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Terahertz Characteristaion of 3D Printed Plastics

Spectra of 3D printed plastics are presented. The recent surges forward in 3D printing technology has seen its application to a wide variety of fields from healthcare to art. Typically users are interested in the mechanical properties and uses of 3D printed objects however we explore the potential of optical properties and uses. In this work 20 commercially available plastics have been characterised. These include five Nylon samples, three PET based samples, two polycarbonate samples, two metallised plastics, polystyrene, polypropylene and six other common commercial 3D printing plastics.

The samples were created with a commercial 3D printer (Makerbot Replicator 2X). Samples have been analysed by Time Domain Spectroscopy (TDS) and Fourier Transform Spectroscopy (FTS). The combination of equipment used allowed us to observe the transmission of each plastic from 0.2 to 180THz. This region typically referred to as terahertz (THz) is of particular interest to us. THz has many applications including non-destructive material characterisation, product monitoring in industry and security imaging [1]. Some characterisation of 3D printed plastics has been undertaken and shows room for exploration in the area [2].

3D printing allows a laboratory to have a method to very quickly and cheaply fabricate optics for various uses. Previously it has been demonstrated that 3D printed plastics are suitable for use when creating aspherical THz lenses and diffraction gratings [3]. Other applications in the THz region that hold great potential include waveguides and polarisers, which rely on the reflectivity of the materials used.

Many plastics present a usable transmission window in the 0.2-1THz range. In particular, the nylon based samples and polyethylene based samples displayed very consistent spectra across manufacturers, despite the various additions made to facilitate printing. Polypropylene was very transmissive however very difficult to print with. The polycarbonate samples were found not only to be the best to print with, but also had a consistently low absorption coefficient, less than 10cm^-1. We observe good agreement when comparing overlapping regions of spectra obtained from different equipment.

As expected, most plastics displayed a very low (<1%) transmission through the 2-20THz range. Noteworthy are the conductive plastics, which have an extremely low transmission; however, they may present a viable alternative to metal plating 3D printed optics in order to obtain usable reflectivities. Reflection data is also presented for this range. We aim to understand the physical properties of these materials and further explore the practical capabilities. 3D printing of THz optics is certainly viable and will continue to become more so as 3D printing technology continues to advance.

[1] R. A. Lewis, Terahertz Physics, Cambridge: Cambridge University Press, 2012.

[2] Busch, S. F., Weidenbach, et al.(2014). Optical Properties of 3D Printable Plastics in the THz Regime and their Application for 3D Printed THz Optics. Journal of Infrared, Millimeter, and Terahertz Waves, 35 (12), 993-997.

[3] Squires, A. D., Constable, E. & Lewis, R. A. (2015). 3D printed terahertz diffraction gratings and lenses. Journal of Infrared, Millimeter, and Terahertz Waves, 36 (1), 72-80.

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