Optical evaluation of polymer deposition for 3D printing

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3D printing is a technology that is revolutionizing the productive sector [1]. It allows the production of free-form components and systems. It may find application from biomedical to aerospace engineering, as well as in the production of unique and specific components needed in basic science laboratories. One of the most common approaches for 3D printing is the fused deposition modeling were a plastic filament is fused and the component shape is modeled by layers deposition [2]. The success in the manufacture of the component is related to the addition between successive deposited layers. Increasing the temperature of the filament to ensure perfect adhesion may compromise the desired shape and function characteristics for the component. Scanning Electronic Microscopy (SEM) is the gold standard technique to ensure the ideal condition for the 3D printing and evaluate the bonding between successive layers [2]. However, in this context, SEM is a destructive technique and do not allow real time application. Low Coherence Interferometry (LCI) is an optical technique capable to performing non-destructive tomography evaluation of scatter medium [3]. Using a Michelson interferometer to measure the backscattered light intensity as a function of depth position associated to a lateral scanning it is possible to obtain a cross-section image of the sample [3]. It is non-invasive, relatively inexpensive technique and could allow real time application during manufacturing. The aim of this work was to investigate the use of low coherence interferometry to evaluate the adhesion of successive layers on 3D printed plastic material. A set of samples were manufactured using a 3D printing (Cliever CL1, Brazil), with layer thickness from $100 - 250\mu m$ using PLA filament. The sample were evaluated using a SEM and a commercial LCI (OCP930SR - Thorlabs Inc.) and the images were compared. It was possible to observe a correlation on the observed fused filaments between the images acquired by SEM and LCI proving that it is possible to use the optical technique as a alternative for 3D printing quality evaluation.

References: [1] Barry Berman, 3-D printing: The new industrial revolution, Business Horizons, Volume 55, Issue 2, March-April 2012, Pages 155-162 [2] Y. Song, Y.Li, W.Song, K. Yee, K.-Y. Lee, V. L. Tagarielli, Measurements of the mechanical response of unidirectional 3D-printed PLA, Materials & Design, Volume 123, 5 June 2017, Pages 154-164 [3] C. Pernechele, D. Fantinel, D. Magrin, L. Lessio and G. Rodeghiero, "Low coherence interferometry-based meter-distance range finder," 2017 IEEE International Workshop on Metrology for AeroSpace (MetroAeroSpace), Padua, 2017, pp. 126-130.