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Low cost 3D printing of electrically conductive porous media for gas diffusion layers

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The functionality of many electrochemical devices such as fuel cells, electrolysers or batteries rely on an electrically conductive porous media. Specifically, in Polymer Electrolyte Membrane (PEM) fuel cells, the gas diffusion layer (GDL) is used to distribute the gases, conduct the electrons and transport the generated water from the reaction sites to the flow fields in the bipolar plates [1]. Due to these requirements, the most common material for GDLs is a carbon paper which is partially covered with polytetrafluoroethylene [2]. Mathematically, carbon paper is a heterogeneous media composed of randomly distributed carbon fibres, defined by its average transport properties, such as porosity, permeability, and conductivity. These properties strongly depend on the manufacturing process and can differ significantly throughout the media . Using carbon paper as GDL material, it is difficult to the optimize the PEM fuel cell over a wide range of operation conditions, i.e. output power and relative humidity of the gases. Numerical simulations show that tailored porous media, i.e. with locally different properties, can improve fuel cell performance [3,4]. However, due to the trade-offs between performance, manufacturability, and cost, designing a commercial GDL is a highly challenging task.

Here, we present an approach to generate electrically conductive porous media based on additive manufacturing with a low cost Fused Deposition Modeling (FDM) printer. FDM is an additive manufacturing method consisting of the extrusion of material trough a nozzle, which is deposited in successive layers to create a 3D object. Usually, the materials used with FDM printers are polymers-based filaments. The polymer is chosen according to the requirements of the printed part, e.g. Acrylonitrile Butadiene Styrene is used due to its relatively high melting point, or Polylactid (PLA) as a low-cost bioplastic. Moreover, some filaments available on the market are composite materials, which can improve the mechanical properties of a printing part or are electrically conductive. Therefore, using FDM to design and optimize GDL is very accessible due to the simplicity and speed of the process in addition to the low cost of the material.
In this study, we used an electrically conductive PLA from Protopasta (Vancouver, Canada), and a standard FDM printer (Ultimaker 2+). The aim of this study was to print thin, porous media with heights up to 150 microns and pore diameters of about 100 microns. This was challenging since the diameter of the nozzle head is about 250 microns. Nevertheless, in this study we have shown that it is possible to print structures with sizes down to 100 microns by using specific infill pattern parameters,. Moreover, the infill pattern can be modified to obtain either regular patterns (left figure), or random heterogeneous structures (right figure). The electrical conductivity of these 3D printed porous media is highly dependant on its structure. We measured values between 0.6 and 0.8 [5]. In conclusion, the 3D printed parts from the electrically conductive PLA can be used for the rapid prototyping of novel GDL structures.

Participation

In-Person

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