SUPPLEMENTARY INFORMATION

Setup for measuring hydrogen sensing capabilities of the ZnO brush beds: Dynamic response of sensitivity of ZnO nano brush beds was measured using a setup which is schematically shown as follows:

Figure S1 shows schematic of gas sensing set up

Figure S2: Schematic for electrical connection of ZnO wires with electrodes.
Nanoseed size estimation from the data obtained from UV-Visible spectrophotometer

![UV-Visible Absorbance Spectrum](image)

Figure S3 shows the characterization of ZnO seeds by UV-Visible spectroscopy

The particle size can be estimated from the experimental UV-Vis absorption spectrum using the following expression derived from the effective mass model:

\[
E_g^* = E_{gbulk} + \frac{\hbar^2 \pi^2}{2r^2} \left( \frac{1}{m_e^*} + \frac{1}{m_h^*} \right) - \frac{1.8e^2}{4\pi\varepsilon_0 r} - \frac{0.124e^4}{\hbar^2 (4\pi\varepsilon_0)^2} \left( \frac{1}{m_e^*} + \frac{1}{m_h^*} \right)^{-1}
\]

..(1)

\( E_g^* \) = band gap energy of the nanoparticle, which will be determined from the UV-Visible absorbance spectrum

\( E_{gbulk} \) = band gap energy of the bulk ZnO (at room temperature), which has the value of 5.392 \times 10^{-19} \text{ J}

\( \hbar \) = Planck’s Constant, 6.625 \times 10^{-34} \text{ J} \cdot \text{s}

\( r \) = particle radius (m)

\( m_e \) = mass of a free electron, 9.11 \times 10^{-31} \text{ kg}

\( m_e^* = 0.29 \ m_e \) (effective mass of a conduction band electron in ZnO)

\( m_h^* = 1.21 \ m_e \) (effective mass of a valence band hole in ZnO)

\( e \) = elementary charge, 1.602 \times 10^{-19} \text{ C}
\[ \varepsilon_0 = 8.854 \times 10^{-12} \text{C}^2\text{N}^{-1}\text{m}^{-2} \text{ (permittivity of free space)} \]

\[ \varepsilon = 5.7 \text{ (relative permittivity of ZnO)} \]

On putting these values in above equations,

Using UV-Visible spectra, the cut-off wavelength was determined as \( \lambda_c = 379 \text{ nm} \).

From this value, the band gap of the ZnO was calculated as:

\[ E_g^* = \frac{(6.626 \times 10^{-34} \text{Js})(3\times10^8 \text{m/s})}{379 \times 10^{-9} \text{m}} = 5.24 \times 10^{-19} \text{ J} = 3.27 \text{ eV} \]

Finally, using the band gap, and other known constants, the particle size can be determined from the effective-mass model.

\[ E_g^* = E_{g\text{ bulk}} + \frac{\hbar^2 \pi^2}{2r^2} \left( \frac{1}{m_e^*} + \frac{1}{m_h^*} \right) - \frac{1.8e^2}{4\pi\varepsilon_0 r} - \frac{0.124e^4}{\hbar^2 (4\pi\varepsilon_0)^2} \left( \frac{1}{m_e^*} + \frac{1}{m_h^*} \right)^{-1} \]
where the values of all constants are defined in [1]. This equation can be rearranged to give a quadratic equation as a function of the radius,

\[ E_g^* r^2 = E_g^{\text{bulk}} r^2 + \frac{\hbar^2 \pi^2}{2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right) - \frac{1.8e^2r}{4\pi\varepsilon\varepsilon_0} - \frac{0.124e^4}{\hbar^2 (4\pi\varepsilon\varepsilon_0)^2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right)^{-1} r^2 \]

\[ \left[ E_g^* - E_g^{\text{bulk}} + \frac{0.124e^4}{\hbar^2 (4\pi\varepsilon\varepsilon_0)^2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right)^{-1} \right] r^2 + \left[ \frac{1.8e^2}{4\pi\varepsilon\varepsilon_0} \right] r - \frac{\hbar^2 \pi^2}{2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right) = 0 \]

\[ ar^2 + br + c = 0 \]

\[ r = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

where

\[ a = \left[ E_g^* - E_g^{\text{bulk}} + \frac{0.124e^4}{\hbar^2 (4\pi\varepsilon\varepsilon_0)^2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right)^{-1} \right] \]

\[ a = 5.232 \times 10^{-19} J - 5.392 \times 10^{-19} J + \frac{0.124(1.602 \times 10^{-19} C)^4}{(6.626 \times 10^{-34} Js / 2\pi) (4\pi(5.7)(8.854 \times 10^{-12} C^2 / Nm^2))^2} \cdot \left( \frac{1}{0.29(9.11 \times 10^{-31} kg)} + \frac{1}{1.21(9.11 \times 10^{-31} kg)} \right)^{-1} \]

\[ a = 2.4147 \times 10^{-20} J \]

\[ b = \left[ \frac{1.8e^2}{4\pi\varepsilon\varepsilon_0} \right] = \frac{1.8(1.602 \times 10^{-19} C)^2}{4\pi(5.7)(8.854 \times 10^{-12} C^2 / Nm^2)} \]

\[ b = 7.284 \times 10^{-29} Jm \]

\[ c = -\frac{\hbar^2 \pi^2}{2} \left( \frac{1}{m_e} + \frac{1}{m_h} \right) = -(6.626 \times 10^{-34} Js / 2\pi)^2 \pi^2 \cdot \left( \frac{1}{0.29(9.11 \times 10^{-31} kg)} + \frac{1}{1.21(9.11 \times 10^{-31} kg)} \right) \]

\[ c = -2.5747 \times 10^{-37} Jm^2 \]

\[ r = \frac{-7.284 \times 10^{-29} Jm \pm \sqrt{(7.284 \times 10^{-29} Jm)^2 - 4(2.4147 \times 10^{-20} J)(-2.5747 \times 10^{-37} Jm^2)}}{2(2.4147 \times 10^{-20} J)} \]

\[ r = 4.8nm \]

\[ 2r = 9.6nm \]

So, the nanoseeds have a particle size of around 9.6 nm, with a band gap of 3.27 eV.