CLAIMS

We claim:

1. A method for fabricating a nanostructured film, comprising:

preparing a first ion-conductive layer formed of a first porous scaffold or a polymer gel containing first electrolytes,

creating a stacked structure comprising a conductive substrate, a first porous template disposed on the substrate, the first ion-conductive layer disposed on the template, and a first metal anode disposed on the first ion-conductive layer;

providing a first plurality of rollers on the first metal anode;

applying pressure to the stacked structure via the first plurality of rollers so that the first porous template conforms and stays attached to the substrate;

applying a first galvanic potential between the first metal anode and the conductive substrate;

growing a first nanostructure from the substrate into the first porous template by first electrochemical deposition so that the substate and the first porous template are bonded together; and

removing the first porous template by chemical dissolution or chemical etching to obtain the nanostructured film.

2. The method of claim 1, wherein the method further comprises a step of providing a conveyor belt beneath the substrate.
3. The method of claim 1 wherein the method further comprises preparing a second ion-conductive layer formed of a second porous scaffold or

polymer gel containing second electrolytes, wherein the stacked structure further comprises, in sequence, a second porous template disposed beneath the substrate, the second ion-conductive layer disposed underneath the second porous template, and a second metal anode, and the method further comprises:

providing a second plurality of rollers underneath the second metal anode;

applying pressure to the stacked structure via the second plurality of rollers so that the second porous template conforms and stays attached to the substrate,

applying a second galvanic potential between the second metal anode and the substrate;

growing a second nanostructure from the substrate into the second porous template by second electrochemical deposition so that the substrate and the second porous template are bonded together; and

removing the second porous template to obtain the nanostructured film by chemical dissolution or chemical etching.

4. The method of claim 1 wherein the first porous scaffold is made of a material selected from the group consisting of membrane, filter film, porous polymer films, foam, fabric, paper, and sponge, and the first polymer gel is selected from the group consisting of hydrogels, organogels, and amphiphilic gels.

5. A method for fabricating a nanostructured film comprising:

preparing a first plurality of ion-conductive tube rollers, wherein each of the first plurality of ion-conductive tuber rollers comprises, in

sequence, radially from outside to inside, a first porous tube containing first electrolytes, and a first anode;

forming a stacked structure comprising a conductive substrate and a first porous template disposed on the substrate,

placing the first plurality of ion-conductive tube rollers on the stacked structure,

applying pressure to the stacked structure via the first plurality of ion-conductive tube rollers so that the first porous template conforms and stays attached to the substrate;

growing a first nanostructure from the substrate into the first porous template by first electrochemical deposition so that the substate and the first porous template are bonded together;

applying a first galvanic potential between the first anode and the substrate; and

removing the first porous template to obtain the nanostructured film by chemical dissolution or chemical etching.

6. The method of claim 5, wherein the method further comprises providing a conveyor belt beneath the substrate.

7. The method of claim 5 wherein the stacked structure further comprises a second porous template disposed underneath the substrate, and the method further comprises:

preparing a second plurality of ion-conductive tube rollers, wherein each of the second plurality of ion-conductive tube rollers comprises, in sequence, radially from outside to inside, a second porous tube, second electrolytes, and a second anode;

placing the second plurality of ion-conductive tube rollers underneath the stacked structure

applying pressure to the stacked structure via the second plurality of ion-conductive tube rollers so that the second porous template conforms and stays attached to the substrate;

growing a second nanostructure from the substrate into the second porous template by second electrochemical deposition so that the substrate and the second porous template are bonded together;

applying a second galvanic potential between the second anode and the substrate; and

removing the second porous template to obtain the nanostructured film by chemical dissolution or chemical etching.

8. The method of claim 5 wherein the first porous tube has a first inner surface and a first outer surface, and wherein at least one of the first inner surface and the first outer surface is further covered with a third ion-conductive layer comprising third electrolytes with a better deformability for a better contact with the first anode and/ or the first porous template than the first porous tube.
9. The method of claim 7 wherein the second porous tube has a second inner surface and a second outer surface, and wherein at least one of the second inner surface and the second outer surface is further covered with a fourth ion-conductive layer comprising fourth electrolytes with better deformability for better contact with the second anode and/or the second porous template than the second porous tube.
10. The method of claim 5 wherein the first anode is a cylindrical rod.

11. The method of claim 5 wherein the first porous tube is formed of a hydrophilic material selected from the group consisting of polyethylene, PTFE, PVDF, and a metal that does not react with the first electrolytes.

12. The method of claim 11 wherein the metal is selected from the group consisting of copper, nickel, stainless steel, titanium, aluminum, platinum, silver, gold, iron, lead, cobalt, and other metals and alloys.

13. A multi-layer product comprising:

a conductive substrate,

a first porous template disposed on the substrate,

a first ion-conductive layer disposed on the template, wherein the first ion-conductive layer is formed of a first porous scaffold or a polymer gel containing first electrolytes;

a first metal anode disposed on the first ion-conductive layer; and

a first plurality of rollers on the first metal anode.

14. The multi-layer product of claim 13 further comprising a conveyor belt beneath the substrate.

15. The multi-layer product of claim 13 further comprising:

a second porous template disposed beneath the substrate;

a second ion-conductive layer disposed underneath the second porous template, wherein the second ion-conductive layer is formed of a second porous scaffold or polymer gel containing second electrolytes;

a second metal anode; and

a second plurality of rollers underneath the second metal anode.

16. A multi-layer product comprising:

a conductive substrate;

a first porous template disposed on the substrate; and

a first plurality of ion-conductive tube rollers on the first porous template, wherein each of the first plurality of ion-conductive tuber rollers comprises, in sequence, radially from outside to inside, a first porous tube containing first electrolytes, and a first anode.

17. The multi-layer product of claim 16 further comprising a conveyor belt beneath the substrate.

18. The multi-layer product of claim 16 further comprising:

a second porous template disposed underneath the conductive substrate;

a second plurality of ion-conductive tube rollers underneath the second porous template, wherein each of the second plurality of ion-conductive tube rollers comprises, in sequence, radially from outside to inside, a second porous tube, second electrolytes, and a second anode.

19. The method of any of the preceding claims, wherein the first nanostructure and second nanostructure are made of a metal selected from the group consisting of copper, nickel, silver, gold, brass, cadmium, chromium, and iron.