Supplementary Information

Surface-Engineered Boron Carbide Nanostructures for Non-Contact Respiratory Monitoring

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S1: Synthesis Procedure :

The preparation for boron carbide nanostructure involves exfoliation of (a) bulk boron carbide, (b) probe sonication, and (c) dispersion of nanostructure in solvent, as shown in Figure S1.

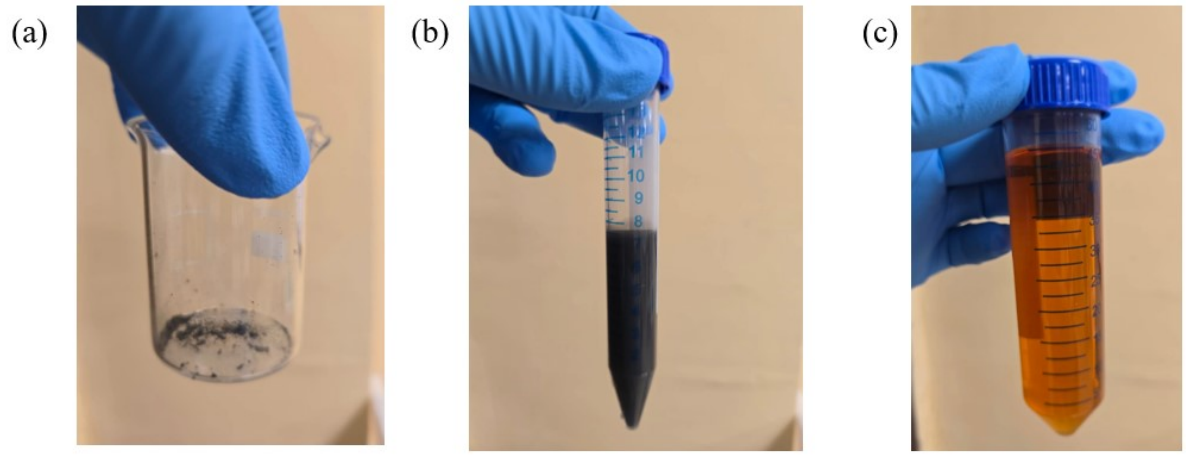

Figure S1: (a) Bulk boron carbide powder, (b) Intermediate stage after probe sonication, (c) boron carbide nanostructure dispersion.

S2: HRTEM analysis

HRTEM analysis of boron carbide (B_4C) is performed via lattice fringes to assess crystallinity and interplanar spacing at the atomic scale. SAED patterns are obtained to identify crystal structure and phase purity through indexed diffraction rings or spots. Fast Fourier transform (FFT) converts real-space lattice images into reciprocal-space information, while inverse FFT (IFFT) isolates specific lattice planes, enabling visualization of defects, strain, and local structural distortions in B_4C nanostructures.

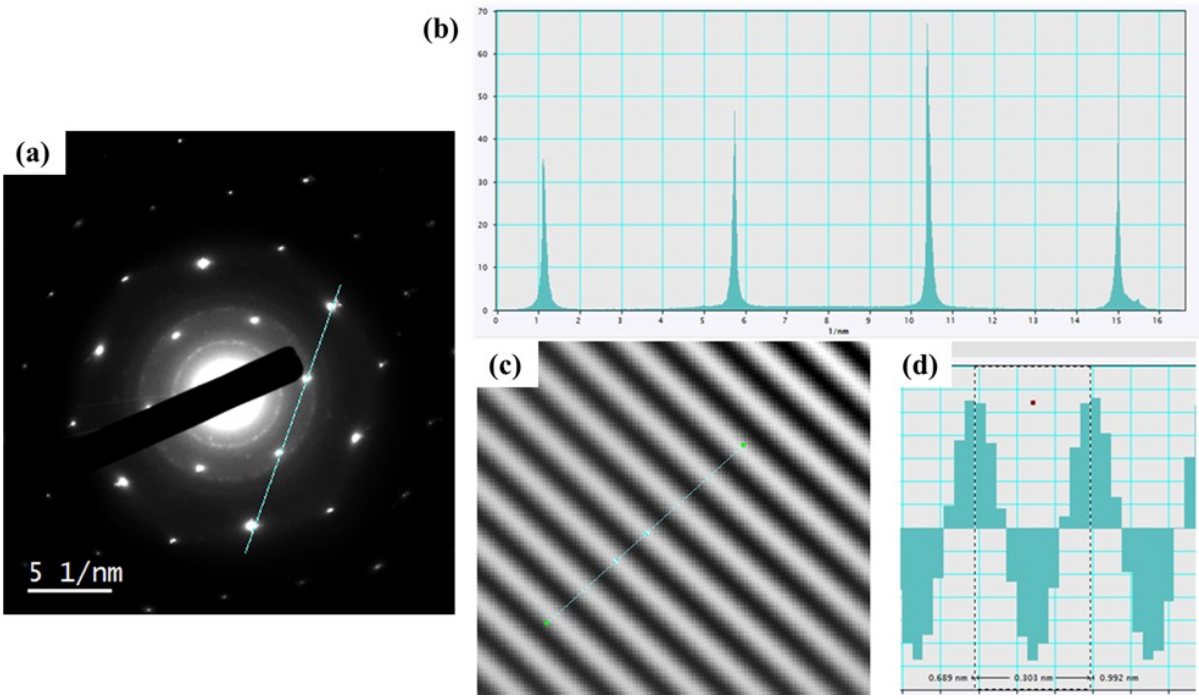

Figure S2. Transmission electron microscopy analysis, (a) SAED pattern of boron carbide, (b) SAED spot profile over the drawn line, (c) IFFT-based interlayer spacing, (d) interlayer distance over the dotted line

S3: Breath Sensing analysis

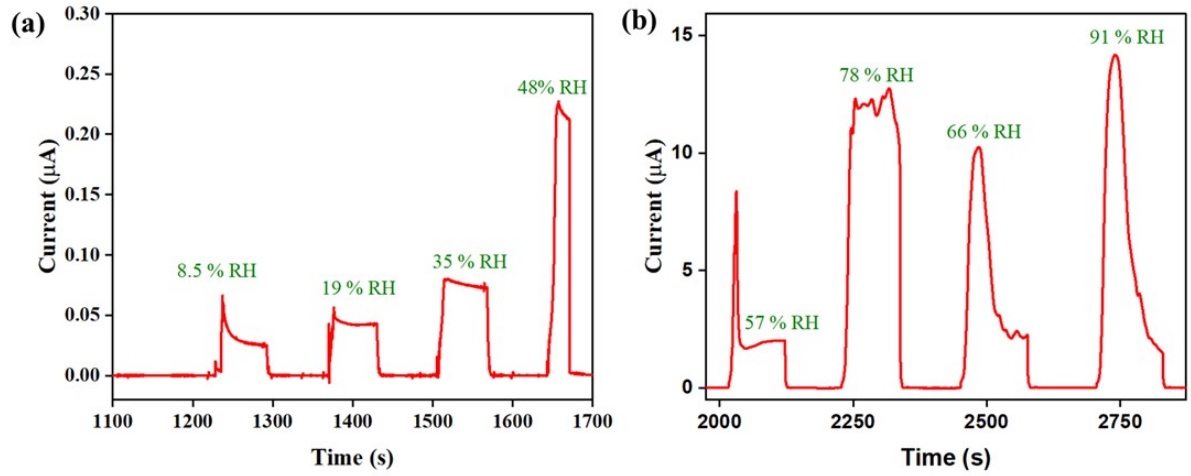

Figure S3: (a) Humidity response of a boron carbide nanostructure within range of 8-48% RH (b) Humidity response of a boron carbide nanostructure with in range of 57 -91 % RH

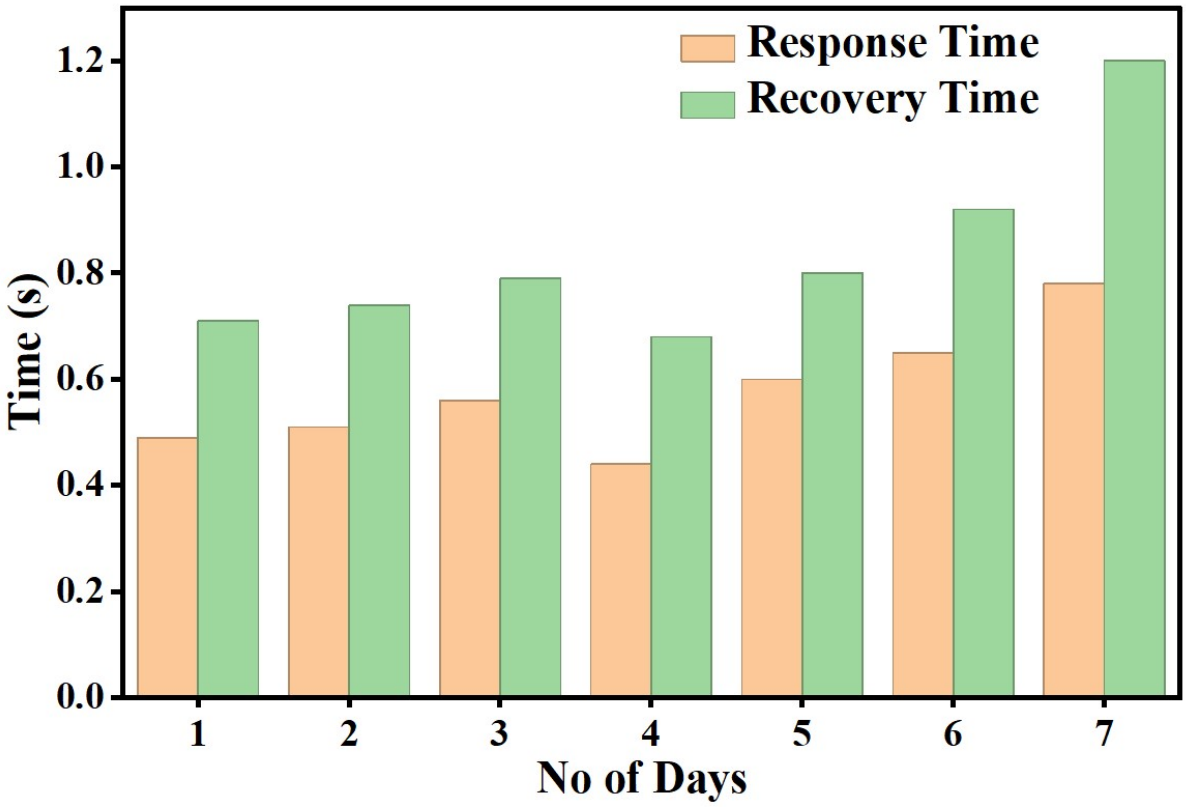

Figure S3: (c) Response of device for 7days cycle

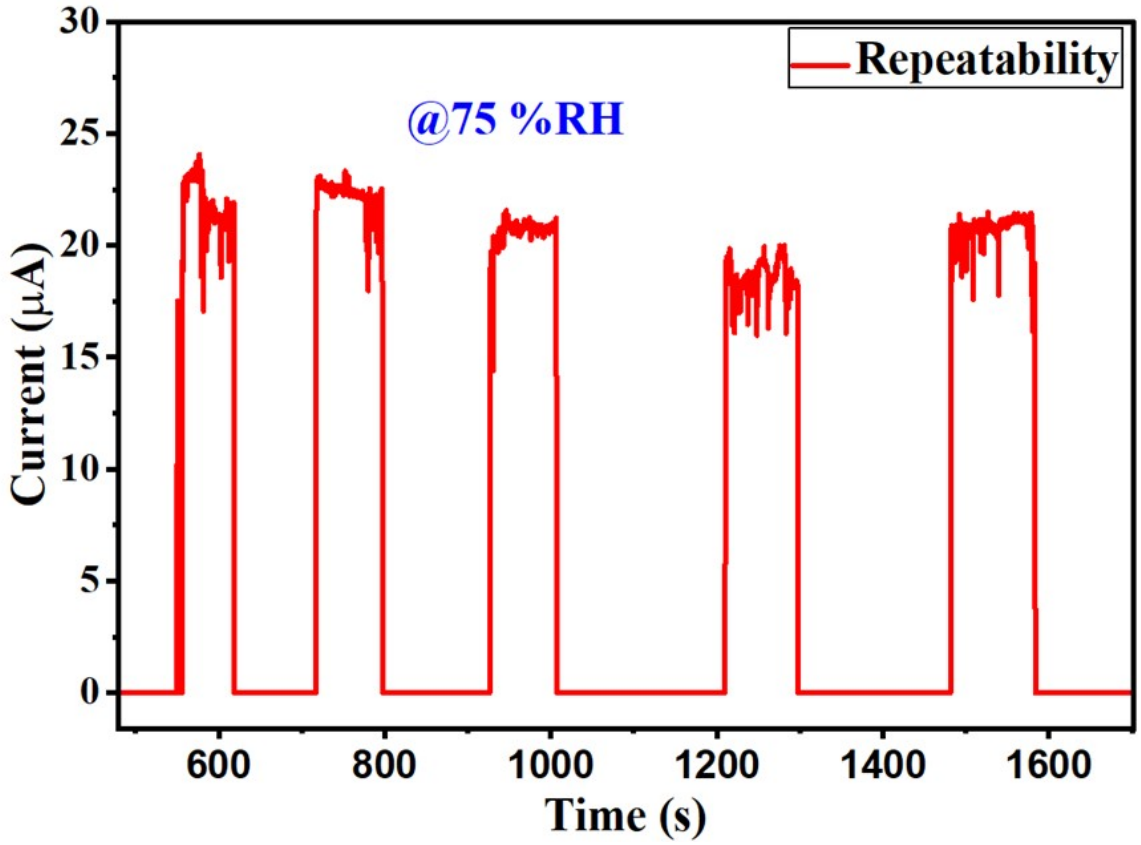

Figure S3 : (d) Repeatability of boron carbide nanostructure sensor at 75 % RH

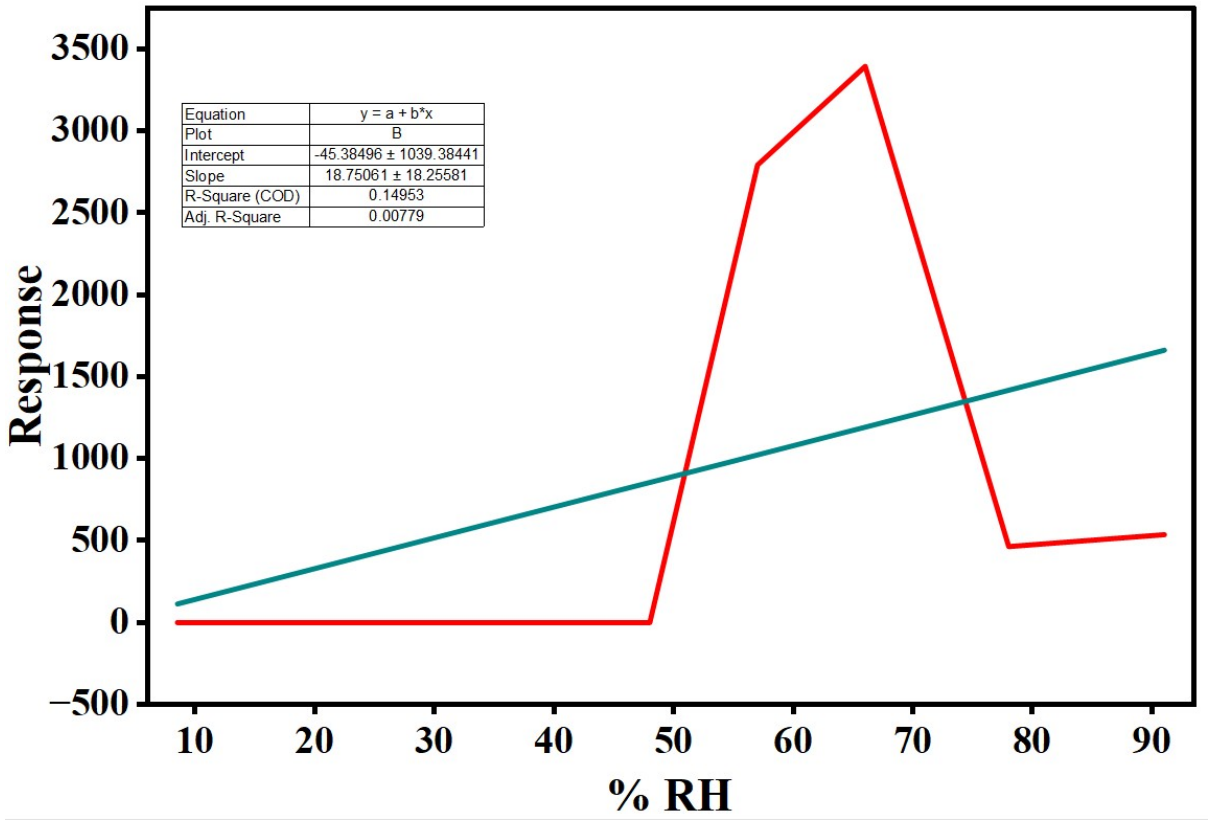

Figure S3: (e) Sensitivity of the device

S4: Calculation of crystallite information

The lattice parameters within the framework of the rhombohedral unit cell are determined by applying Bragg's Law: $2d \sin\theta = \lambda$, where d represents the interplanar spacing, θ denotes the Bragg angle, and λ signifies the wavelength of Cu Kα radiation (1.5406 Å).

In a rhombohedral system, the interplanar spacing is additionally connected to the Miller indices and lattice constants as follows:

$$\frac{1}{d^2} = \frac{4}{3} \cdot \frac{h^2 + hk + k^2}{a^2} + \frac{l^2}{c^2}$$

The indexed peaks can be utilised and fitted to the aforementioned relations to estimate lattice constants. A reduction in both a and c values from the stoichiometric values (a ≈ 5.6 Å, c ≈ 12.1 Å) is anticipated for boron-rich samples, reinforcing the hypothesis of partial carbon substitution.

Additionally, the Scherrer equation was utilized to determine the crystallite size, based on the peak broadening noted in the 57° reflection:

$$D = {}^{K\lambda}/_{\beta\cos\theta}$$

In this context, D represents the average crystallite size, K denotes a shape factor (commonly 0.9), β indicates the full width at half maximum (FWHM) measured in radians, and θ refers to the diffraction angle.