

### 3d printing of graphene-polymer composites

N. Decorde<sup>a</sup>, R.C.T. Howe<sup>a</sup>, F. Tomarchio<sup>a</sup>, C. Paukner<sup>b</sup>, J. Joaug<sup>b</sup>, K. Koziol<sup>b</sup>, T. Hasan<sup>a</sup>, A.C. Ferrari<sup>a</sup>, F. Torrisi<sup>a</sup>

<sup>a</sup> Cambridge Graphene Centre, University of Cambridge, Cambridge CB3 0FA, UK

<sup>b</sup> Cambridge Nanosystems, Cambridge CB5 8HY, UK

[nbd23@cam.ac.uk](mailto:nbd23@cam.ac.uk)

3d printing is a rapidly growing field. It consists in the deterministic layer-by-layer printing of 3d objects of almost any shape, from a Computer Aided Design source file. Its versatility [1], the limited number of process steps [1] and reproducibility [2], make 3d printing one of the most promising techniques for rapid design and prototyping. Fused Modeling Deposition (FMD) (*i.e.* layer-by-layer deposition of melted and extruded polymer through a nozzle [3]) is the most popular 3d printing technique thus far, because of its simplicity and the use of common thermoplastic polymers, such as Poly Lactic Acid (PLA) [4], Acrylonitrile Butadiene Styrene (ABS) [4], Polycarbonate (PC) [4], *etc.* However, polymer composites with Young's Modulus higher than few GPa [5] or electrical conductivity higher than few S/m [6], or with a combination of both properties are still not available.

Graphene's electrical, thermal, optical and mechanical properties can be used to create composites with higher electrical and mechanical properties than the starting materials [7]. Here, we demonstrate 3d printing of a graphene-polymer filament by FMD. Graphene powder produced from methane plasma cracking (Fig1.a) is blended with PLA using two different routes: wet mixing in chloroform and dry mixing at 250°C. The composite is then extruded at 160°C into a solid filament (Fig1.c) and 3d printed by FMD. Figs.1d,e show pure polymer and graphene composite 3d-printed objects. The electrical and mechanical properties of the 3d printed structures are investigated by conductivity and tensile strength measurements. Ink-jet printing of graphene, as first reported in Ref. [8], is now an ever growing field, with increasing industrial interest, now including a variety of other 2d materials. We believe our demonstration of 3d printing of graphene will also stimulate a new field, soon to include a variety of other layered materials.

#### References

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#### Figures



Figure 1: (a) Graphene Powder, (b) PLA pellets (c) Filament of PLA (White) and Graphene-PLA (Black), (d) Printed structure with pure PLA and (e) graphene-PLA composite.