

Supplementary Information

Hair-Compatible Sponge Electrodes Integrated on VR Headset for Electroencephalography

1. Fabrication of FCA and sponge electrode integration onto VR headset

The patterns of the FCA circuits were designed by AutoCAD and produced by a laser cutter (U4, LPFK Laser & Electronics). The process involved the following steps:

1. A 25 μm -thick PET film was covered with a double-sided polyimide (PI) tape with a PET liner.
2. The PET/PI/PET film was cut into FCA outline patterns with 10 mm-diameter holes at the recording sites, and the excess was peeled off to get the FCA outline.
3. The top PET liner was removed, and a 25 μm -thick copper film was attached to the exposed PI double-sided tape.
4. Another 25 μm -thick Kapton tape was added as an insulation layer on top of the copper film.
5. The film was cut into the FPC patterns, and the excess was peeled off to get the FCA with insulated 1 mm-wide copper traces.

2. Supplementary Figures

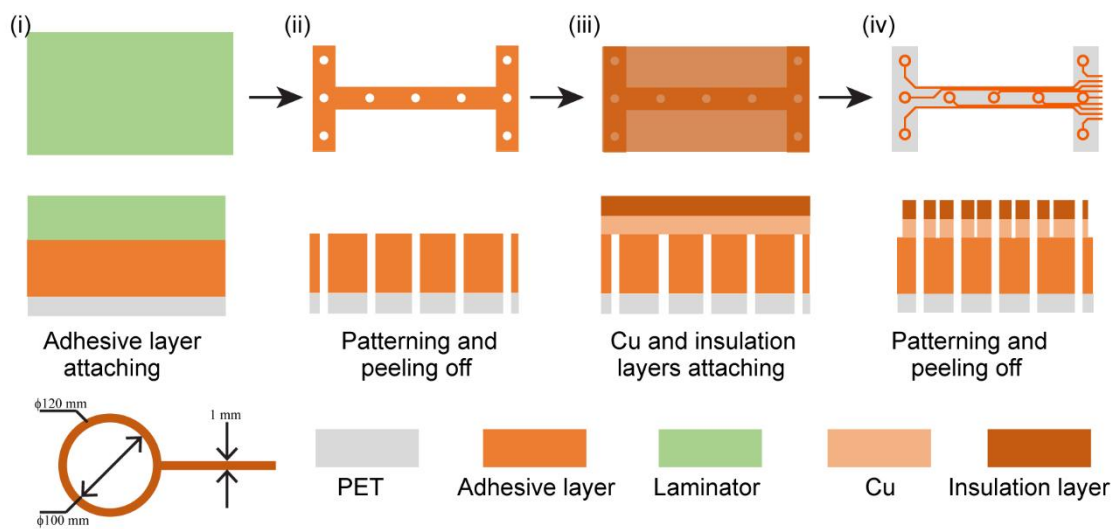


Figure 1. Schematic of the fabrication process of the FCA.

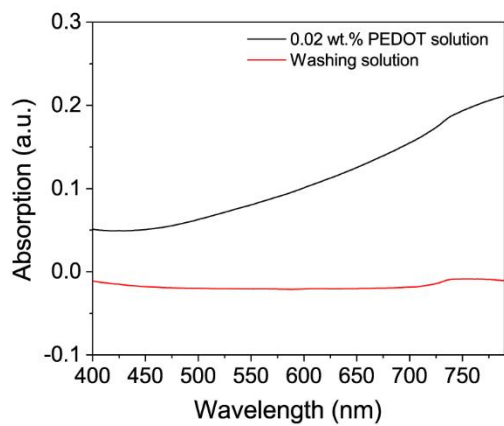


Figure 2. UV-vis spectrum of the washing solution and a highly diluted PEDOT:PSS solution.

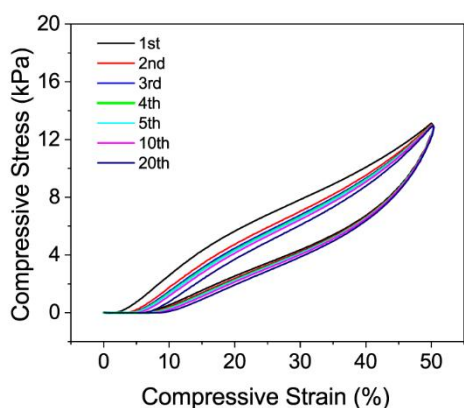


Figure 3. Stress-strain curve of the PMA sponge recorded under repeated loading and unloading at 50% strain for 20 cycles.

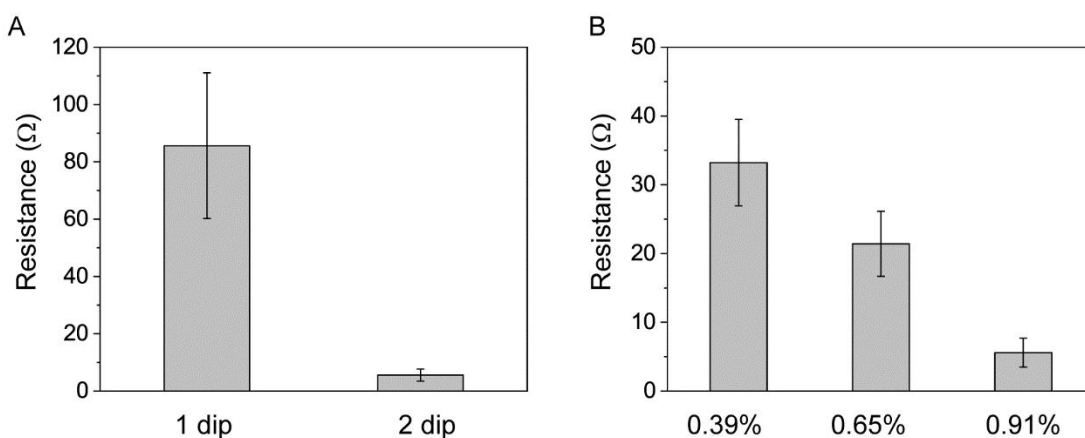


Figure 4. Resistance of the PMA sponges prepared with different parameters. (A) Comparison of the PMA sponges with different dipping cycles ($n = 12$). (B) Comparison of the PMA sponges prepared in PEDOT:PSS solution with different PEDOT:PSS concentrations ($n = 12$).

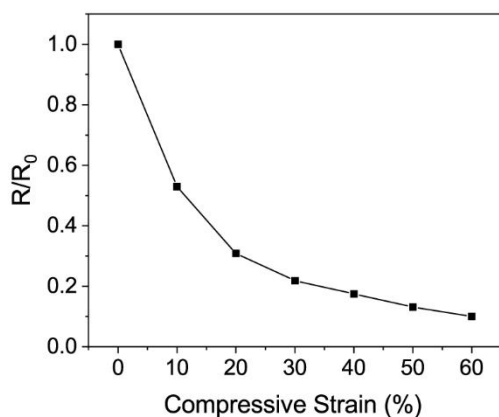


Figure 5. The decrease of the sponge resistance with the increase of compressive strain.

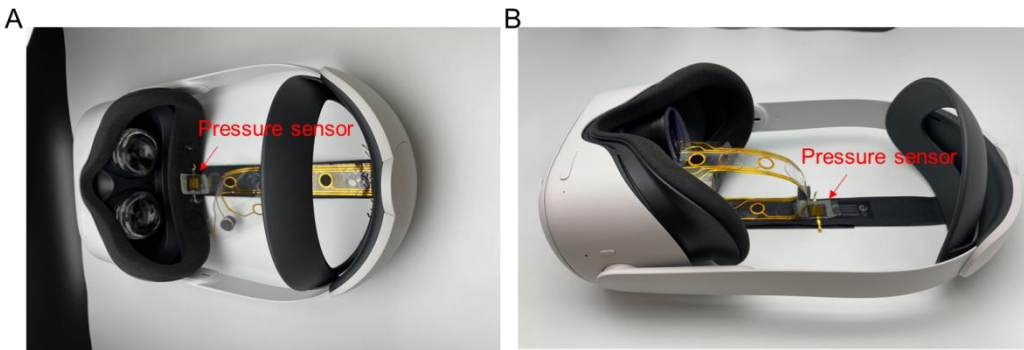


Figure 6. The setup used in measuring the pressure exerted by the VR headset strap on the hairless site (A) and on the hairy site (B).

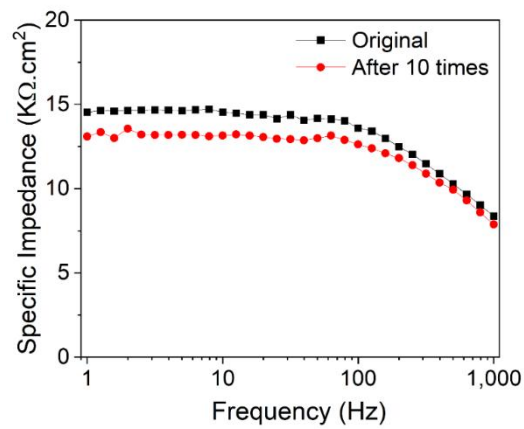


Figure 7. The comparison of the contact impedance of sponge electrodes on the forehead before and after ten uses.

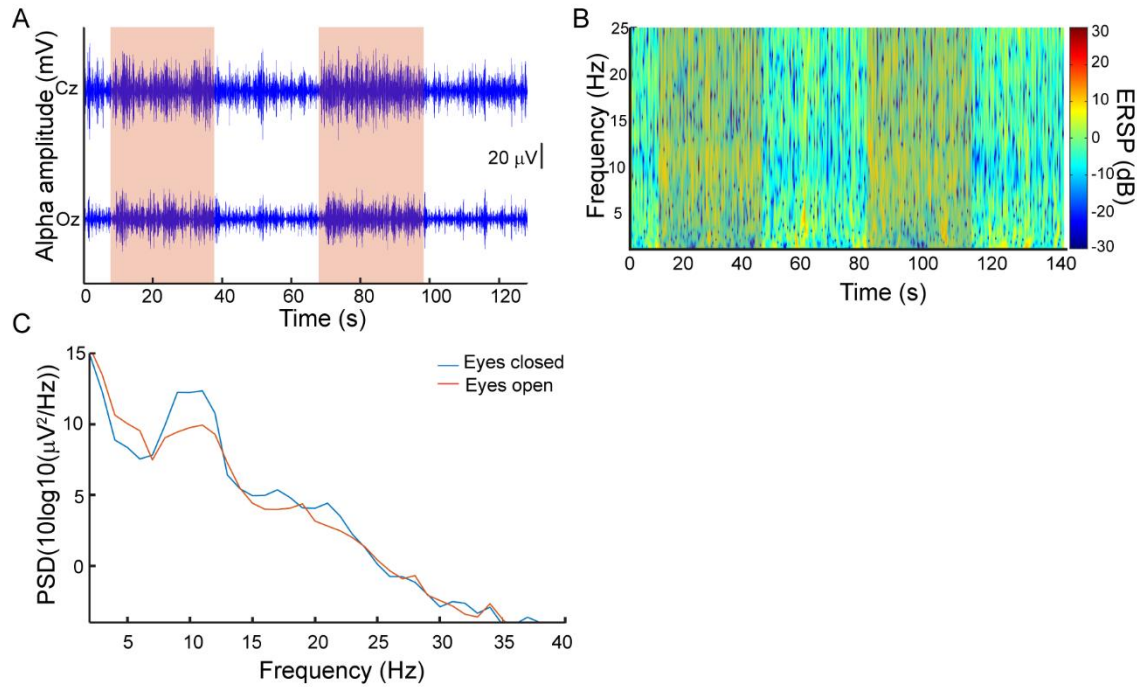


Figure 8. (A) Alpha bandpass filtered EEG signals (8-12 Hz) captured during eye-close and eye-open periods after 60 min. (B) Time-frequency analysis of the EEG signals recorded at Oz. Colors show event-related spectral perturbation (ERSP), calculated as the ratio of average amplitudes in the experimental condition (eyes-close or eye-open) to the baseline epoch (taken from the start of the recording before subject instructions were given) after 60 min. In (A) and (B), the shaded areas indicate an eye-closed period. (C) PSD of the EEG signals recorded at Oz under eyes-close (blue) and eye-open (red) conditions after 60 min.

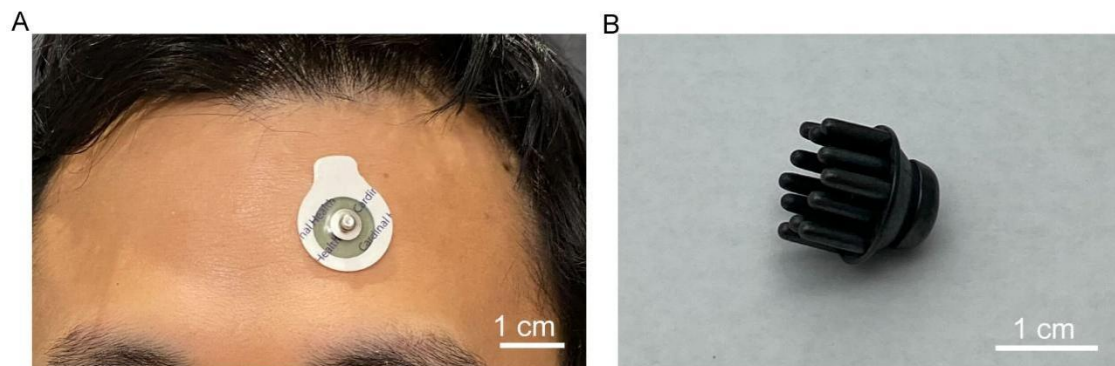


Figure 9. Photographs of the commercial solid gel electrode (A) and comb electrode (B) used for comparison during EEG recording.

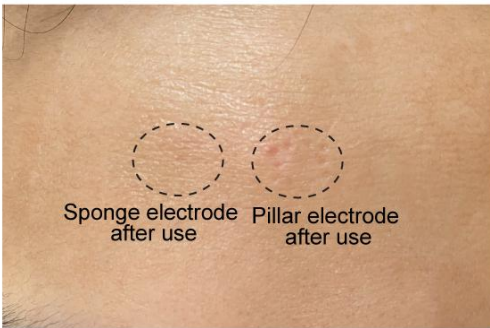


Figure 10. The comparison of the skin wearing medical tape fixed sponge electrode (left) and comb electrode (right) for 1 h.