Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Wearable Strain Sensor Based on Carbonized Nano-Sponge/Silicone Composite for Human Motion Detection

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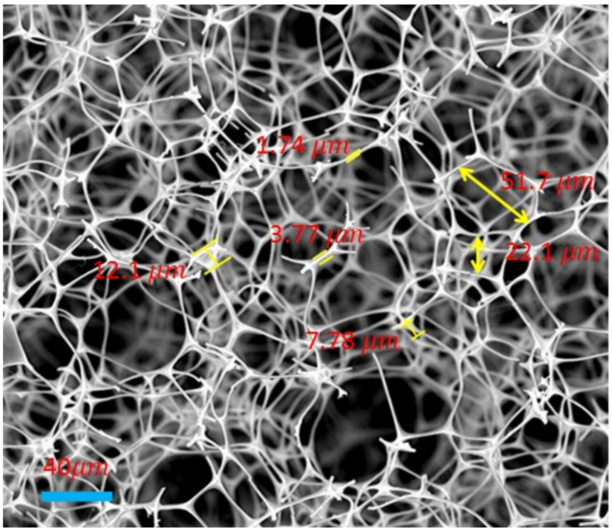

Fig. S1 SEM image of one CNS indicating the typical sizes of fibers, joints and cellulars.

The structure of the carbonized nano-sponge (CNS) is composed of fibers and joints. As shown in Fig. S1, the diameter of CNS fibers and joints is mainly in the range of 1-4 and 5-15 μm, respectively. Moreover, the size of single cellulars is in the range of 20-100 μm.

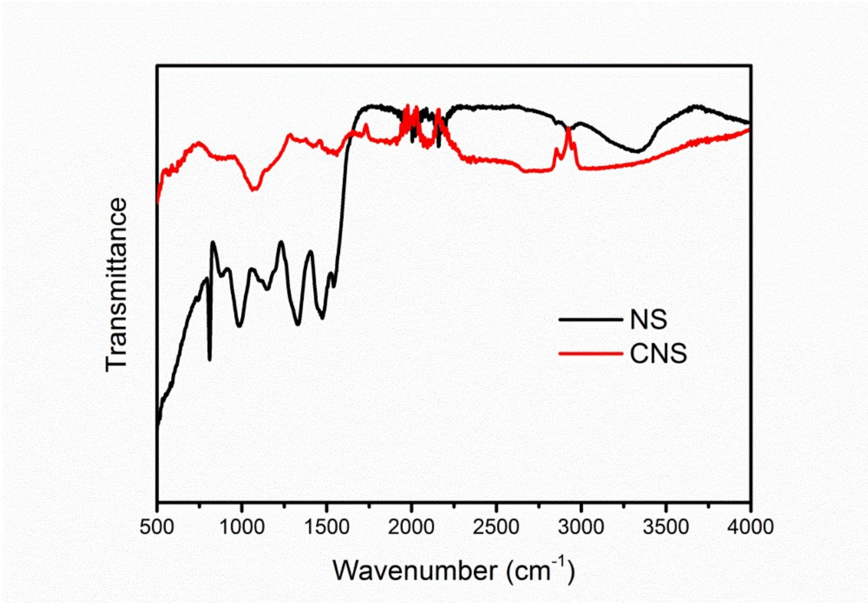

Fig. S2 FTIR spectra of NS and CNS.

It is known that the formula of melamine is $C_3N_3(NH_2)_3$. FTIR was conducted to reveal the chemical compositions of nano-sponge (NS) and CNS. As shown in Fig. S2, the absorption peaks of NS at around 1000-1300 cm^{-1}, 1480 cm^{-1} and 3300 cm^{-1} attribute to the vibration of C-N, -C=N- and N-H groups, respectively,[1-3] which agrees well with the structure of melamine. After carbonization, most of the absorption peaks in NS disappear, and only some weak peaks can be observed in CNS, confirming the removal of most of organic functional groups in NS.

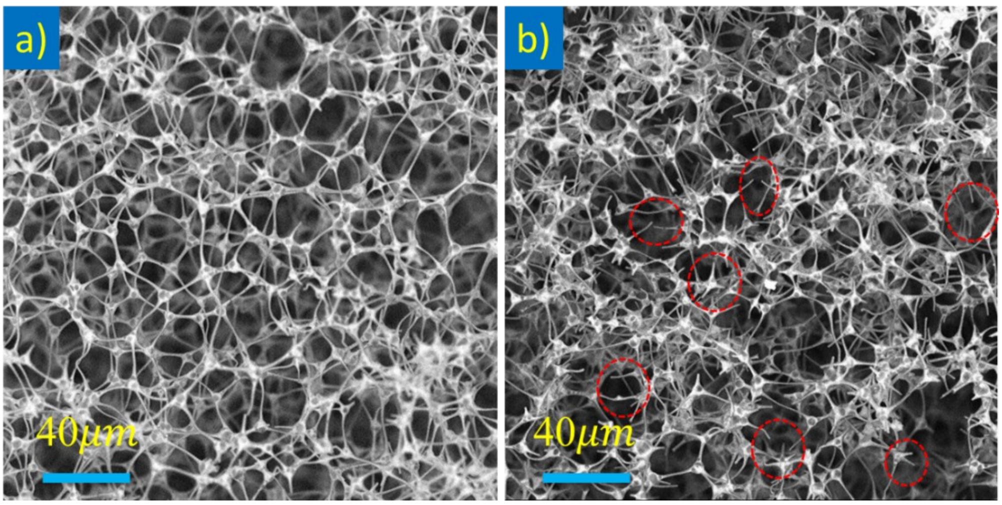

Fig. S3 Microstructure of the as-prepared CNS (a) before and (b) after 1000 loading-unloading cycles, red circles indicate the failure locations.

The micro-structure of the CNS before and after 1000 loading-unloading cycles is shown in Fig. S3. It is observed that after 1000 loading-unloading cycles, numerous structural failures as marked by red circles are observed as shown in Fig. S3b.

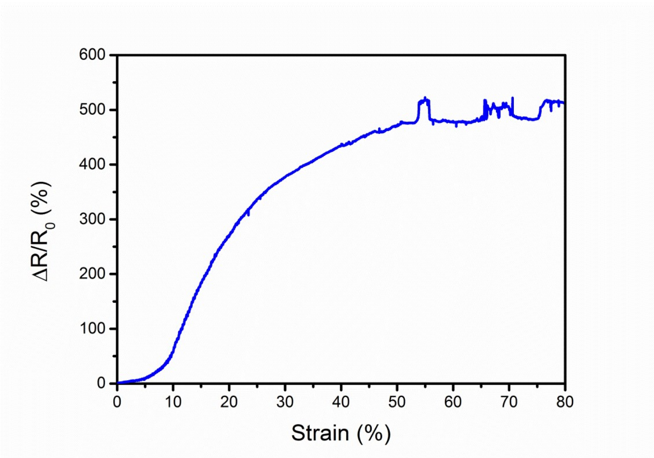

Fig. S4 The typical RCR-strain curve of the CNS/silicone composite with compressive strain up to 80%.

As shown in Fig. S4, the monotonic increasing trend of the RCR-strain curve of the CNS under compression is halted at the strain of 52%, after which the RCR responsive behavior of the CNS is changed to unpredictable. Thus, the working compressive strain range of the CNS/silicone composite is below 50%. The cracks, holes and interface separation can be observed in Fig. S5 for the broken parts of the CNS strain sensor. Fig. S6 shows that the shapes of RCR responsive curves resemble the strain curves applied.

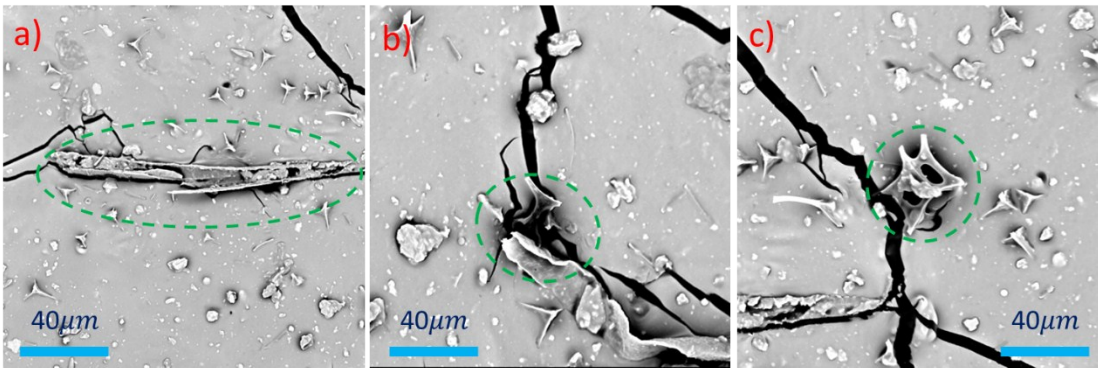

Fig. S5 Typical microstructure of the CNS/silicone composite with compressive loading: (a) crack, (b) hole and (c) interface separation.

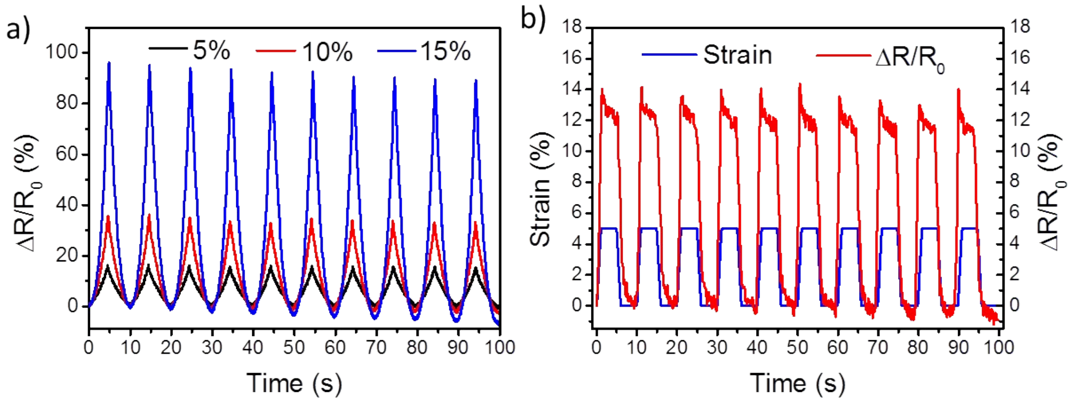

Fig. S6 RCR response of the CNS/silicone composite to cyclic compressive loading with (a) triangular and (b) rectangular loading.

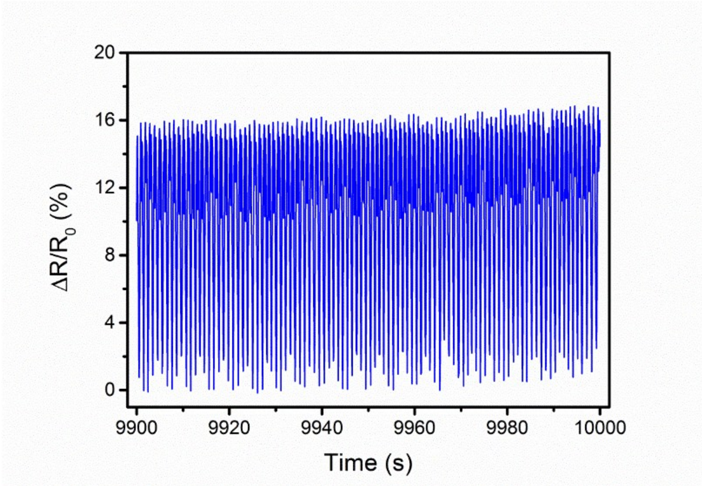

Fig. S7 The durability of the CNS/silicone composite at a frequency of 1 Hz with the 5% strain peak for 10,000 cycles.

The durability of the RCR with 10,000 cycles of compressive loading and unloading was tested and the RCR responsive behavior the CNS/silicone composite for the last 100 cycles is presented in Fig. S7. It can be observed that the RCR magnitude of the CNS/silicone composite after 10,000 cycles is still as high as around 80% of its initial value, indicating its high reliability.

References

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