Fabrication and Evaluation of Screen Printed Fabric Electrode Arrays

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Introduction

The recent emergence of electrode arrays for functional electrical stimulation (FES) of nerves using electrical currents has been shown to enable greater muscle selectivity and reduced fatigue compared with use of large individual surface electrode pads. However, existing fabrication techniques are expensive and have flexibility constraints which limit patient uptake and scope for clothing-based wearable application.

Method

In this work a flexible and breathable fabric electrode array (FEA) is developed, fabricated entirely by screen printing the active electrode array directly onto standard fabric. The printed FEA has required the development of bespoke polymer based screen printable pastes, and consists of four printed functional layers: an interface layer, a conductive silver layer, an encapsulation layer and a carbon loaded silicone rubber layer. The FEA materials have been cytotoxicity tested to confirm they are biocompatible. The dry carbon loaded rubber contact yields improved comfort and lifespan compared to a standard conductive hydrogel.

Results

Tests have shown that the FEA can provide highly accurate assistance of movement. The FEA can produce over 90% of the angular joint movement generated by the leading alternative which is a flexible PCB array on polycarbonate with a hydrogel layer. Furthermore, joint movement has greater repeatability on FEA compared to the PCB plastic electrode array. Different reference postures (‘pointing’, ‘pinch’ and ‘open hand’) have been achieved by stimulating an optimised selection of elements.

Discussion

The feasibility of manufacturing fabric electrode arrays using low temperature screen printable materials has been demonstrated which establishes the potential for wearable FES technology with a high level of breathability and flexibility. Fabric surface roughness has been reduced significantly by using an interface layer between the conductor and the rough fabric. Printing a single deposit of silver on the fabric interface layer has achieved better conductivity than on Kapton (a flexible polyimide film used widely in printed electronics) when the interface layer was used on the fabric.

Conclusion

The FEA has potential for wide medical application for assistance and rehabilitation in both clinical and home environments.