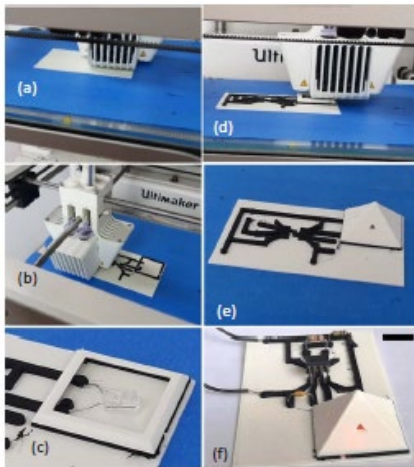


## Abstract

Fused filament fabrication (FFF) is a cheap and widely used 3D printing technology, but the conductive thermoplastic filaments used to print electronics in FFF have very high resistivity compared with other technologies. In our work, we have developed a novel technique to use a flash of high energy white light from a PulseForge system to ablate away thermoplastic from the surface of conductive filaments to leave behind a metal rich, highly conductive surface layer. Using this approach, we have demonstrated an increase in conductivity by up to two orders of magnitude. Building on this technique, we have also shown that this flash ablation metallization technique can be used to accelerate electroless plating of metals onto 3D printed parts without reducing adhesion.

## Printing Electronics with FFF

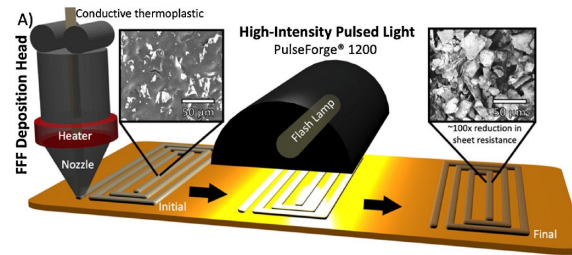
- FFF – layers of melted thermoplastic used to build complex parts
- Printing conductors possible using conductive thermoplastics (composite filaments based on embedded metal or carbon particulate)
- Conductivity poor (~4+ orders of magnitude lower) than bulk metals and silver inks
- Best suited for sensors or other low power/current applications



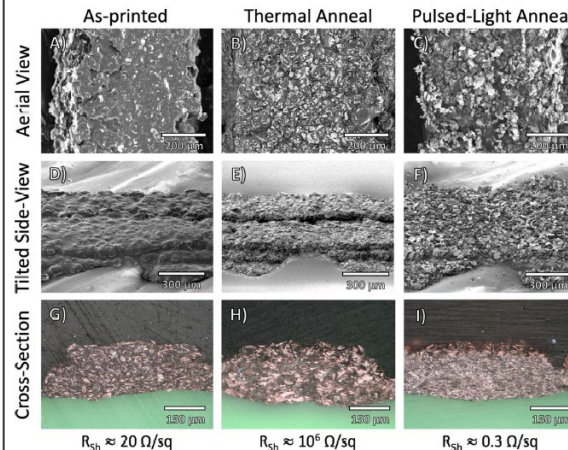
N. Lazarus et al., Smart Mater. Struct. 2020

## Flash Ablation Metallization (FAM)

- High energy pulse of white light used to ablate away surface of conductive FDM filament to leave behind a thin, metal rich layer
- Relies on photonic sintering system (PulseForge) widely used for sintering silver inks
- Demonstrated both to obtain higher conductivity, as well as to accelerate electroless plating process



- Copper loaded commercially available filament (Electrifi, Multi3D LLC.) used to demonstrate technology
- Heating alone results in dramatic increase in resistance
- Flash ablation results in two orders of magnitude reduction in resistance

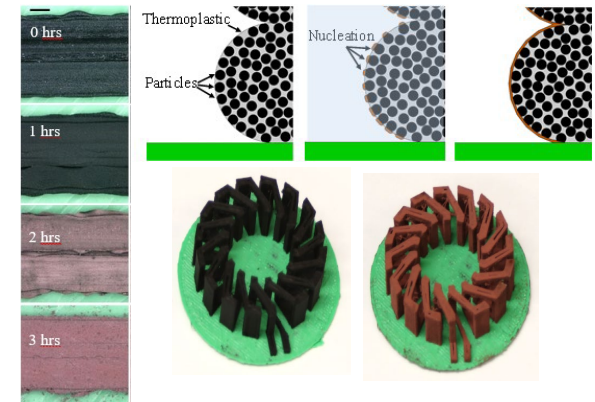


J. Cardenas, N. Lazarus et al., Addit. Manuf., 2020

## Electroless Plating

- Surface reaction with plating bath used to drive metallization process
- Nucleation from conductive particulate such as metal particles or carbon black
- Capable of plating numerous independent conductors simultaneously, including deep within 3D printed structure

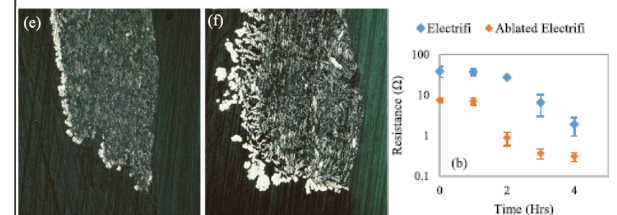
### Selective Electroless Plating in FDM



- Relatively slow process (takes extended period to expose particles for plating)
- Flash ablation metallization demonstrated to accelerate the process
- Exposed metal particulate allows rapid initiation of electroless plating and shorter processing time

## After Electroless Plating

Electrifi      Ablated Electrifi



N. Lazarus et al., Addit. Manuf. 2022