons. Therefore, the steady excess of minority carriers along  $z$  is obtained by solving the following equation,

$$0 = \alpha \eta \beta \Phi_{ph} e^{-\alpha z} - \frac{\Delta p_{ph}(z)}{\tau_p} + D_p \frac{\partial^2 \Delta p_{ph}(z)}{\partial z^2} \quad (\text{vi})$$

If all excess carriers are extracted at  $z = T$  [12], the solution of equation (vi) can be approximated by,

$$\Delta p_{ph}(z) = \frac{\tau_p \eta \beta \Phi_{ph}}{\alpha L_p^2} \left[ \alpha L_p e^{-z/L_p} - e^{-\alpha z} \right] \quad (\text{vii})$$

where  $L_p \equiv \sqrt{D_p \tau_p}$  is the diffusion length of minority carries. The previous approximation is valid only if  $\alpha^2 L_p^2 \gg 1$ . In the case of ZnO,  $\alpha^{-1}$  of near UV photons (wavelength from 400 to 250 nm) is almost constant at 50 nm [13] and  $L_p$  is estimated to be above 2  $\mu\text{m}$  [IV]. Thus, the product  $\alpha^2 L_p^2 \sim 1600 \gg 1$  verifies this restriction.

In quasi-neutral conditions, ( $\Delta p_{ph}(z) \approx \Delta n_{ph}(z)$ ), the photo-generated current density  $j_{ph}$  along the  $x$ -axis at depth  $z$  can be expressed as,

$$j_{ph}(z) = q \Delta n_{ph}(z) v \quad (\text{viii})$$

where  $q$  is the elemental charge and  $v$  the carrier velocity. To obtain the photo-generated current  $I_{ph}$  through the section of the nanowire ( $W \cdot T$ ) (see figure 1), the following integral must be evaluated,

$$I_{ph} = \int_{W \times T} \vec{j}_{ph} \cdot \vec{ds} = W \int_0^T j_{ph}(z) dz \quad (\text{ix})$$

obtaining,

$$I_{ph} = q W v \frac{\tau_p \eta \beta \Phi_{ph}}{\alpha L_p^2} \left\{ \alpha L_p^2 \left( e^{-T/L_p} - 1 \right) - \frac{1}{\alpha} \left( e^{-\alpha T} - 1 \right) \right\} \quad (x)$$

If the thickness of the nanowire fulfils,

$$\alpha^{-1} < T < L_p \quad (xi)$$

and  $v$  is expressed as,

$$v = \frac{\mu^* V}{L} \quad (xii)$$

where  $\mu^*$  is the electron mobility,  $V$  the applied voltage and  $L$  is the length of the nanowire, equation (x) becomes,

$$I_{ph} = q \frac{W}{L} \beta \eta \tau \mu^* V \Phi_{ph} \quad (xiii)$$

This expression is identical to equation 11, which was obtained assuming a constant generation profile until  $\alpha^{-1}$ . Therefore, it can be concluded, in first approximation, that the existence of a non – uniform absorption profile would not modify the results presented here.

Let us also analyze the evolution in time of the photo-generated carriers  $\Delta p_{ph}$ . As we have demonstrated, uniform adsorption profile can be assumed without loss of generality. Therefore, equation (i) can be rewritten as

$$\frac{\partial \Delta p_{ph}}{\partial t} = g_{ph} - \frac{\Delta p_{ph}}{\tau_p}. \quad (xiv)$$

The steady solution ( $\partial \Delta p_{ph} / \partial t = 0$ ) of this equation is given by,

$$\Delta p_{ph} = g_{ph} \tau_p \quad (xv)$$

which corresponds to equation 2, if we assume quasi-neutral conditions ( $\Delta p_{ph} \approx \Delta n_{ph}$ ), electron-hole recombination in pairs ( $\tau_p = \tau_n = \tau$ ) and  $g_{ph} = \eta F/V_{ph}$ , where  $\eta$  is the quantum efficiency of pairs generation by one photon,  $F$  the absorption rate of photons, and  $V_{ph}$  the photo-generation volume.

If the light is turned on at  $t = 0$  and  $\Delta p_{ph}(0) \approx \Delta n_{ph}(0) = 0$ , the transient solution of equation (xiv) is,

$$\Delta n_{ph}(t) = g_{ph} \tau_p \left( 1 - e^{-t/\tau_p} \right) \quad (\text{xvi})$$

Since  $i_{ph}(t)$  is proportional to  $\Delta n_{ph}(t)$ , an exponential raise of  $i_{ph}(t)$  is predicted by turning on the light source before reaching the steady state (equation xv). On the other hand, if the light is turned off at  $t = 0$ , the transient solution of equation xiv is,

$$\Delta n_{ph}(t) = g_{ph} \tau_p e^{-t/\tau} \quad (\text{xvii})$$

assuming a complete extinction of the charge excess long time after turning off the light:  $\Delta p_{ph}(t \rightarrow \infty) \approx \Delta n_{ph}(t \rightarrow \infty) = 0$ . Now,  $i_{ph}(t)$  relaxes exponentially when turning off the light source as proposed in equation 4.

The time scale of these two processes are determined by the lifetime  $\tau$ , which can be estimated from time resolved measurements of  $I_{ph}$ . This is the procedure we followed in this work. Lifetime  $\tau$  may differ in raise and decay processes due to charge separation and trapping effects [12].

References:

[I] Özgür, Ü.; Alivov, Y. I.; Liu, C.; Teke, A.; Reshchikov, M. A.; Doğan, S.; Avrutin, V.; Cho, S. J.; Morkoç, H. *J. Appl. Phys.* **2005**, *98*, 041301.

[II] Batzill, M.; Diebold, U. *Prog. Surf. Sci.* **2005**, *79*, 47–154.

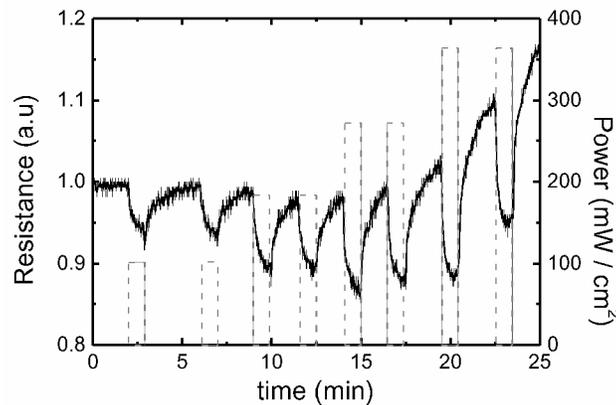
[III] Erhart, P.; Klein, A.; Albe, K. *Phys. Rev. B* **2005**, *72*, 085213.

[IV] Kiliç, C.; Zunger, A. *Phys. Rev. Lett.* **2002**, *88*, 095501.

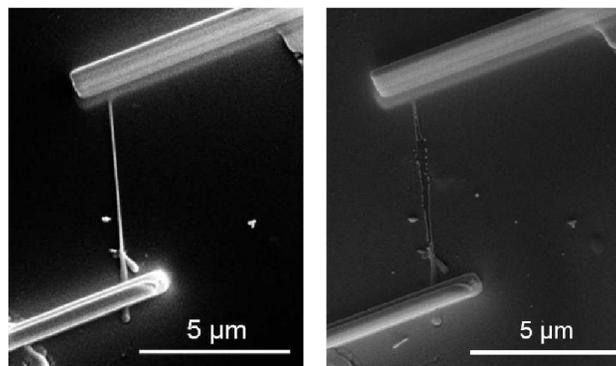
[IV] Lopatiuk-Tirpak, O.; Chernyak, L.; Xiu, F. X.; Liu, J. L.; Jang, S.; Ren, F.; Pearton, S. J.; Gartsman, K.; Feldman, Y.; Osinsky A.; Chow, P. *J. Appl. Phys.* **2006**, *100*, 086101.

## II) Self-heating effects on nanowires:

Dissipated power  $P$  in nanowires increases their temperature  $T$  due to Joule heating effect, as described by the authors elsewhere [14]. If individual nanowires are used as photodetectors, one critical parameter to preserve their integrity is the current  $I$  [19]. It was experimentally demonstrated that high power UV pulses dramatically increase photocurrent  $I_{ph}$  (figure I), leading to an irreversible degradation of these devices by melting (figure II).



**Figure I.** Photoresponse of a  $\text{SnO}_2$  nanowire [11] as function of fast UV pulses. The UV lamp was used in this experiment. It can be observed how the nanowire does not recover the resistance baseline with increasing UV intensity. (Dashed lines indicate UV pulses).



**Figure II.**  $\text{SnO}_2$  nanowire before (left) and after (right) applying a UV light pulse of  $P = 365 \text{ mW/cm}^2$ . The nanowire is completely destroyed after the measurement due to self-heating effects.