4D PRINTING OF HYBRID MATERIALS WITH MATERIAL EXTRUSION METHOD

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Key Words: 4D printing, hybrid materials, plastics, metals, composites

4D printing is a process where 3D printed parts transform into another structure over the influence of external energy input. The external energy can be, e.g. temperature or light. Hybrid materials combine materials from different families, such as plastics, metals and composites. Combining 4D printing with hybrid materials makes manufacturing parts with exciting properties such as self-sensing and reacting to the environment possible. This study will look at preliminary results from such a combination from a manufacturing process perspective and discuss future outlook.

Materials in the study are commercially available polymer and 4D printing filaments, metal wires and composite rods. The device is a material extrusion based Anisoprint 4A continuous carbon fiber 3D printer. Various parameters were initially tested to be able to process the materials. Self-sensing part was a shape form consisting of polymer and continuous metal wire going back and forth. Self-sensibility was tested by bending the part measuring the change of the resistance. 4D printing material with a combination of continuous carbon fibres was activated by heat by placing the part in hot water for fast and more uniform heating. The 4D printing performance as a shape recovery was optically measured and calculated.
As a result, examples of self-sensing structures and 4D printed shape memory polymer with continuous carbon fibers could be produced and demonstrated (Figure 1)[1,2]. The self-sensing parts resistance has a direct response to the bending; however, the change is relatively small, so more accurate measuring is needed. 4D printing with continuous carbon fibers improves the shape recovery rate remarkably compared to pure 4D printing filament.

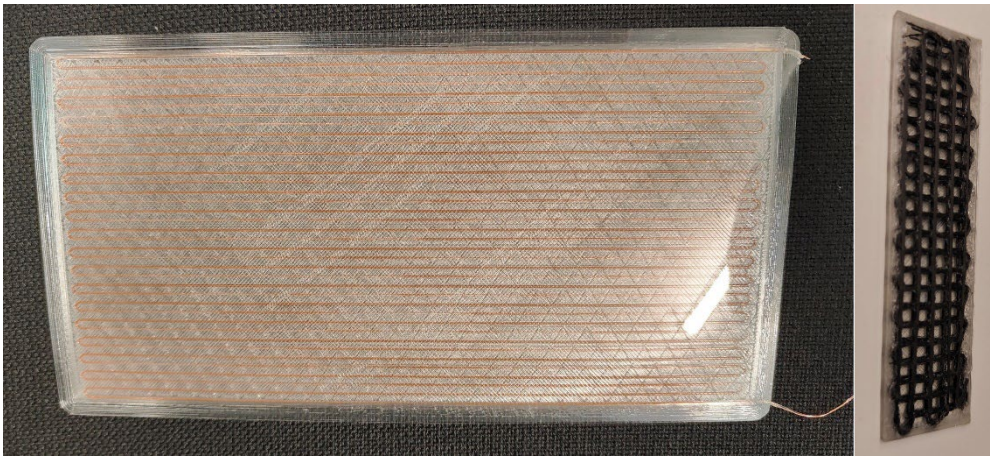

Figure 1 – Self-sensing structure on the left and 4D printed shape memory polymer with continuous carbon fiber on the right.

The future outlook would be to combine the self-sensing capability and 4D printing behaviour and to see what kind of performance it is possible to achieve with this material extrusion based method and from the combination of 4D printing filament and continuous metal wires.

References:
[1] S. Siddharth Kumar, Jan S. Akmal, Mika Salmi. 4D printing of shape memory polymer with continuous carbon fibre. Submitted to the journal.
[2] Jan Akmal, Mika Salmi. Additive manufacturing of self-sensing parts through material extrusion. Submitted to the journal.