Electronic Supplementary Material (ESI) for Environmental Science: Nano.

Supporting Information

Improved antibacterial activity of 3D wrinkled graphene oxide films implemented with irreversibly shrinkable shape-memory polymer substrate

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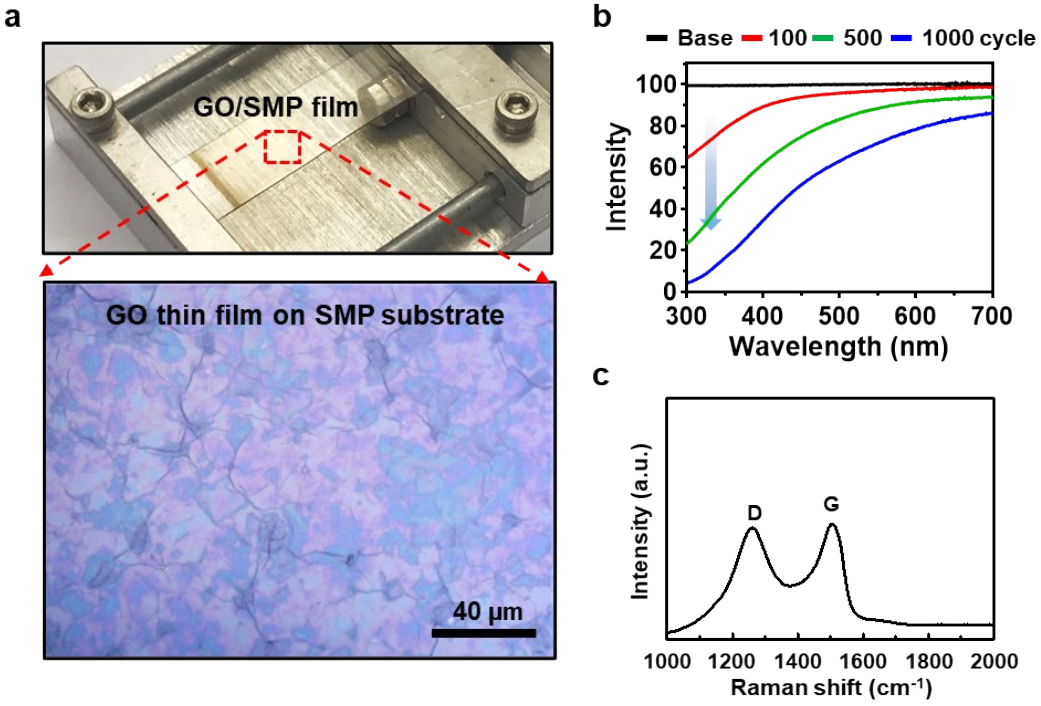

Fig. S1 (a) A digital image of GO-coated SMP film mounted on a fixture jig and optical micrographs of GO film surface. (b) Transmission spectra on the GO/SMP films depending on the numbers of the deposition cycles (i.e., GO thickness). (c) Representative Raman spectra of GO film.

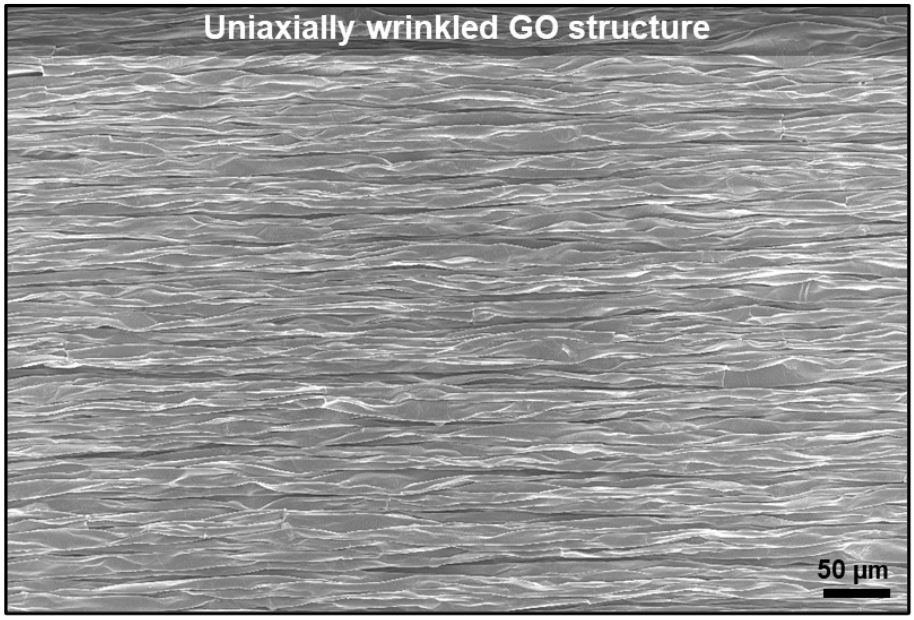

Fig. S2 A representative SEM image of the wrinkled GO structure in a highly aligned configuration over a large area produced from uniaxial mode.

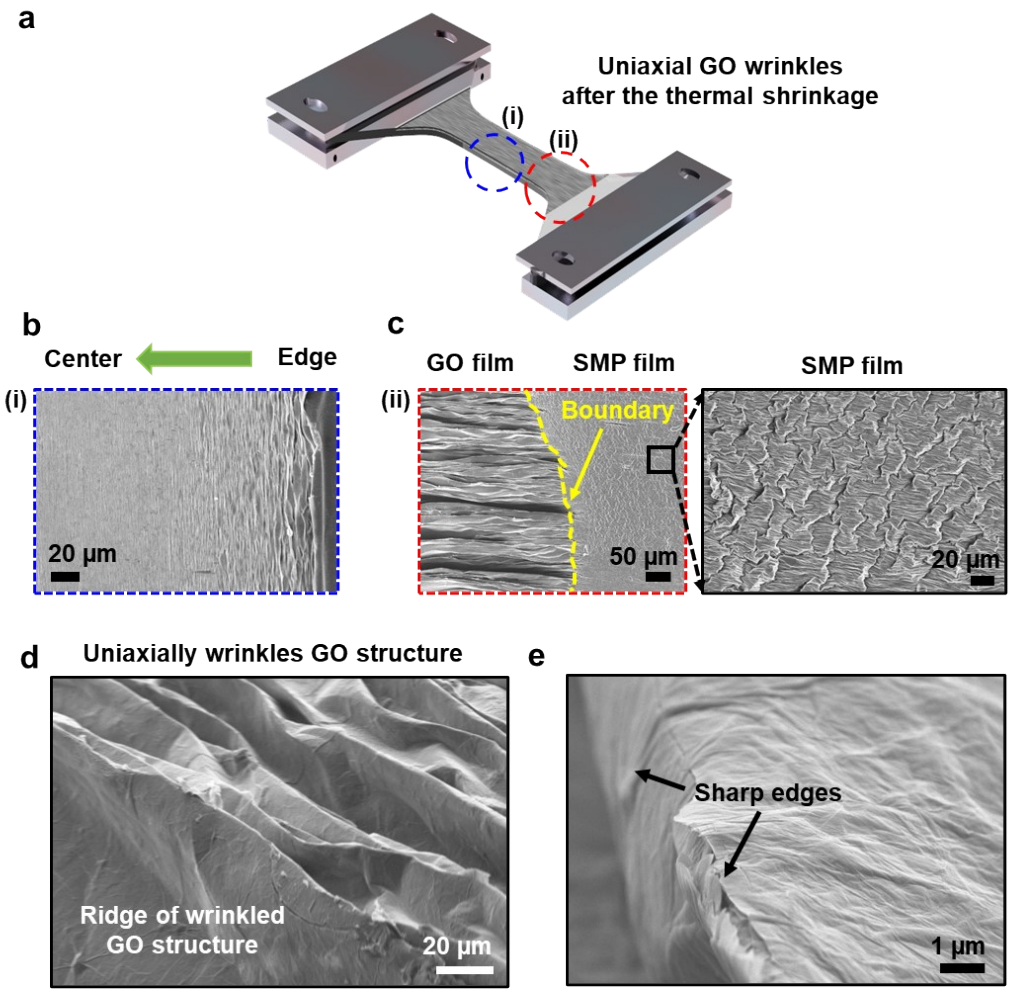

Fig. S3 (a) Schematic illustration of thermally shrunk GO/SMP film when fixed on both ends in a uniaxial mode. (b) SEM image of the wrinkled GO film surface from edge to the center location. (c) SEM images captured at the boundary between GO film and bare SMP substrate after the shrinkage process; only the wrinkles were formed on the GO film area. (d-e) SEM images measured from a tilted view; wrinkles with high-height ridges and sharp edges were observed all over the surface areas.

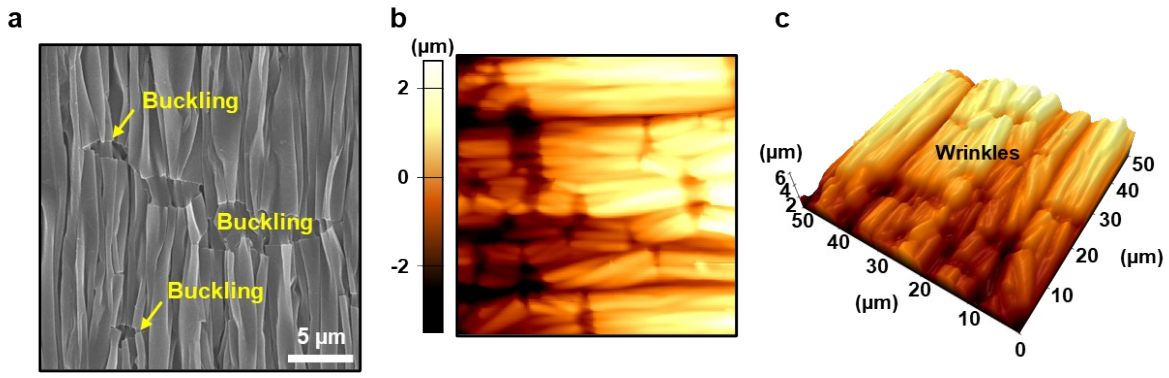

Fig. S4 Micro/nanostructured topographical features of the wrinkled GO film. (a) A macroscopic SEM image with buckles and wrinkles (b-c) Collected AFM images at the same location; the partially cleaved structures and nanoscopic wrinkles were found.

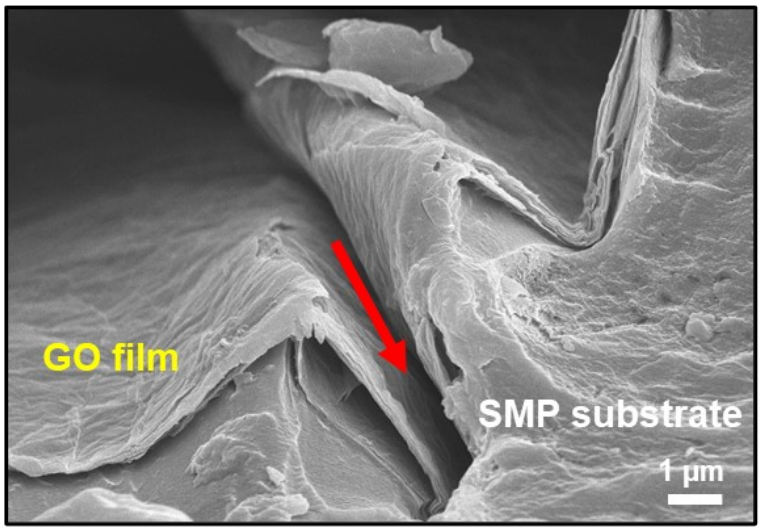

Fig. S5 A highly magnified SEM image from the side-cut view for the wrinkled GO film on the SMP substrate; a red arrow indicates the tightly folded GO film inside the SMP substrate in the middle of the thermal shrinkage process.

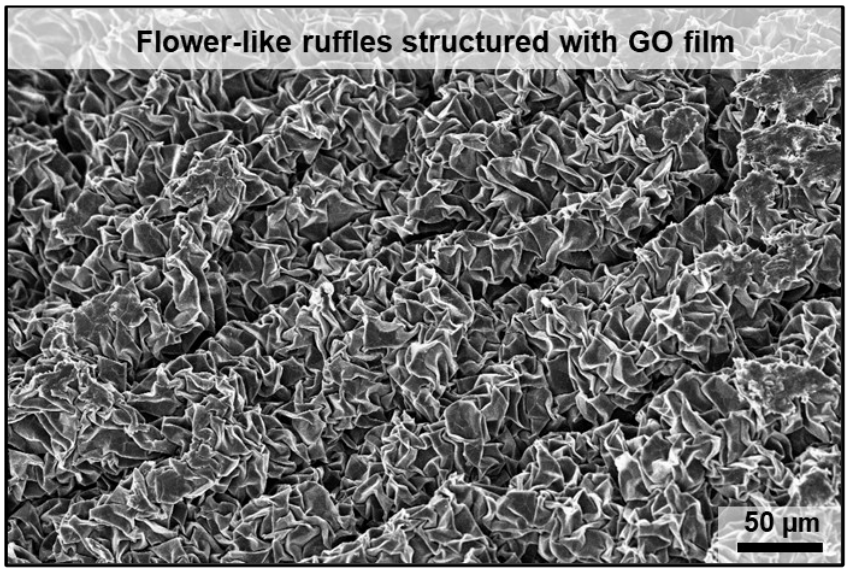

Fig. S6 A representative SEM image of a highly uniform array of flower-like arrangement of ruffles structured in GO film over a large scale.

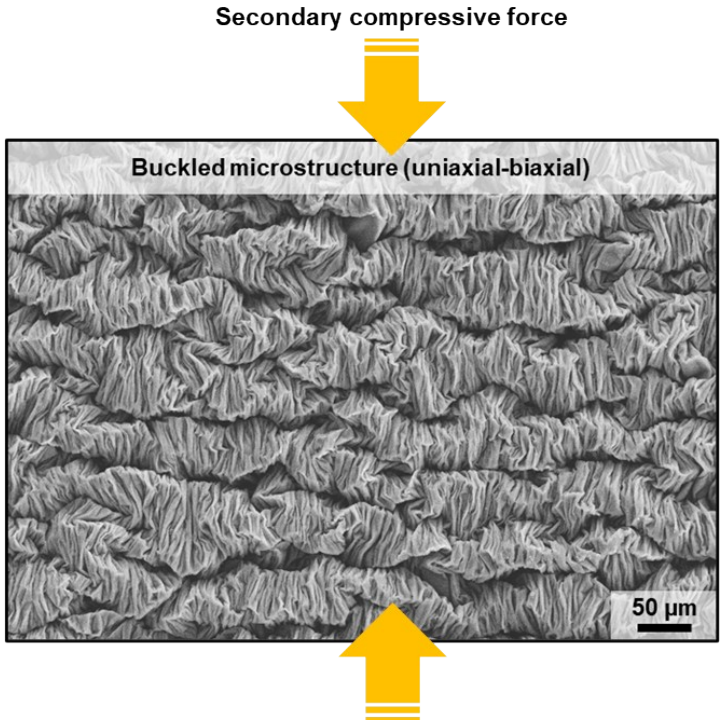

Fig. S7 A representative SEM image of buckled microstructure of GO film with wrinkled features produced by uniaxial-biaxial mode over a large area.

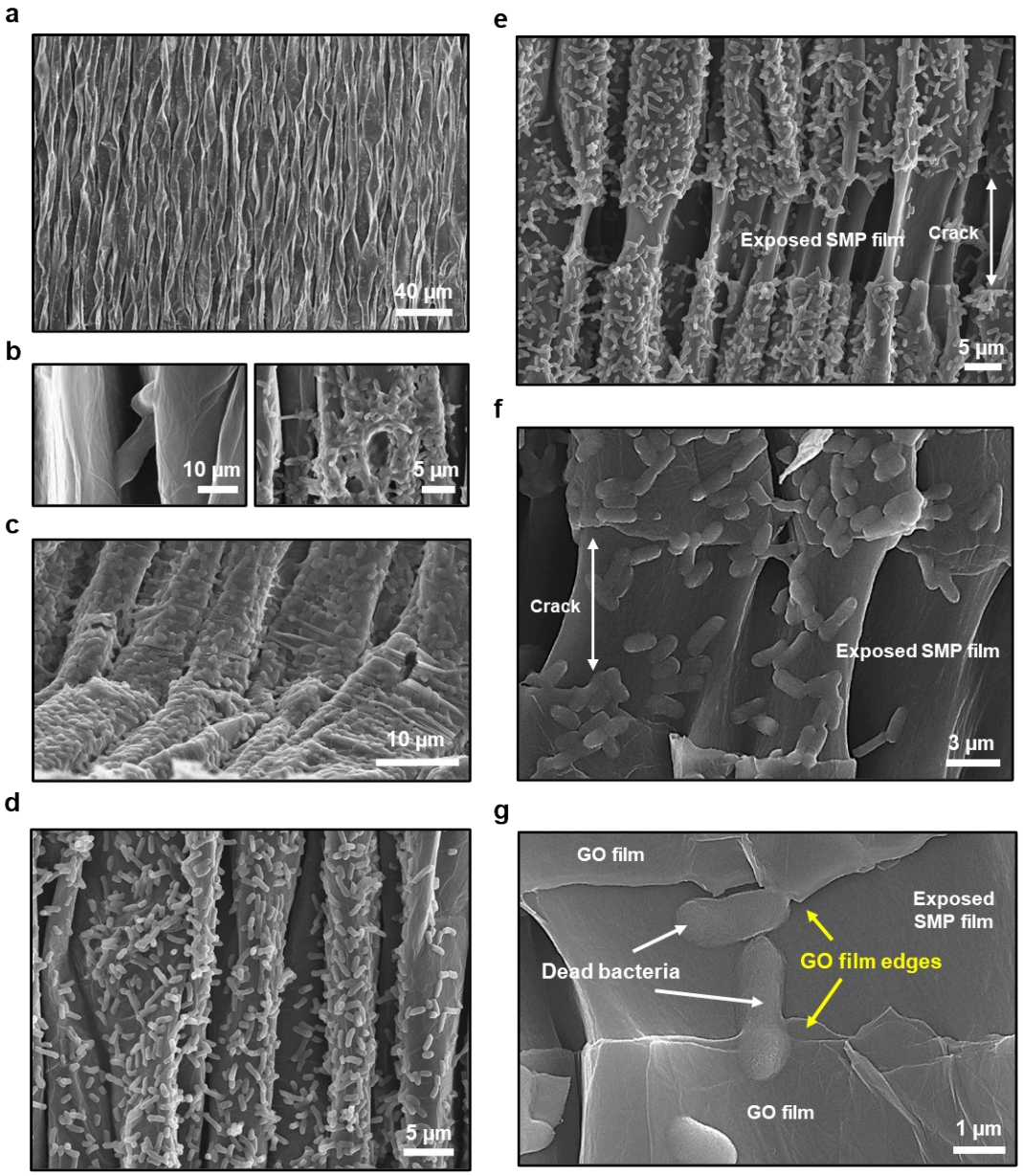

Fig. S8 A set of SEM images captured after the bacteria cell incubation. (a) Macroscopic view of wrinkled GO film. (b) Magnified view field of the wrinkled GO film before (left) and after (right) the bacteria cell incubation. (c) Tilted view of the trapped bacteria cells in between the wrinkled GO surface. (d) Top view of the spreading bacteria cells on the ridges and edges of the wrinkled GO surface. (e) A captured image of a crack in the wrinkled GO structure; most bacteria cells adhered to the GO surface. (f) A magnified image of the exposed SMP film with different densities of bacterial cells. (g) Magnified dead bacterial cells located at the edges of GO film with close contact.

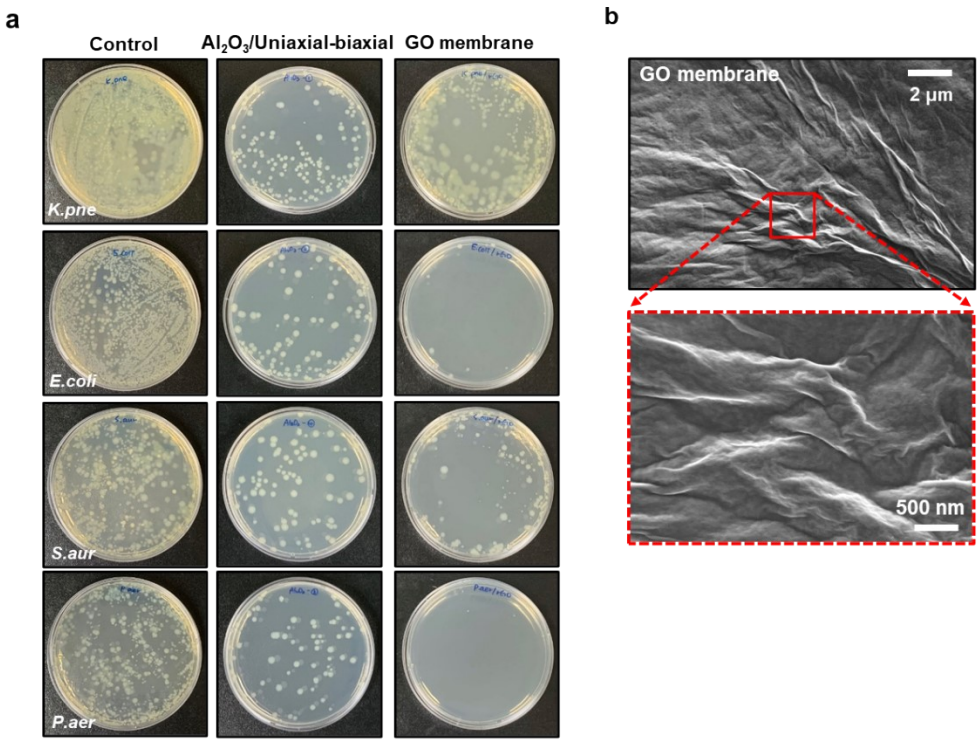

Fig. S9 (a) Photographs of colony formation in agar plate after contact with the samples of the GO films (i.e., Al_2O_3/Uniaxial-biaxial and GO membrane) (b) Representative SEM images of the GO membrane; the sharp sub-wrinkles in a micro/nanoscale are spontaneously formed.

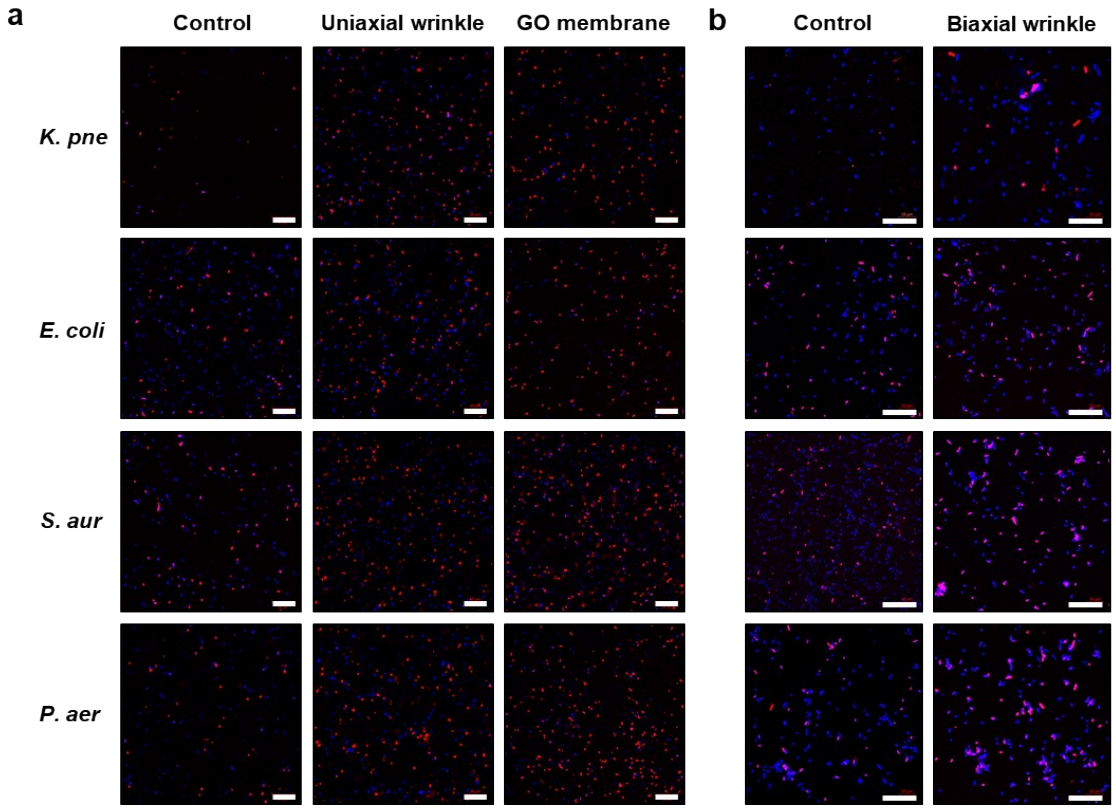

Fig. S10 Antibacterial activity of GO samples prepared by uniaxial mode and GO membrane (a), and biaxial mode (b), against bacteria (*K. pne*, *E. coli*, *S. aureus*, and *P. aer)*; the fluorescent images show live cells stained by DAPI (Blue) and dead cells stained by PI (red) (all scale bars are 20 μm).

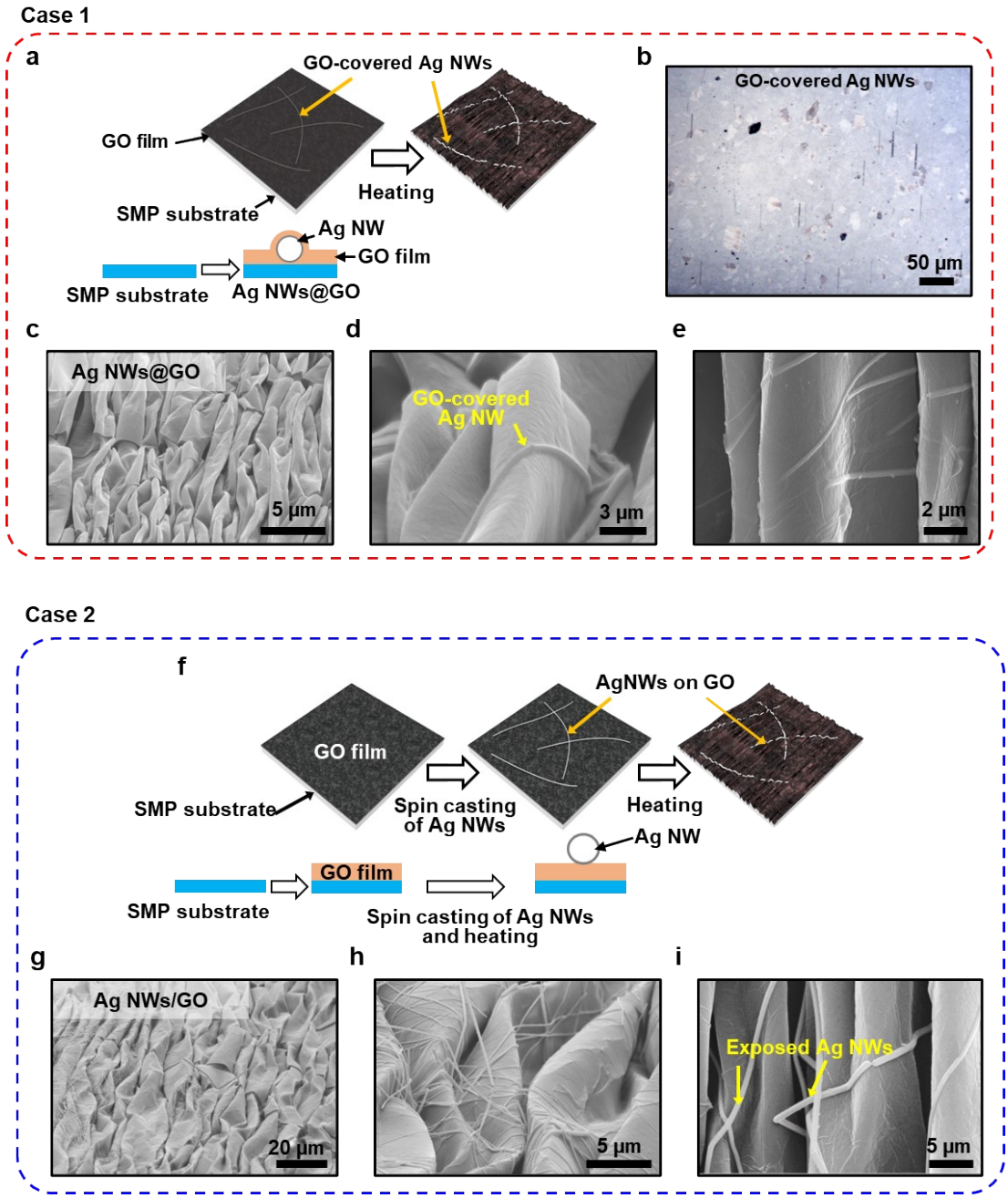

Fig. S11 Process flows to prepare Ag NWs@GO hybrid films. Case 1: (a) Conceptual diagram of manufacturing Ag NWs@GO composite film using a meniscus-driven self-assembly process. (b) An optical micrograph of the surface of the flat Ag NWs@GO film on SMP substrate. (c-e) Representative SEM images of wrinkled Ag NWs@GO film produced from the shrinkage of the biaxial mode. Case 2: (f) Conceptual diagram of manufacturing Ag NWs/GO film through the spin casting of Ag NWs solution on a GO/SMP film. (g-i) Representative SEM images of wrinkled Ag NWs/GO from the shrinkage of the biaxial mode.

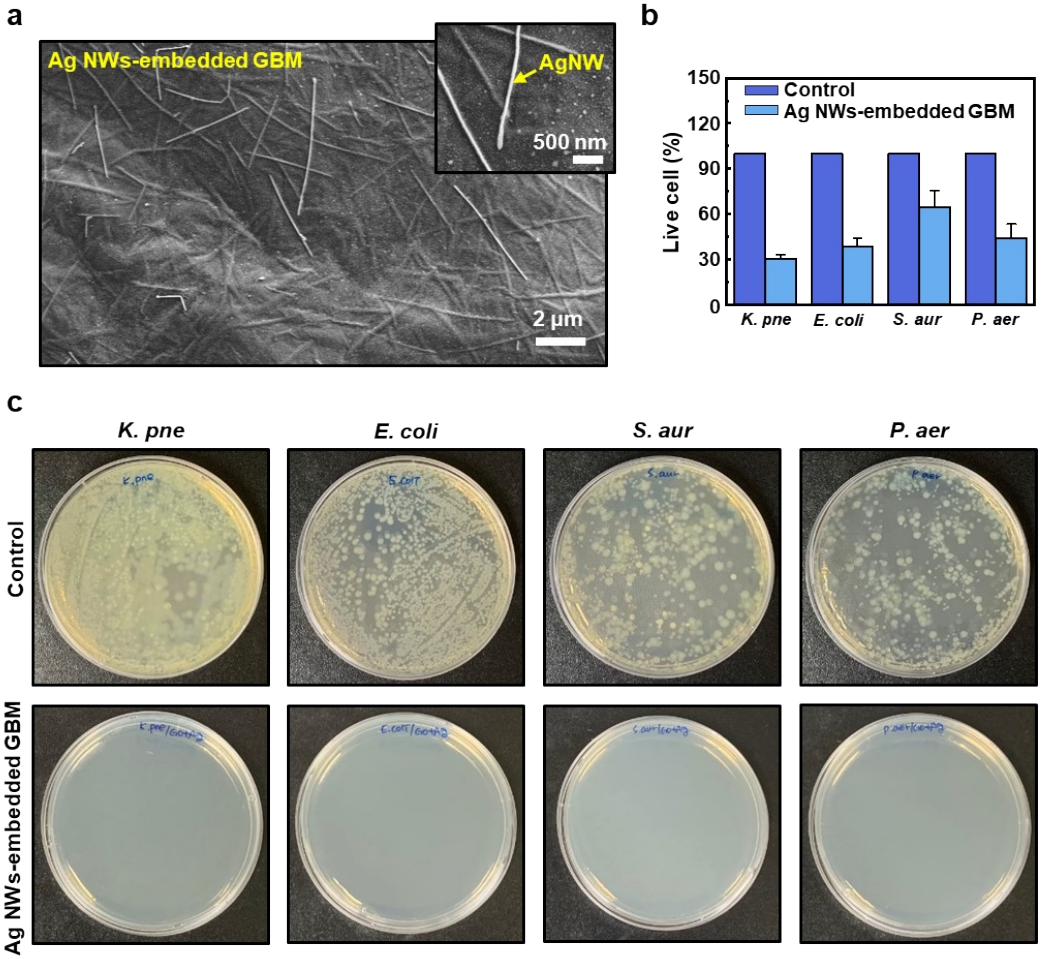

Fig. S12 a) Representative SEM images of the Ag NWs-embedded GBM. b) A set of results on the live/dead cell assay for *K . pne*, *E. coli*, *S. aureus*, and *P. aer* cells after contact with the prepared sample surface. c) A set of photographs of the colony formation on agar plate.

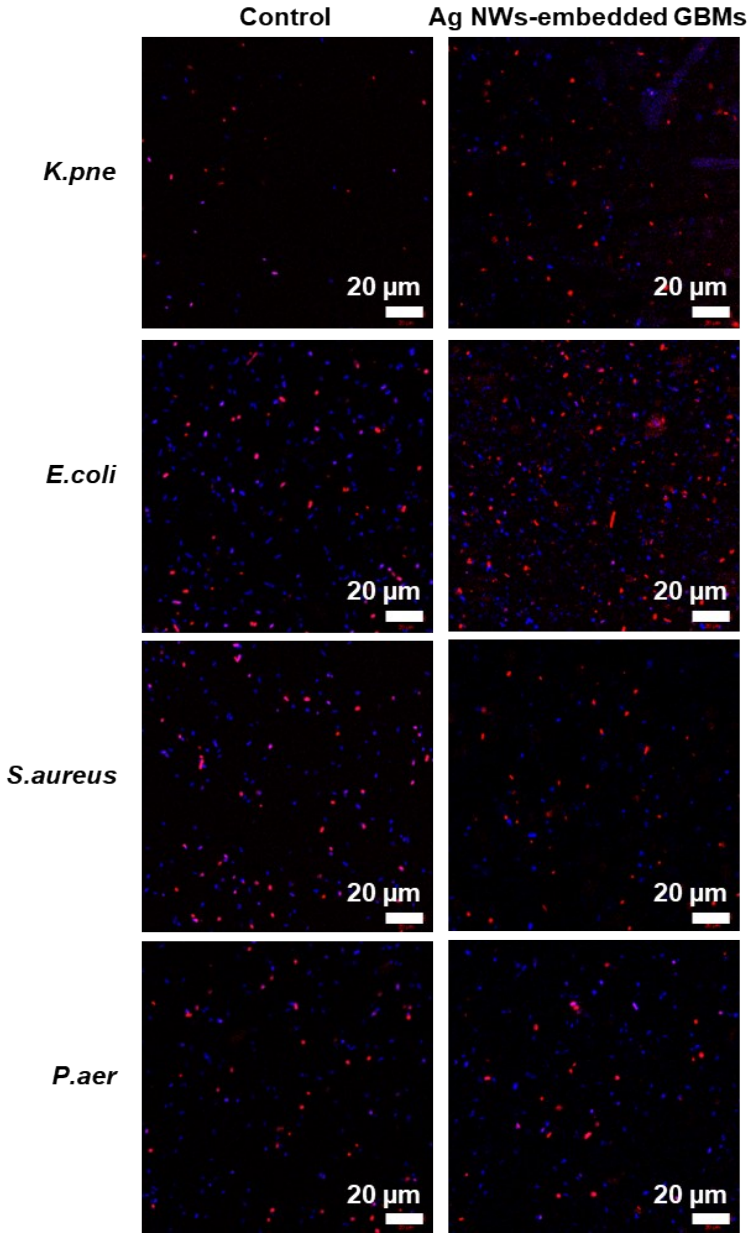

Fig. S13 Qualitative observation of antibacterial activity using staining of live and dead cells; the fluorescent images show live cells stained by DAPI (Blue) and dead cells stained by PI (red). (all scale bars are 20 μm)