Electronic Supplementary Material (ESI) for Nanoscale Horizons.

Supplementary

Flexible InP-ZnO Nanowire Heterojunction Light Emitting Diodes

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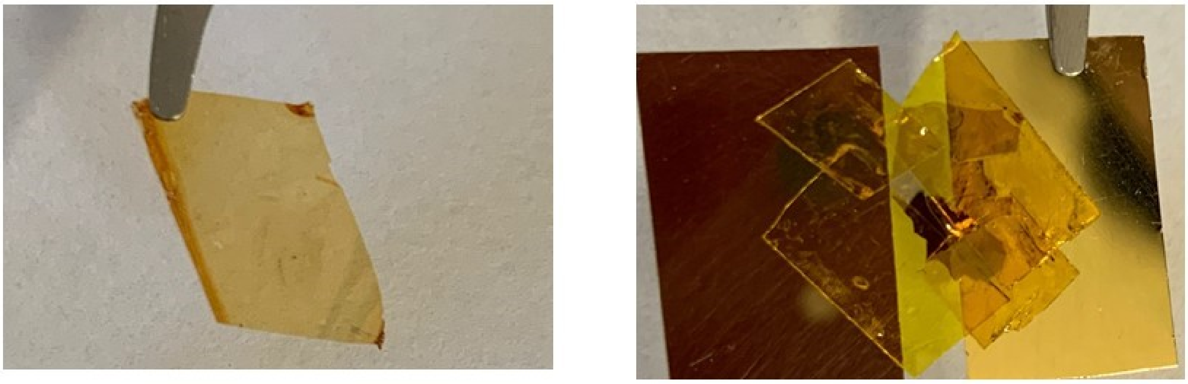
(a) (b)



1. Photo of flexible LED

Fig. S1 (a) SU-8 lifted off film from the substrate with embedded NW array (b) Final device with gold pad on acetate film on two sides that are used to connect the p and n regions of the nanowire array

2. Analysis of I-V characteristics of on-substrate NW LED

To calculate the turn-on voltage and series resistance, I-V curve at higher voltages was extrapolated as a straight line. x-intercept of the line gives turn-on voltage and the slope of line provides series resistance. Extrapolation of the curve is indicated in Fig. S2(a). To calculate ideality factor and reverse saturation current ln(I) vs V was plotted in the forward bias direction and fitted using a straight line as shown in Fig. S2(b). Current in a diode is given by [1]:

$$I = I_s\left(e^{\frac{qV}{nkT}} - 1\right) \tag{1}$$

where I_s = reverse saturation current

q = charge on a electron (1.6 x 10 $^{-19}$ C)

n = ideality factor

k = Boltzmann's constant (1.380649×10^{-23} J·K^{-1})

T = temperature (300 K)

For sufficiently large bias eq. (1) can be written as:

$$I = I_s\left(e^{\frac{qV}{nkT}}\right) \tag{2}$$

Taking natural log on both sides:

$$\ln(I) = \ln(I_s) + \frac{q}{nkT}V \tag{3}$$

By plotting ln(I) vs V, the reverse saturation current and ideality factor can be obtained from the y-intercept and slope, respectively.

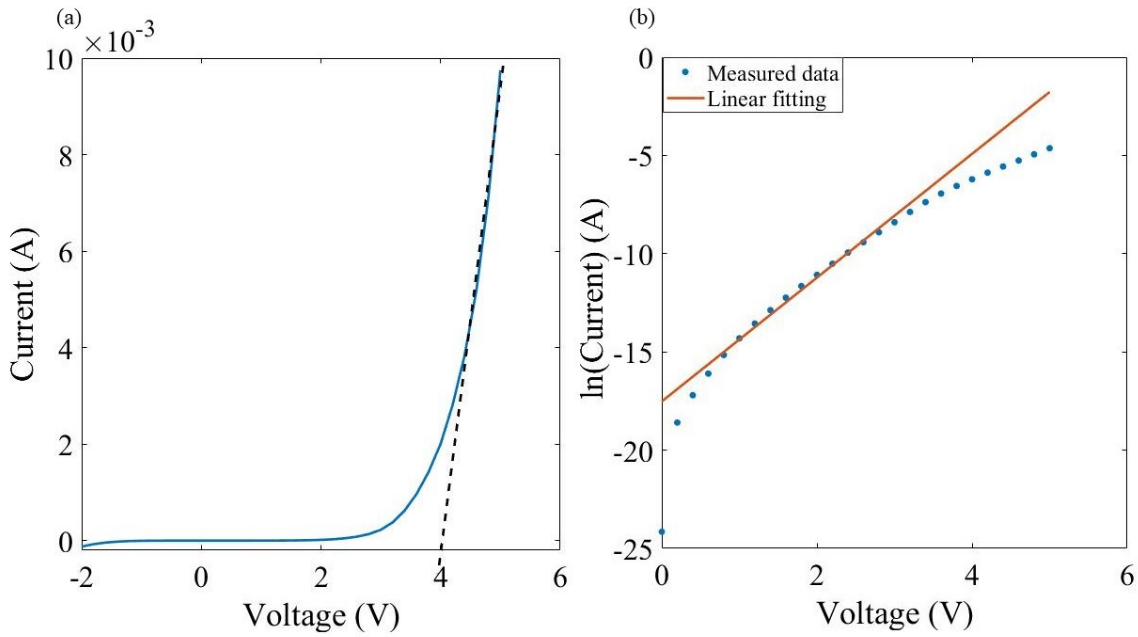


Fig. S2 (a) I-V characteristics of the device at room temperature. (b) Plot of ln (I) vs V.

3. Calculation of depletion region

The depletion region the p-InP nanowire can be calculated by [1]:

$$X_p = \sqrt{\frac{2\varepsilon_n \varepsilon_p N_D (V_{bi} - V)}{q N_A (\varepsilon_p N_A + \varepsilon_n N_D)}} \quad (4)$$

$$X_n = \sqrt{\frac{2\varepsilon_n \varepsilon_p N_A (V_{bi} - V)}{q N_D (\varepsilon_p N_A + \varepsilon_n N_D)}} \quad (5)$$

$$X = X_p + X_n \quad (6)$$

$$V_{bi} = \frac{(\emptyset_p - \emptyset_n)}{q} \quad (7)$$

Where, X, X_p, X_n = total depletion width, depletion with in the p and n regions, respectively.

$N_A = 6.75 \times 10^{16}$ cm^{-3}

$N_D = 2 \times 10^{19}$ cm^{-3}

$Ø_p = 4.65$ eV [2]

$Ø_n = 3.7$ eV [3]

$\varepsilon_p = 12.35\varepsilon_0$ [4]

$\varepsilon_p = 10.4\varepsilon_0$ [5]

$V = 0$, (unbiased EBIC)

Using above mentioned equations, a depletion width of 138.85 nm is derived, consistent with the value calculated from the EBIC results.

4. Flexible LED

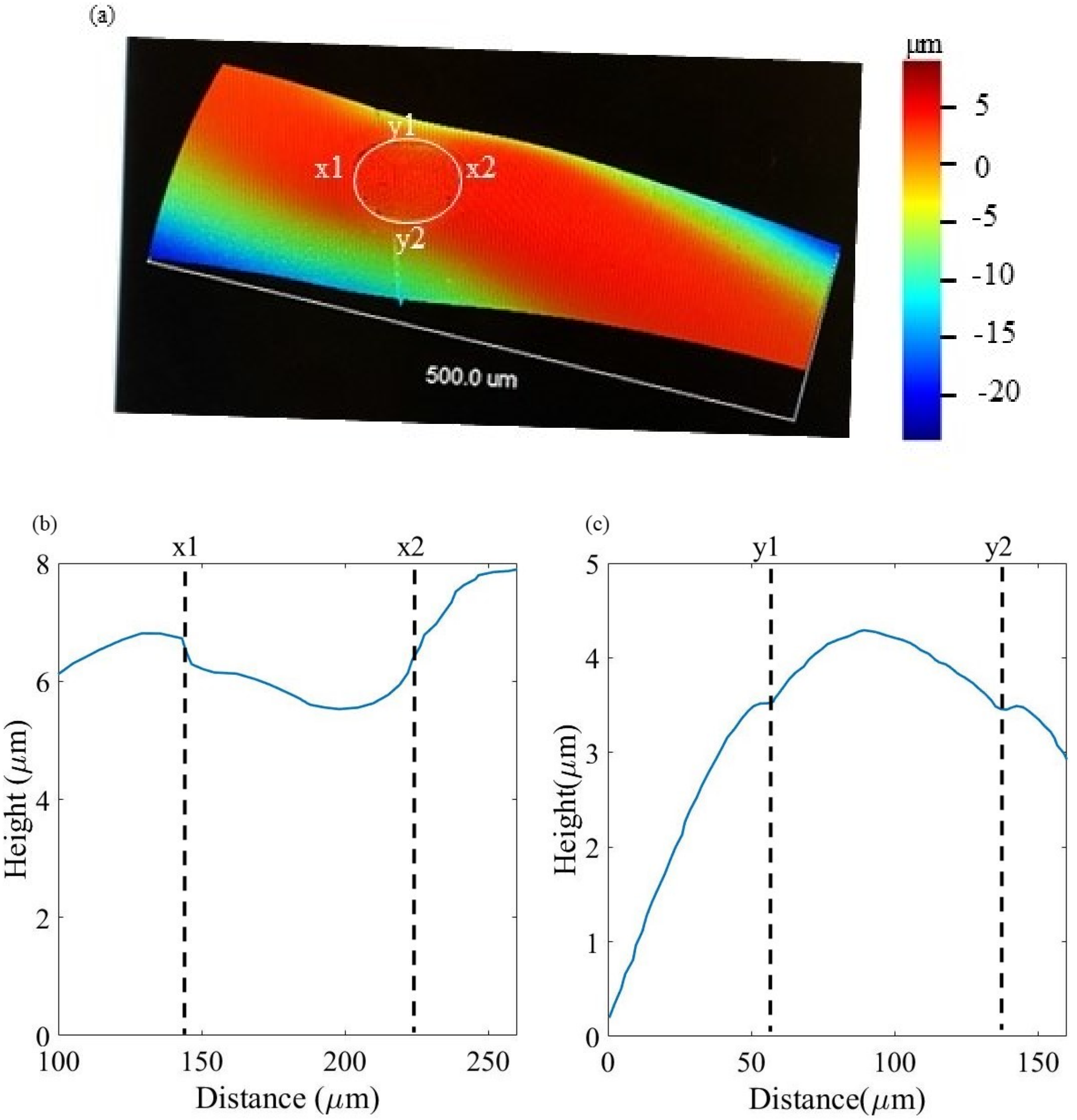


Fig. S3 (a) Surface profile of flexible LED captured from optical profilometer. The region where the NW array is located is indicated by the white circle. (b) Surface profile scan along points x1 to x2. (c) Surface profile scan along points y1 to y2.

Figs. S3 (a) & (b) show that curvature of the flexible NW device varies across the array.

5. I-V comparison of flexible LED and substrate LED

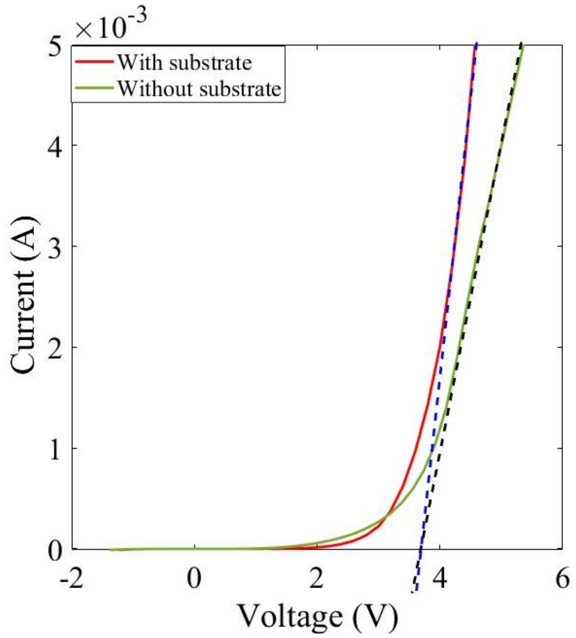


Fig. S4 I-V characteristics of the flexible and with substrate devices at room temperature

Using above-mentioned method (section 2), the turn on voltage is about 3.5 V for both the on-substrate and flexible device.

References:

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