CLAIMS

1. A noise management system for a window, the system comprising:

an active noise control (ANC) module disposed in or adjacent to a ventilation channel of the window and configured to substantially cancel low-frequency noise entering the ventilation channel; and

a passive sound absorbing module disposed in or adjacent to the ventilation channel and configured to absorb both high-frequency noise entering the channel and harmonic sounds generated by the ANC module.

2. The noise management system as claimed in claim 1, wherein the ANC module comprises at least one multi-cell transparent electroactive film speaker comprising a plurality of electroactive cells, and wherein each cell is individually operable for generating a sound signal anti-phase to the low-frequency noise.

3. The noise management system as claimed in claim 2, wherein each electroactive cell comprises a transparent electroactive film, a transparent substrate, a transparent bottom electrode and a transparent top electrode.

4. The noise management system as claimed in claim 3, wherein the transparent electroactive film comprises a transparent piezoelectric polymer or a transparent electroactive polymer.

5. The noise management system as claimed in claim 3 or 4, wherein at least one of the transparent top and bottom electrodes comprises a coating of a transparent conductive material selected from a group consisting of indium tin oxide (ITO), carbon nano-tube, carbon nano-bud, graphene, metal nano-wires, and poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS).

6. The noise management system as claimed in any one of the preceding claims, wherein the passive noise absorbing module comprises mechano-electrical conversion elements and/or electro-thermal conversion elements.

7. The noise management system as claimed in claim 6, wherein the mechano-electrical conversion elements comprise a piezoelectric polymer, a charge electret polymer, piezoelectric ceramic particles, or a combination thereof.

8. The noise management system as claimed in claim 7, wherein the piezoelectric polymer comprises one selected from a group consisting of polyvinylidene fluoride (PVDF), polyvinylidene fluoride–trifluoroethylene (P(VDF-TrFE)), polyvinylidene fluoride-co-hexafluoropropylene (P(VDF-HFP)), and wherein the charge electret polymer comprises one selected from a group consisting of polypropylene, polyethylene terephthalate, polytetrafluoroethylene, polyimide, polymethylmethacrylate, or ethylene vinyl acetate cyclic olefin.

9. The noise management system as claimed in any one of claims 6 to 8, wherein the electro-thermal conversion elements comprise a conductive material or a lossy material.

10. The noise management system as claimed in claim 9, wherein the conductive material comprises one selected from a group consisting of carbon nanotubes (CNT), graphene, carbon black, and conductive metal particles.

11. The noise management system as claimed in claim 9, wherein the lossy material comprises one selected from a group consisting of aluminum nitrate nonahydrate ($Al(NO_3)_3 9H_2O$), aluminum chloride hexahydrate ($AlCl_3 6H_2O$), tetra-n-butylammonium chloride (TBAC), and ammonium acetate (NH_4OAc).

12. The noise management system as claimed in any one of claims 6 to 11, wherein the mechano-electrical conversion elements and electro-thermal conversion elements form a porous composite having a volume porosity of at least 85%.

13. A window system comprising at least one noise management system as claimed in any one of the preceding claims.

14. A method of managing noise, comprising:

substantially cancelling low-frequency noise entering a ventilation channel of a window using an active noise control (ANC) module disposed in or adjacent to the ventilation channel;

absorbing high-frequency noise entering the channel using a passive sound absorbing module disposed in or adjacent to the ventilation channel; and

absorbing harmonic sounds generated by the ANC module using the passive sound absorbing module.

15. The method as claimed in claim 14, further comprises detecting the low-frequency noise using a reference microphone before substantially cancelling the low-frequency noise.

16. The method as claimed in claim 15, wherein the ANC module comprises at least one multi-cell transparent electroactive film speaker comprising a plurality of electroactive cells, and wherein substantially cancelling the low-frequency noise comprises individually operating each cell to generate a sound signal anti-phase to the low-frequency noise based on the detection.

17. The method as claimed in any one of claims 14 to 16, further comprising detecting a remaining noise after the absorption and adjusting the ANC module based on the detected remaining noise.

18. The method as claimed in any one of claims 14 to 17, wherein absorbing the harmonic sounds generated by the ANC module using the passive sound absorbing module comprises absorbing sounds having a frequency below 1 kHz.

19. A method of installing a noise management system on a window, the method comprising:

disposing an active noise control (ANC) module in or adjacent to a ventilation channel of the window, wherein the ANC module is configured to substantially cancel low-frequency noise entering the ventilation channel; and

disposing a passive sound absorbing module in or adjacent to the ventilation channel, wherein the passive sound absorbing module is configured to absorb both high-frequency noise entering the channel and harmonic sounds generated by the ANC module.

20. The method as claimed in claim 19, wherein the ANC module comprises a plurality of multi-cell transparent electroactive film speakers, and wherein disposing the ANC module comprises spatially distributing the speakers at different locations along the ventilation channel.