Construction and performance of a multifunctional bio-inspired flexible sensor with actuation and electromagnetic shielding

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Abstract

A hierarchically ordered structure of flexible sensor was fabricated with gelatin, $Ti_3C_2T_x$ MXene and WMM via layer-by-layer assembly. The results of SEM showed that the structure with a top layer of mimicking mussel structure of $Ti_3C_2T_x$ MXene, a middle layer of like neural cage network of $Ti_3C_2T_x$ MXene@gelatin, and a bottom layer of $Ti_3C_2T_x$ MXene@WMM with "brick-mortar". The flexible sensor could work in air and water with the sensing property (5.6 kPa^{-1} and 16.5 kPa^{-1}) normally, excellent stability (2000 cycles) and respond time (178 ms and 156 ms). In addition, it showed well electromagnetic shielding (52 dB of EMI shielding, 99.99% of shielding effectiveness) and actuation by infrared light and moisture with controlled deformation. The plant germination experiments illustrated that the flexible sensor was friendly to the environment. Moreover, the multifunctional sensor was demonstrated great applications in flexible wearable to monitor human joints and movement, intelligent switch to warning for the heavy rain and high temperatures, and protective device to protect a human body. The flexible sensor could be used in multiple service environments and apply to electronic skin and human - machine interaction.

Design Strategy

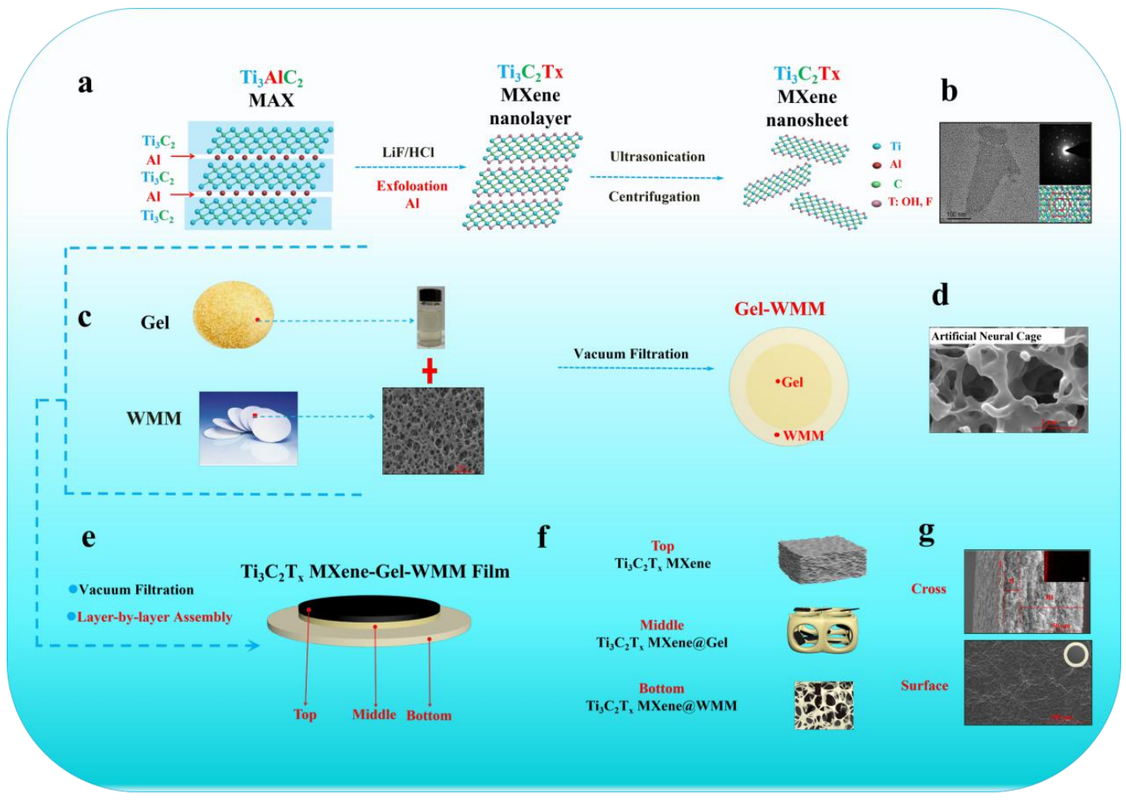

Figure 1 fabrication process diagram of the $Ti_3C_2T_x$ MXene-Gel-WMM advanced sensor. Preparation process of $Ti_3C_2T_x$ MXene (a). TEM image of $Ti_3C_2T_x$ MXene nanosheet (b). Preparation process of Gel-WMM (c). Surface of SEM image of Gel-WMM (d). Schematic diagram of the $Ti_3C_2T_x$ MXene-Gel-WMM advanced sensor (e). Schematic diagram of the hierarchically ordered structure the $Ti_3C_2T_x$ MXene-Gel-WMM advanced sensor (f). SEM images of the surface and cross sections of the $Ti_3C_2T_x$ MXene-Gel-WMM advanced sensor (g).

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Results

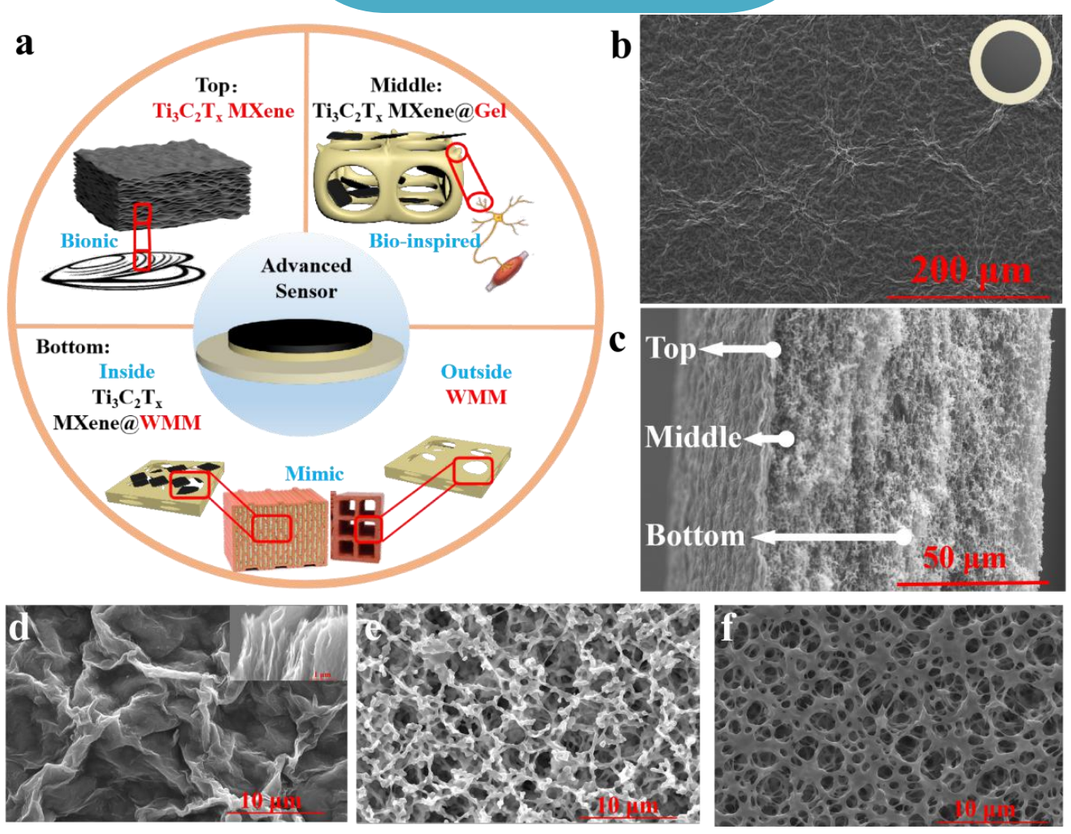

Figure 2 morphology of flexible sensor. Schematic illustration of advanced sensor is interior and partially enlarged view is exterior (a). The advanced sensor SEM images of inside surface (b) and cross (c) section. The SEM images of $Ti_3C_2T_x$ MXene (d), Gel (e), and WMM (f) are shown.

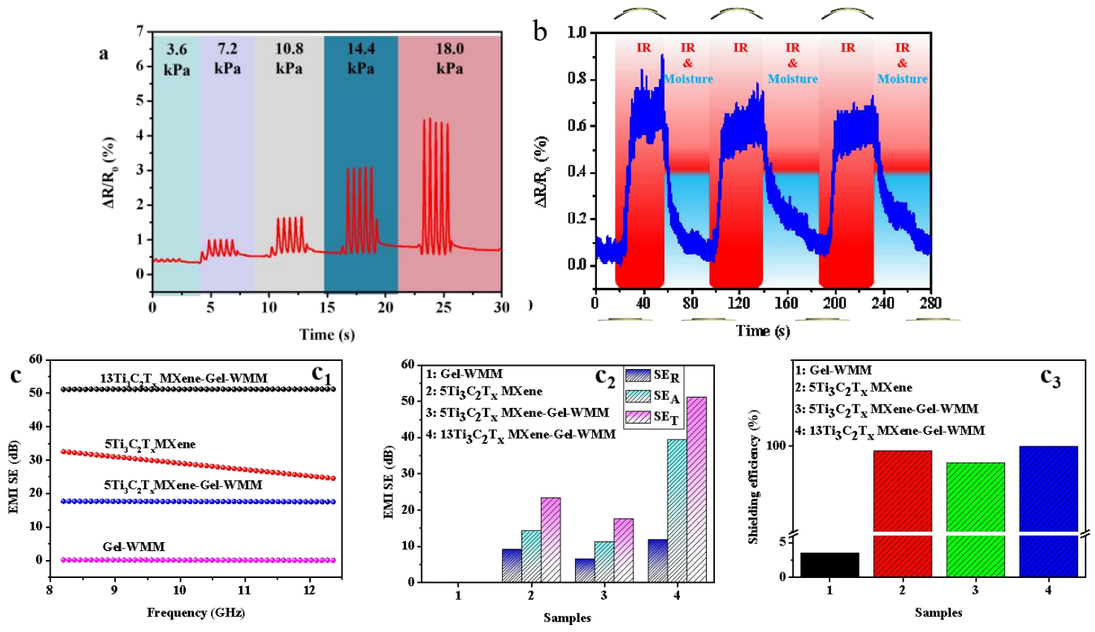

Figure 3 device with the real-time sensing property reacting to changeable pressure (3.6, 7.2, 10.8, 14.4, and 18.0 kPa) by discontiuous pressure change in air (a), actuation of IR and IR & moisture (b), and EMI (c) of flexible sensor.

Conclusions

In summary, inspired by nature, we designed a hierarchically ordered and heterostructure structure of advanced sensor composed of $Ti_3C_2T_x$ MXene, gelatin, and WMM via layer-by-layer assembly with characteristic of sensing, actuating, and EMI.

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