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## CTI Success Story

### Embroidered Electrodes for Muscle Stimulation

**Electrical muscle stimulation can alleviate pain and support the rehabilitation of the physically handicapped. At the same time, athletes and fitness enthusiasts are increasingly interested in this technology. As part of a CTI project, ETH Zurich and EMPA St. Gallen are investigating new electrode material in collaboration with Compex Medical SA and Bischoff Textil AG.**

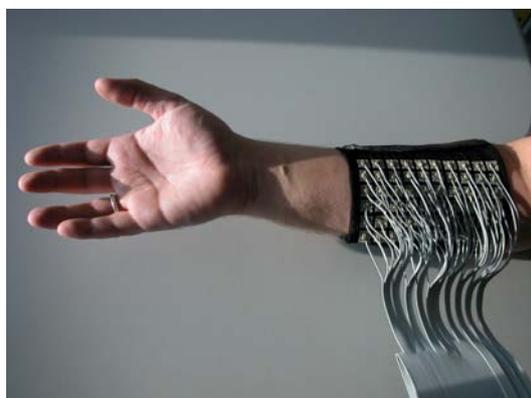
Electrical stimulation is a widely-used muscle activation procedure. It involves electrodes being attached to the respective part of the body just like adhesive plasters. Cables connect them to the stimulation device, with which the desired program category can be selected, and the intensity adjusted to suit the affected muscle. The stimulation has a direct effect on the nerve responsible for movement, thereby triggering natural muscle activity. This method is particularly beneficial in the event of muscle atrophy, for strength and endurance training, pain treatment, and functional physical therapy.

#### Complex Objectives: New Electrode Material

Klaus Schönenberger, Vice President of Research and Development of Compex Medical SA, the market leader in electrostimulation for sports and rehabilitation, was eager to secure a leading technological edge in this area: under the leadership of Professor Manfred Morari and Thierry Keller from the Institute for Automatic Systems of ETH Zurich and in collaboration with the Institute for Electronics, the fibre specialists of EMPA, and the company Bischoff Textil AG, which had already provided evidence of its expertise in embroidered electrodes in other CTI promotion projects, the idea was born to develop new electrode material and to integrate it into

fabric. The aim was to improve control of the distribution of the stimulation current, thereby achieving more intensive stimulation, enhanced muscle selectivity, and better wearing comfort.

To facilitate the application of the electrodes to relevant body parts, the initiators intended to use embroidery technology for their multi-channel



**An array of embroidered electrode elements for dynamic control of the grasping movement.**  
Photo: ESG/ETHZ

a few more years before the product will be ready for the market.

electrodes and to embed these in an article of clothing connected to a battery-powered stimulation device. In contrast to conventional stimulation devices with their cable spaghetti, the connection issue as well, was to be solved by means of embroidery.

### **Development of Conductive Synthetic Fibre**

For optimum electrical transmission of the stimulation impulses through the skin into the body, the integration of the electrodes in fabric necessitated conductive synthetic fibres with defined electrical properties. In an earlier CTI project, the EMPA group 'Functional Fibres and Textiles' had developed a low-pressure plasma chamber equipped with a cylindrical magnetron. Using this system, metals can be deposited on synthetic yarn in a continuous and controlled manner, resulting in optimum electrical conductivity. The textile substrates were coated with a homogeneous layer that ensured even load distribution, resulting in a level of electrical conductivity corresponding to that of the skin surface. Moreover, the coating makes the substrate adhere well to the skin and is resistant to repeated use.

The electrodes were tested on the skin of healthy subjects. Relevant test parameters included the distribution of electrical current, impedance, induced muscular action, and intensity of stimulation as well as sensation and comfort. In this way, stimulation efficiency and comfort were assessed both quantitatively and qualitatively.

### **Basis for New Products**

By means of the full integration of the electrode surface in textiles, embroidery patterns and pad contours and sizes can be made-to-measure. This opens the way for new products such as clothes and sleeves for treating chronic pain or functional electrical stimulation systems that train and restore coordinated movement of handicapped patients. Moreover, the product can also be used in the field of sports, e.g. for fitness applications, strength and endurance training for athletes, relaxation of muscular tension, or simply for physical relaxation.

Having closely cooperated over a period of 15 months, the project partners have presented satisfactory results; they have provided evidence of the feasibility of their idea. However, it will take

#### **Further Information**

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