SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA17107 - European Network to connect research and innovation efforts on advanced Smart Textiles
STSM title: Laser welded textile integrated electro-mechanical systems for assistive devices in medical Applications
STSM start and end date: 01/04/2021 to 30/04/2021
Grantee name: Martin Seidenberg

PURPOSE OF THE STSM:

The purpose of the STSM was to study wearable electro-mechanical systems for tremor assisting devices manufactured through textile laser welding. Such systems function by having metal coated textiles separated by a dielectric film, each functioning as an electrode, which are then electrically charged causing attractive electrostatic forces and therewith frictional forces between the two textile layers. The principle of using conductive textiles to manufacture electro-mechanical devices such as clutches and brakes has been described by several groups and researchers in the last years, most notably Ramachandran et al. in 2018. In the STSM such systems were manufactured using a novel manufacturing technology for textile integrated circuitry based on textile laser welding, potentially improving textile integration, strength of the frictional forces and usability. The manufacturing process entailed the choice of suitable materials and process parameters, conducting welding trials and subsequently testing for conductivity, abrasion, resistance to bending and washability of the produced specimens.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

After the application's approval and before the start of the mission Mr. Seidenberg detailed the proposed list of materials and equipment with the team at Empa which ordered all necessary items so that they were available from the outset. Furthermore, two planning workshops between Nicolas Fromme of Empa as well as Martin Seidenberg of ITA were held for the specification of requirements with regard to the electro-mechanical devices and to plan laser welding experiments for the first half of the STSM. In the first working week of the STSM material specifications all textiles were determined through analysis by DSC and TGA. To determine the absorbance for laser light the textiles were subjected to UVVis spectrometry. With the laser welding equipment at Empa, a set of process parameters for all materials was determined in laser welding trials and subsequent measurement of conductivity and resistance to abrasion. Subsequently in week 2, specimens for testing of the electro-mechanical devices were designed with optimal testing capabilities in mind. A further set of specimens was designed for subsequent evaluation in a tremor suppression testbench setup. Through laser welding and subsequent processing steps (coating with the dielectric Piezotech RT-TS, interfaces to measuring equipment) the specimens for testing of their capabilities were manufactured. Based on the results attained in week 2, the set of specimens for testing of the tremor suppressing capabilities in a testbench setup was manufactured using laser welding technology and further
Processing coating with dielectric and attachment of electrical equipment in week 3. The frictional forces between two sets of electrodes were measured with voltages ranging from 300 to 1500 volts. Furthermore, the thickness and manufacturing parameters for the dielectric films with which all electrodes were coated were varied systematically to compare their influence on the frictional forces. In the foruth week all results of

the previous three weeks were compiled, reviewed and prepared for presentation in the bi-weekly meeting of Empa's research group 401 on Thursday, April 29th. The results were critically discussed, and the determination was made whether to pursue a joint research project on the topic at hand or alternative applications. Furthermore, all relevant parties that were involved with the STSM shared their experiences and lessons learned from the STSM for future STSMs and other collaborative activities between Empa and ITA.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

A combination of textile and metal foil as well as a set of parameters to join the two materials using laser light was found in week one of the STSM. The textile chosen was a polyester/polyether-ester block-copolymer laminate by Sympatex, Wuppertal, Germany. Copper metal foils with a thickness of 1 µm were chosen as the most suitable electrode materials. After the initial welding trials the specimens were designed based on the available information in literature, such as Ramachandran et al 2018, Hinchet et al 2018, 2020 and others. Electrodes consisted of 3 by 3 cm squares with 1 mm by 2 cm attachment lines for the high voltage power source. The electrodes were welded in pairs of two and coated with Piezotech RT-TS afterwards. P(VDF-TrFE-CTFE) is a ferroelectric polymer that exhibits high electrostrictive strain and a high dielectric constant. A solution by weight of 14% Piezotech RT-TS in 86% MEK was used in all coating experiments. The coating was performed with automatic blade bar coater directly onto the laser welded electrodes. Samples were then dried and annealed at 40° C for 2 hours in a vacuum oven. Testing of the electro-mechanical systems was carried out using a Spellman high-voltage power source. Two electrodes were stacked with the dielectric coatings facing each other and a voltage of 300 volts applied to the system. With the voltage in place, the shear force required to separate the two electrodes was measured. While there was a noticeable attraction between the two electrodes starting from 300 volts, the shear forces did not reach literature figures (20kN @ 800 V and 10 cm²) in any of the experiments carried out. In fact, the forces obtained were inconsistent, irregular and unstable making their measurement extremely difficult. Experimentation with different coating thicknesses, welding parameters and electrode designs did not reach satisfactory results to warrant integration of the electrodes into a more complex testing setup which would resemble a anti-tremor orthosis. However, it was agreed that the approach still warrants further review. Due to shortness of time no optimization on the homogeneity of the dielectric films could be carried out. Neither could the films be analyzed for imperfections. Improving the smoothness of the electrode surfaces could further improve the performance of the electromechanical systems. Such improvements could be made by using textile laminates with thicker membranes and smoother welding surfaces.

FUTURE COLLABORATIONS (if applicable)

The parties involved agreed that the results obtained do not warrant publication at this point in time. At the moment no future STSMs or other activities to further pursue the topic are planned. The parties will continue to work together and utilize the results of this STSM in future cooperations.