Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA 17107

Grantee name: Hannah Kelbel

Details of the STSM

Title: Self-shaping curved origami and kirigami textiles for interior

Start and end date: 14/05/2022 to 13/06/2022

Description of the work carried out during the STSM

Three main concepts have been investigated: Origami – folding of planar surfaces in 3dimensional shape, Curved Origami – folding of planar surfaces with curved creases and Kirigami – cutting and folding of planar surfaces in 3dimensional shape. For each concept basic prototypes have been created using 3D printing on pre-stressed textiles. Promising concepts have been translated to digital models both in CAD (Fusion 360 and Rhino) and physical simulation to identify shape change as well as technical feasibility. First, the shape generation of curved Origami has been identified as most promising considering the bending properties of textiles. Curved origami are also considered very harmonious to human eyes as they mimic natural behaviour. In opposition to the planned work cutting is not considered at this point of time since initial test have not led to promising results.

Curved origami structures consist of deployable surfaces. A concept to parametrise the printing structures builds on the generators of these deployable surfaces. Literature research has been performed to identify appropriate translations to 3D printing on textiles since a transfer from 3dimensional shape to 2dimensional shape has to be performed. Based on research 3D printing patterns have been generated for surfaces with either convex or concave curvature. For this research this principle transferred to printing with silicone and PLA (see Figure 1). Different approaches have been taken for the different materials. The printing with silicone has been successful in recreating curved origami behaviour. For printing PLA generating rulings has shown good result but will now be continued to be investigated by Hannah Kelbel in Aachen. The patterns have been validated with COMSOL Multiphysics and parameters have been varied. Influencing parameters have been identified: prestress of textile, angle of rulings, thickness of printed structures, printing material.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

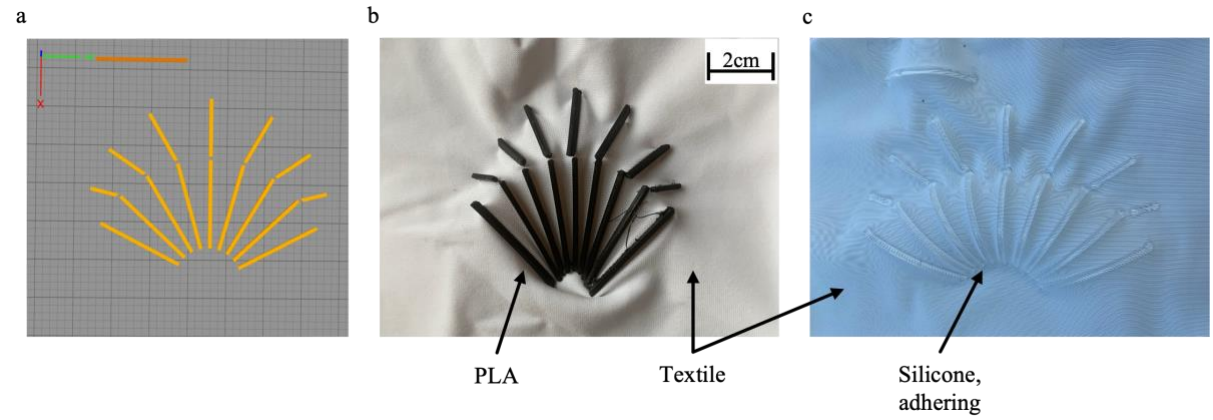

Figure 1: a) CAD-model of curved orgigami structure b) printed with PLA on textile c) printed with silicone on textile

Through this research local adhesion between printed beams and textile has come up as an interesting investigation direction (see Figure 2). It was observed that depending on the material properties the tension was distributed differently resulting in either inflection points on the printed non-adhering beams or in complex bending behaviour of the textile. In addition, the concept or kirigami can be applied. Knowledge from flexible electronics have been adapted to the present material structure. The need to understand this has been identified as more urgent that scaling up the process. Therefore, no scaling up has been performed in opposition to what has been planned for WP 4. The need for more simulation has been identified leading to further investigations. Which are continued.

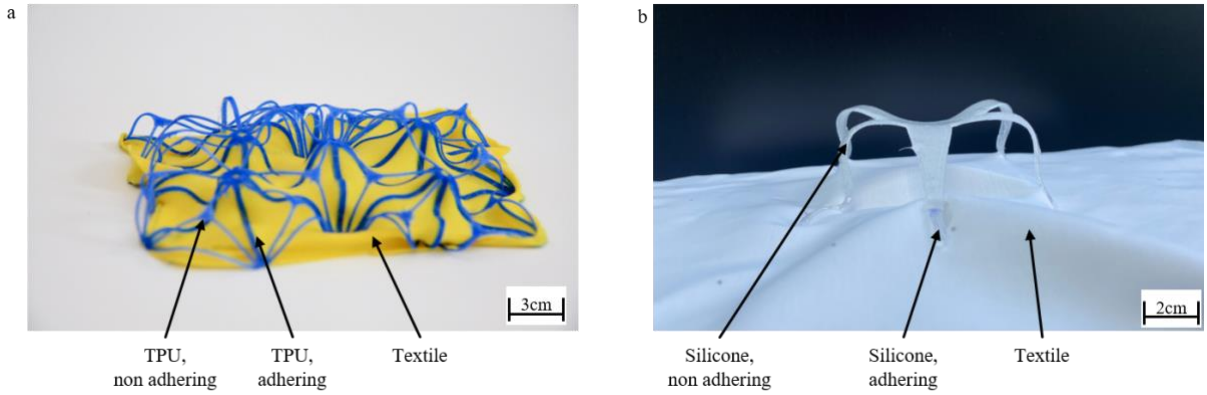

Figure 2: 4D Textiles with local adhesion a) made with TPU b) made with silicone

Description of the STSM main achievements and planned follow-up activities

The STSM has resulted in a comprehensive understanding of curved origami structures made by additive manufacturing on pre-stressed textiles. It will allow to design both pleasing and functional surfaces for the interior. Applying stress to the textile allows the structures to fully convert in either 2dimensional or 3dimensional surfaces. Instead of air diffusion light reflection has been studied. More than that, a new investigation area has been identified which is very promising: multi-layer structures with local adhesion between printed beams and prestressed textile. To the best of the collaborators knowledge this is very

new to the field and can contribute to flexible and adaptable surfaces with applications e.g., in light reflecting surfaces. The research is continued. The collaborators have agreed on regular exchange. Further 3D printing test are and will be performed at ITA Aachen University while simultaneously simulation will be performed by Marcelo Dias in Edinburgh. An abstract has been accepted and a presentation is planned at the 1. 4D Materials Design and Additive Manufacturing 2022 organized by the 4D printing society in September 2022. Building on the existing network of both collaborators an application for European funding is planned. Currently, an application for an ETN is planned. Further contributors might be the University of Aalto, Finland and the University of Potsdam, Germany. Furthermore, a visit of Marcelo Dias to Aachen is planned for the autumn this year for which we will apply for further funding.