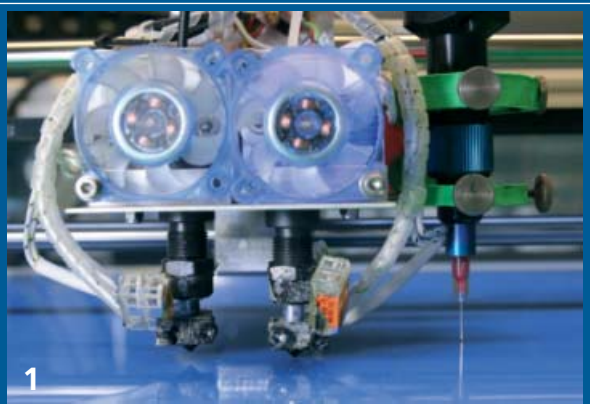


1

3D PRINTING OF POLYMERS WITH INTEGRATED ELECTRONICS AND SENSORS

THE TASK

Additive manufacturing provides a freedom of design and styling like nothing before. Component geometry can be modified for function, which was impossible before in terms of material use and efficiency. A wider variety of materials and technologies adds value to parts made by additive manufacturing. The additional integration of functionalities, such as integrated sensors or printed electronic components, can expand the functional range and add value to the components.

Many electronic functionalities can be manufactured using printing technologies. These include, for instance, sensors in the form of RFID antennae or other sensors for strain, temperature or pressure measurement. Printed sensors for chemical-physical analysis, detection of humidity, radiation or special chemical components are the state of the art.

Combining techniques from classical additive manufacturing with printing technologies, such as dispenser printing or aerosol printing, is a popular and economical way to produce complex multifunctional components in one step.

OUR SOLUTION

The combination of fused filament fabrication (FFF) and dispenser-printing (see information box) makes it possible to equip the components as they are being processed with additional functions during structure building. Mainly thermoplastic structural materials are FFF-printed, whereas the electronic materials can be dispenser-printed. To implement the combination of techniques, an open source FFF printer was equipped with an additional dispenser printing head. Because of the layer-by-layer part building in additive manufacturing with the FFF printer, functional pastes can be applied in each component plane.

The dispenser-printed structures can be quickly and efficiently dried and sintered by means of the plasma technique at atmospheric pressure or with radiant heaters. Functions can be added by dispenser printing on the surface of components made by the FFF technique, on the one hand. On the other hand, the structures can also be completely integrated in the component. This technology can also be combined with other additive manufacturing techniques.

Conductors printed on uneven FFF surface

2

3

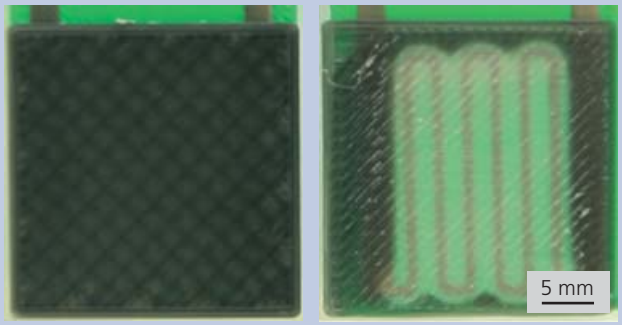
RESULTS

To demonstrate the combination of these techniques, heating structures made of silver paste were integrated into an FFF-printed ABS component by dispenser printing. These heating structures can be used to heat near-surface regions in various systems. Figure 4 shows the working principle with a thermochromatic filament that is black at room temperature and white to transparent at temperatures above 40 °C.

Printed conductors can also be directly applied to sculptured or uneven component surfaces (Fig. 2) to implement near-surface functions in components.

Even more complex functionalities, such as interdigital electrodes for chemical measurements, can be placed at a desired point on a component. Figure 3 shows an interdigital electrode configuration used in Li-ion cells. The electrodes are made of lithium iron phosphate and lithium titanate.

FFF component with integrated heating elements



4

The Fraunhofer IWS has developed pastes for the specific electronic functionalities and integrated them into additively manufactured components as well.

Infobox: Fused Filament Fabrication (FFF) and dispenser printing

Fused Filament Fabrication (FFF)

A fused plastic filament is printed layer by layer to build up the structure in 3 dimensions. Filaments are typically thermoplastics, but can also be made as composites, filled with metallic particles, natural fibers, glass fibers, etc.

Dispenser printing

A viscous paste or ink is printed. The paste is dispensed as a line in an x,y,z axis motion with a needle dispenser or drop by drop (jet dispenser) to the desired point. The paste ingredients are metals, ceramics, plastics or nanoparticles.

1 FFF printer with integrated dispenser unit
3 Printed interdigital electrode for Li batteries (dispenser printing)

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