Thermo-electro-mechanical characterisation of 3D printed multifunctional materials

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3D printing has become a widespread technology to design complex geometries [1]. There are numerous methods that allow to implement the 3D printing process [2]. Among them Fused Deposition Modelling (FDM) is a common technique using filaments made by different materials such as thermoplastic, metal, wood or composite [3]. The emergence of conductive filaments made of carbon particles reinforced thermoplastic allows to print integrated electrical circuits on 3D parts. Some studies have been done on the electrical properties of conductive filament [4] including self-heating [5], however the electrical properties once the glass transition temperature (Tg) is overtaken by Joule's heating have not been studied.

In this project the influence of the printing parameters (e.g. layer height, printing direction, nozzle diameter) on the mechanical and electrical properties of carbon particles reinforced PLA has been studied. A ductile mechanical behaviour has been exhibited in the thinner layer height sample while the bigger layer heights showed a brittle fracture. The degree of crystallinity of printed samples has been measured by DSC to explain the difference in fracture behaviour between the samples printed with different layer heights. A thermodynamic simulation has been carried out to find the temperature profile and to determine the cooling rate of the deposed filaments. The results illustrate that the thinner layer height cools faster after extrusion and do not reheat significantly the previous deposed layer. Difference in electrical properties have also been shown according to the printing direction and heating method. A more reliable electrical behaviour is revealed in the 0°printing direction sample than in 90° sample and a bigger increase of resistance when heated by oven is observed.

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