CLAIMS

1. An electrochemical transistor comprising

   a solid polymer electrolyte layer comprising an ion-coordinating polymer and an ionic liquid incorporated into the ion-coordinating polymer;

   a gate electrode that is deposited on a first main side of the solid polymer electrolyte layer;

   a source electrode and a drain electrode; and

   a channel comprising a semiconducting material facing a second main side of the solid polymer electrolyte layer and connecting the source electrode with the drain electrode, the second main side being opposite to the first main side,

   wherein the solid polymer electrolyte layer comprises microstructures on the second main side.

2. The electrochemical transistor of claim 1, wherein a cation of the ionic liquid is selected from 1-ethyl-3-methylimidazolium $[EMIM]^+$, 1-butyl-3-methylimidazolium $[BMIM]^+$, 1-methyl-3-octylimidazolium $[OMIM]^+$, 1-decyl-3-methylimidazolium $[DMIM]^+$, Mg^{2+}, Ca^{2+}, Zn^{2+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, Ba^{2+}, or a combination thereof.

3. The electrochemical transistor of claim 1 or claim 2, wherein an anion of the ionic liquid is selected from the group consisting of bis(fluorosulfonyl)imide ($[FSI]^-$), bis(trifluoromethylsufonyl)amide $[TFSI]^-$, dicyanamide $[DCA]^-$, hexafluorophosphate $[PF_6]^-$, tetrafluoroborate $[BF_4]^-$, trifluoromethanesulfonate $[OTF]^-$, diethyl phosphate $[DEP]^-$, ethyl sulphate $[EtOSO_3]^-$, perchlorate $[ClO_4^-]$, lactate, chloride $[Cl^-]$, fluoride $[F^-]$, bromide $[Br^-]$, hexafluoroantimonate (SbF_6^-), nitrate, bisulphate (hydrogen sulphate), tetraphenylborate $[B(C_6H_5)_4^-]$, , thiocyanate, acetate, hexyltriethylborate, nonafluorobutanesulfonate, tris[(trifluoromethyl)sulphonyl]methide, trifluoroacetate, heptafluorobutanate, tetrachloroaluminate ($AlCl_4^-$), heptachlorodialuminate ($Al_2Cl_7^-$), tetrachlorocuprate, or a combination thereof.

4. The electrochemical transistor of any one of claims 1 to 3, wherein the semiconducting material is a semiconducting organic material.

5. The electrochemical transistor of any one of claims 1 to 4, wherein the semiconducting organic material is selected from the group consisting of poly(3,4-ethylenedioxythiophene) (PEDOT), polyaniline (PANI), poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS), poly(3-hexythiophene-2,5-diyl) (P3HT), poly[(5-fluoro-2,1,3-benzothiadiazole-4,7-diyl)(4,4-dihexadecyl-4H-cyclopenta[2,1-b:3,4-b']dithiophene-2,6-diyl)(6-fluoro-2,1,3-benzothiadiazole-4,7-diyl)(4,4-dihexadecyl-4H-cyclopenta[2,1-b:3,4-b']dithiophene-2,6diyl)] (PCDTFBT), fullerene, fullerene derivatives, for example, fullerene derivatives with glycolated side chains, [6,6]-phenyl-C71-butyric acid methyl ester ($PC_{70}BM$), or a combination thereof.

6. The electrochemical transistor of any one of claims 1 to 5, wherein the channel further comprises an additional additive selected from the group consisting of an additional ionic liquid, ethylene glycol, poly(ethylene oxide), Triton X-100, dimethyl sulfoxide, and x-sorbitol or a combination thereof.

7. The electrochemical transistor of any one of claims 1 to 6, wherein a monomer of the ion-coordinating polymer comprises vinylene, vinylidene fluoride, methacrylate, ethylene oxide, vinyl alcohol, ethylene carbonate, vinyl pyrrolidone, or a combination thereof.

8. The electrochemical transistor of any one of claims 1 to 7, wherein the ion-coordinating polymer is selected from the group consisting of poly(vinylidene difluoride) (PVDF), poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP), poly(vinylidene fluoride-co-trifluoroethylene) (PVDF-TrFE), poly(ethylene oxide) (PEO), poly(vinyl alcohol) (PVA), poly(ethylene carbonate) (PEC), poly(vinyl pyrrolidone) (PVP), a sulfonated tetrafluoroethylene based fluoropolymer-copolymer (Nafion), or a combination thereof.

9. The electrochemical transistor of any one of claims 1 to 8, wherein a weight ratio of the ionic liquid to the ion-coordinating polymer is from 10:1 to 1:30.

10. The electrochemical transistor of any one of claims 1 to 9, wherein a weight ratio of the ionic liquid to the ion-coordinating polymer is from 5:1 to 1:1.

11. The electrochemical transistor of any one of claims 1 to 10, wherein the microstructures are selected from the group consisting of micro-pyramids, micro-domes, micro-pillars, micro-fibers, micro-cones, or a combination thereof.

12. The electrochemical transistor of any one of claims 1 to 11, wherein the solid polymer electrolyte layer has a thickness of from about 0.1 μm and about 1000 μm.

13. The electrochemical transistor of any one of claims 1 to 12, wherein a flexible layer comprising an organic layer is disposed on a side of the gate electrode that is not facing the solid polymer electrolyte layer.

14. The electrochemical transistor of claim 13, wherein the flexible layer comprising an organic layer is selected from the group consisting of polyimide, polyethylene terephthalate, parylene-C, polydimethylsiloxane, polyethylene naphthalate, cellulose, polyacrylonitrile, carbon paper or a combination thereof.

15. The electrochemical transistor of claim 13 or claim 14, wherein the flexible layer encapsulates the electrochemical transistor.

16. The electrochemical transistor of any one of claims 1 to 15, wherein a ratio (WdL^{-1}) of a channel width (W) times channel thickness (d) to a channel length (L) is between 20 nanometer to 20000 nanometer.

17. The electrochemical transistor of any one of claims 1 to 16, wherein a transconductance of the electrochemical transistor is within 0.1 milli-Siemens to 50 milli-Siemens.

18. The electrochemical transistor of any one of claims 1 to 17, wherein the source electrode and the drain electrode are disposed on a substrate.

19. The electrochemical transistor of claim 18, wherein the substrate comprises silicon oxide, glass, quartz, polymers, metal foil, cellulose, or a combination thereof.

20. The electrochemical transistor of any one of claims 1 to 19, wherein the gate electrode is modified with a non-polarizable layer facing the first main side of the solid polymer electrolyte layer.

21. The electrochemical transistor of any one of claims 1 to 20, wherein the gate electrode is in contact with the first main side of the solid polymer electrolyte layer.

22. The electrochemical transistor of any one of claims 1 to 21, wherein the channel comprising a semiconducting material is in contact with the second main side of the solid polymer electrolyte layer.

23. A process for making an electrochemical transistor, the process comprising:
- providing a first transistor part comprising:
  - a source electrode and a drain electrode disposed on a substrate,
  - a channel connecting the source electrode with the drain electrode; wherein the channel comprises a semiconducting material;
- providing a second transistor part comprising:
  - providing a solid polymer electrolyte layer comprising an ion-coordinating polymer and an ionic liquid incorporated into the ion-coordinating polymer;
  - disposing the solid polymer electrolyte layer on a gate electrode;
- assembling the electrochemical transistor by disposing the second transistor part on the first transistor part such that the solid polymer electrolyte layer is on one side facing the gate electrode and on the other side facing the channel comprising the semiconducting material, wherein the solid polymer electrolyte layer comprises microstructures on the side facing the channel.

24. The process of claim 23, wherein the solid polymer electrolyte layer is formed by at least one method selected from the group consisting of: spin-coating, screen-printing, and inkjet-printing.

25. The process of claim 23 or claim 24, wherein the solid polymer electrolyte layer is formed by being spin-coated on a template.

26. A pressure sensor comprising the electrochemical transistor of any one of claims 1 to 22 or obtained from a process of any one of claims 23 to 25.