Zoom link for Phd defence on 23 April at 11am:
https://syddanskuni.zoom.us/j/67094794007?pwd=T2lEV2VpbnU5QUNKWXNPT1ZjKzAydz09;

Abstract

The use of additive manufacturing (AM) within the field of mechatronics creates exciting opportunities for the integration of 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, the output 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.

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Resumé (Danish)

Brugen af additiv produktion (additive manufacturing – AM) indenfor arbejdsfel-tet mekatronik skaber spændende nye muligheder for integration af elektronik med avancerede mekaniske enheder. Modulariteten af 3D printning er tidligere blevet forbundet med hurtig prototypefremstilling, hvor fremskridt indenfor både udstyr og materialer har gjort det tilgængeligt i ikke-industrielle sammenhænge. Efter screening af teknologien og dens udvikling, er to AM-teknologier valgt for at håndtere den forskningsopgaven ”hvordan kan elektronik integreres ind i mekatron-isk prototypefremstilling ved hjælp af 3D-printning”. De to valgte teknologier, ”Vat Photopolymerisation (VPP)” og ”Fused Filament Fabrication (FFF)” anvender hen-holdsvis harpiks-hærdning og termoplastisk ekstrudering. Efterfølgende er disse to processor og deres tilhørende materialer beskrevet, og forskningen er valideret gen-nem casestudier. Denne metodik er konsekvent anvendt gennem denne afhandling, hvilket løbende præsentere resultaterne som en serie af proof-of-concepts.

For VPP, er det vist at elektronisk standard komponenter kan integreres i 3D printede substrater gennem polymer-svejsning. Casestudier beskriver applikationer indenfor effektransmission og ”wearables” , med fremhævning af deformations måling af topologi-optimerede strukturer og gitre. Den naturligt høje opløsning i VPP gør den specielt velegnet til avancerede prototype-stadier og, som følge af udviklingen i materialer, også til forbrugerprodukter.

Vedrørende termoplastisk ekstrudering, har vi adresseret 3D printning af de elektrisk ledende baner som kredsløb for elektroniske standardkomponenter, fri for ledninger eller traditionelle forbindelser i metal. Det er fundet, at grundet høj kontaktmod-stand er denne metode energi ineffektiv. Tilhørende casestudies beskæftiger sig med at mindske kontaktmodstanden ved at påføre tryk, og at håndtere applikationer så som dynamiske mekatroniske produkter med en indbygget strømkilde, og med interfaces af digitale signaler mellem sensorer og microcontrollere.

De førnævnte proof-of-concepts adressere ikke blot forskningsopgaven, men skaber også fundamentet for fremtidigt arbejde, som for eksempel kan indebære konform FFF printning indenfor en mekatronisk kontekst, specielt hvis de strømledende materialer forbedres, eller hvis integrationen af metal 3D-print anvendes til at skabe kredsløbsbanerne. Resultaterne indenfor VPP applikationer, sammen med 3D-scanning, kan anvendes til fremstillingen af individualiserede, optimered ”wearables” med integreted måling, til anvendelse indenfor sport, professionel og dagligdags brug.