Abstract

The use of additive manufacturing (AM) within the field of mechatronics creates exciting oportunities for the integration electronics with advanced mechanical devices. The modularity of 3D printing has historically been linked to rapid prototyping, where advances on both equipment and material fronts have made it accessible in non-industrial contexts.

After a screening of the technology and its evolution, two AM techniques are selected to address the research task of how electronics can be integrated within mechatronic prototyping by use of 3D printing. The two techniques, Vat Photopolymerization (VPP) and Fused Filament Fabrication (FFF), rely on resin hardening and thermoplastic extrusion, respectively. Subsequently, the processes and their associated materials are described, and the research task is validated by means of case studies. This methodology is consistent throughout the thesis, forwarding findings as a series of proofs-of-concept.

In the case of VPP, it has been shown that standard electronic components can be integrated within 3D printed substrates by means of polymer welding. Case studies describe applications within power transmission and human wearables, with emphasis on the deformation sensing of topology optimized structures and lattices. The inherent high resolution of VPP renders it well-suited for advanced prototyping stages and, correlated to advances in materials, even consumer products.

Regarding thermoplastic extrusion, we have addressed 3D printing the electrically conductive traces as circuitry for standard electronic components, free of wires or classic metal connectors. It is found that due to high contact resistivity, this method is energy inefficient. Case studies concern themselves with lowering the contact resistivity by means of applied pressure, and handle applications such as dynamic mechatronic products with an on-board power source, along with digital signal interfacing between sensors and microcontrollers.

The aforementioned proofs of concept not only serve to address the research task, but also constitute the foundation for future work, which can, as an example, rely on conformal FFF 3D printing in the mechatronic context, particularly if conductive filaments improve along with the potential integration of metal 3D printing for creating the circuit traces. The findings within VPP applications, coupled with 3D scanning, lend themselves towards the creation of custom, optimized wearables with integrated sensing in sports, professional and daily use.