FOCUS ON SOME PECULIAR BEHAVIORS OF POLYMERS IN THE CONTEXT OF ADDITIVE MANUFACTURING PROCESSES

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Rather than 'Additive manufacturing', the key word in our laboratory (Polymer Materials Engineering) is 'Polymer materials'. The particularity is to cover all aspects of polymer materials science from fundamental chemistry and physics to processing and properties. Within the framework of Additive Manufacturing, our approach is to distinguish the stages in various processes where the particular behavior of polymer materials is incriminated and to study or tune this behavior. In this communication, two examples will be shown; the first one concerning the rheological behavior of silicone for Liquid Deposition Modeling (LDM) and the other one concerning the solidification stage of polypropylene for Laser Powder Bed Fusion (LPBF).

LDM of silicone (mostly Polydimethyl siloxane, PDMS) can be a solution to make some soft elastomeric parts of very low rigidity, for example, to mimic soft human tissues of which the Young's modulus is included in the range of 10 kPa to 10 MPa. Under 100 kPa, are very soft tissues as prostate, skin, liver. LDM for such soft materials is not as obvious as 3D printing of classical polymers (PLA, ABS, photo resins …) because the initial liquid silicone is of very low viscosity without any hold, which makes it impossible to build a 3D object. In this presentation, we will show how the PDMS formulation can be improved to keep a low viscosity, allowing the extrusion of a thin filament, while providing a yield stress flow behavior to the material for maintaining the shape of the layer by layer made object (see *Figure 1*). The idea is to blend a RTV 2 silicone formulation with a hydrophilic liquid or a hydrogel to make an emulsion of a sufficient yield stress threshold. The removing of the dispersed phase after curing can even lead to a softer material compared to the original RTV2 silicone.

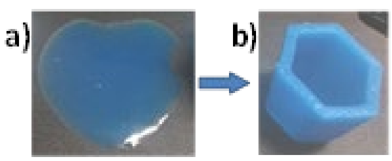

Figure 1 – a) As-received PDMS, b) Part printed with PDMS / Poloxamer suspension.

The second example concerns LPBF with polypropylene (PP) that is still more seldom than polyamide (PA12). In-depth understanding of the melting and coalescence behavior as well as of the crystallization is a key aspect to control parts microstructure and properties. In the present work, the aim is to account for self-nucleation effect in the crystallization step during the building stage. More specifically, the crystallization kinetics of a propylene-ethylene random copolymer has been studied by DSC. Sintered parts microstructure was investigated via polarized light optical microscopy (POM), scanning electron microscopy (SEM) and wide-angle X-rays diffraction (WAXD) experiments. This brought to light the importance of considering the significant nucleating effect on the solidification stage. Indeed, crystallization from a self-nucleation molten state revealed to be a condition for half-crystallization times to be consistent with experimental observations. The presence of these germs leads to alternate patterns of very fine microstructured, oriented transcrystalline and isotropic spherulitic regions in every layer (see Figure 2).

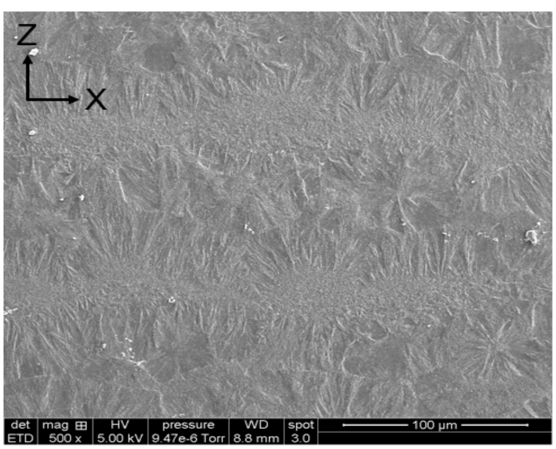

Figure 2 –SEM picture of a part cross-section prepared by chemical etching.