University of BRISTOL
Bristol Composites Institute (ACCIS)
ADVANCED COMPOSITES COLLABORATION FOR INNOVATION & SCIENCE

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Final report: Laser modified fibres

Unduloid-reinforcing carbon fibres were produced using controlled laser irradiation which resulted in expanded and ablated regions along the fibre axis, Figure 1 [1, 2, 3]. These modulated carbon fibres were created at predetermined regions, and their diameters were locally increased up to 53%, forming outward taper angles of up to 1.8° and tested mechanically demonstrating that the majority of the single fibre stiffness, in tension, was maintained. When modified single carbon fibres were embedded into a compliant matrix and pulled-out, extensive ploughing from the taper ends contributed to a ~7-fold increase in work of pull-out compared to the as-received carbon fibres (Figure 2).

Subsequently, fibres could be laser modified multiple times along the fibre axis and be used to increase the strain-to-failure of composites. Expanded fibre regions would break, and the tapered ends which are formed would then mechanically interlock with the matrix and resist fibre pull-out. High powered laser treatment is a promising route to generate tapered carbon fibres, translating a key geometric feature of natural composites to the current state-of-the-art structural materials.

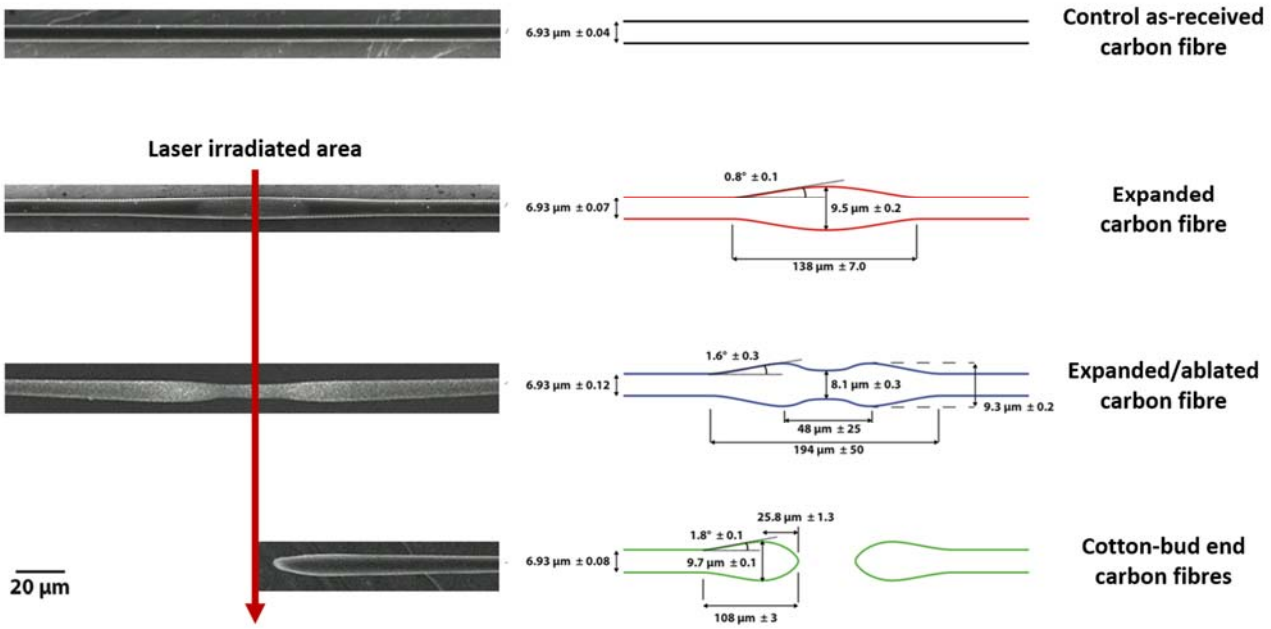

Figure 1. Laser irradiated carbon fibres and the various shapes produced.

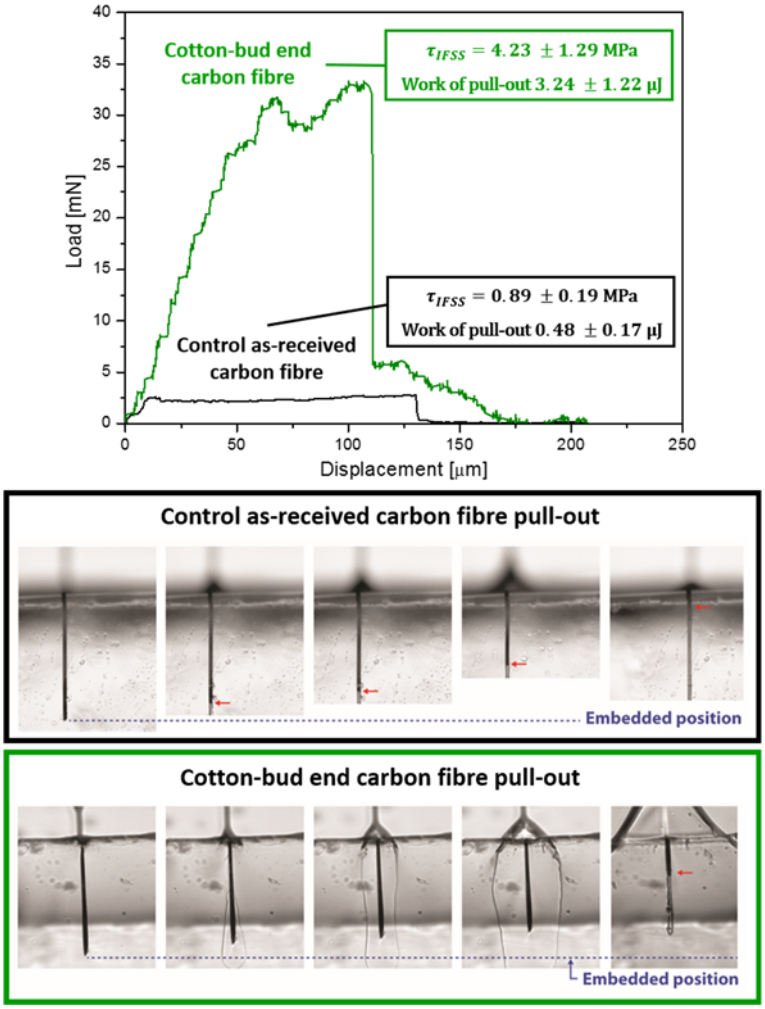

Figure 2. Modified single fibre pull-out tests from a compliant matrix.

References

[1] Blaker J J, Anthony D B, Tang G, Shamsuddin S-R, Kalinka G, Weinrich M, Abdolvand A, Shaffer M SP, Bismarck A, 2016, Property and Shape Modulation of Carbon Fibers Using Lasers, *ACS Applied Materials and Interfaces*, **8** (25), pp 16351–16358. DOI: 10.1021/acsami.6b05228

[2] Blaker J J, Anthony D B, Tang G, Shamsuddin S-R, Abdolvand A, Shaffer M SP, Bismarck A, 2015, Carbon fibres with modulated properties and shape along the fibre length, *20th International Conference on Composite Materials (ICCM20)*, Copenhagen, Denmark, Paper ID: 5210-2

[3] Bismarck A, Blaker J J, Anthony D B, Qian H, Maples H A, Robinson P, Shaffer M SP, Greenhalgh ES, 2016, Development of novel composites through fibre and interface/interphase modification, *37th Risø International Symposium on Materials Science IOP Publishing, IOP Conf. Series: Materials Science and Engineering* **139** 012001. DOI: 10.1088/1757-899x/139/1/012001