Specular Transmittance of 3D printed plastic at different thickness

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1 Introduction

This report examines the specular light transmittance through 3D printed plastic walls at various thicknesses. If a 3D printed enclosure is conceived with the intention of isolating the interior from light for example, it is important the transmittance be low. The 3D printing process can leave small holes in each layer as the plastic is laid down, so it is important to gauge at what thickness of printed plastic printed these voids become porous to light.

2 Manufacture

The sheets of plastic tested were manufactured using fused deposition modelling. This process involves using a material stock in a filament to be extruded through a heated nozzle and laid down in layers until the model has been created. The plastic used was acrylonitrile styrene acrylate (ASA), which is a UV stable version of the popular acrylonitrile butadiene styrene (ABS).

The printing process lays down the material following a pattern constructed via the software. Due to warping and cracking factors this type of printing doesn't allow for completely solid printing. Therefore there will always be voids of some kind in the tool path the machine uses

The thickness and measured density of the sheets are tabulated below in Table 1.

Sheet Index	Dimensions(mm)	Density (gcm^{-3})
1	$25 \times 25 \times 0.39$	0.62
2	$25 \times 25 \times 0.58$	0.62
3	$25 \times 25 \times 1.11$	0.65
4	$25 \times 25 \times 2.18$	0.65

Table 1: Dimensions and measured densities of the plastic sheets. The solid density of ASA plastic is between 1-1.2 gcm^{-3}, so the measured density represents 50-60% of the solid density

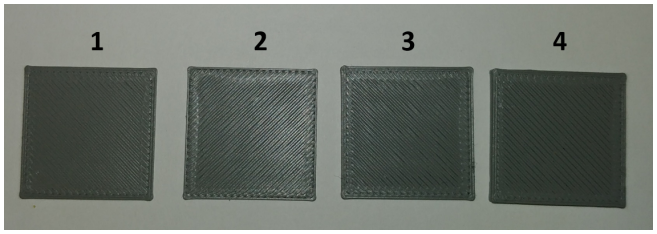

Figure 1: Photograph of the sample Plastic sheets used in the testing. The lines of fibre are visible to the eye

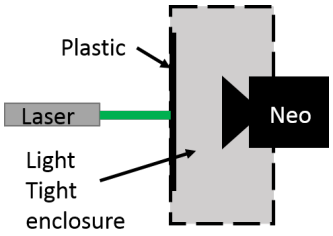

Figure 2: Schematic of setup. A Laser illuminated the plastic sheets, its image captured by an ANDOR Neo camera. A 22 mm Lense at f/0.95 was used, with the sample places to take up most of the image. Black anodised aluminium was used to light tight the set-up, as shown

3 Method

A schematic of the set-up is shown in Figure 2. A Laser (0.9 mW, 520 nm) was shone onto the 3D printed plastic sheets. An image of the sheets was taken from the other side, using an Andor Neo camera. Reference images were collected with the laser turned off. The specular light transmitted was found by taking the integrated counts above background across the section of the image in which the sheet was present. The total incident light was found by doing the same to an image of the Laser light shone directly into the camera. Different exposure times needed to be used for each reading to avoid saturation, but this was accounted for during analysis. The transmittance was expressed as the percentage of the incident Laser light that got through the sheets.

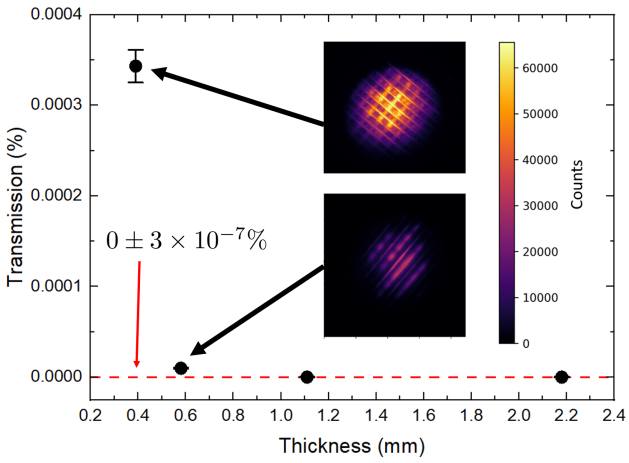

Figure 3: Graph showing Transmission of Laser light through the plastic sheets at different thicknesses. An image captured for the two non zero transmissions are also shown. Past 1.1 mm, the transmittance is below the detectable background (measured with an Andor Neo, which with the lens used had a noise floor of $3 \times 10^{-7}\%$). The top colour map was taken with a 0.3 s exposure, while the lower one with 6 s

4 Results

From the thicknesses tested, as seen in Figure 3, 1.1 mm was the cut-off point where no light was detected to be transmitted.

The images acquired at approximately 0.3 and 0.85 mm show that light enters through filament like voids,diffracting through the voids between the criss-cross of fibres that are laid down in the 3D printing process. It can be seen that the transmittance drops rapidly between 0.3 and 0.85mm, with the image going from a clear spot to a mostly extinguished blur, with some light diffracting through the voids. At thicknesses above 1.1mm, the amount of light was lower than the read noise floor of the Andor Neo used. This is quantified by the standard deviation per pixel, and has a minimum detectable transmittance of $3 \times 10^{-7}\%$). This is judged to be low enough to be taken as 0.

5 Conclusion

It can be concluded that while the voids in the structure of the 3D printed plastic do allow light to diffract through, a thickness of greater than 1.1 mm will ensure the 3D printed wall is light tight.