

# Curriculum Vitae

## Personal Details

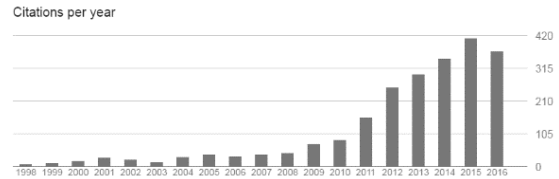
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Date of Birth: 4th May 1966 (50 Years)



*A widely respected academic who has over twenty nine years experience in initiating, developing, conducting and managing research whilst teaching over a wide range of aspects of fibre reinforced polymers and administrating a Masters course in Composites. He is a Professor in Composite Materials at The Composite Centre and Aeronautics Department at Imperial College London, with a PhD in damage growth in composite materials. He has a H-index of 24 ([Google Scholar](#)), having published 55 papers (2360 citations), three textbook books and four patents. His two areas of particular expertise are in fractographic analysis of polymer composites and development of multifunctional (structural power) materials.*

## **Career Summary**

Aug 2016	Professor of Composite Materials
Oct 2014	Director of the Composites MSc (Aeronautics)
Oct 2009	Awarded FIMMM
Oct 2009	Reader in Composite Materials
Oct 2006	Senior Lecturer in Composite Materials
Feb 2003 – Present:	Composites Centre, Aeronautics, Imperial College London
Oct 2001	Awarded CEng and MIMMM
Oct 1987 – Feb 2003:	RAE, Farnborough (Composite Structures Section) DERA as from April 1992 Structural Materials Centre, DERA as from April 1996 Future Systems Technology, QinetiQ as from July 2001

## **Research**

Prof Greenhalgh currently manages seven PhDs and four Post-Docs. He has had sixteen PhDs who have successfully completed their studies and has previously managed ten Post-Docs.

**Failure Analysis and Accident Investigation:** Prof Greenhalgh is an internationally recognised expert in failure analysis of polymer composites, and one of only a handful in the world. He has over twenty-nine years experience in failure analysis and fractography of composites, ranging from studies into micro-mechanisms in coupons, investigation of failures in structural components, through to post-mortem investigations, both in-service and from industry. This includes acting as an expert witness in litigation cases and undertaking accident investigations on both vehicles and components (aerospace and non-aerospace). In particular, he had involvement in the NASA investigation into the American Airlines A300 crash in New York (06/2002), cracking in interior panels for commuter trains (2000) and as a consultant on the Senna Formula One crash investigation (2002). Recent Expert Witness work has included CFRP bike fork failures, GF thermohalters and a US helicopter (EC135T1) accident. Prof Greenhalgh has been responsible for setting-up and maintaining a failure analysis facility at Imperial College London. He is highly competent in optical and scanning electron microscopy, and is familiar with a range of physical analysis and microscopy techniques. In 1990 he initiated a European working group on composites fractography (GARTEUR). In 2009 he was the sole author of the only textbook (Woodhead Publishing Limited, ISBN 1845692179) on composites fractography, which has sold over 1000 copies worldwide. He has been invited to give a number of presentations and keynote lectures on this topic, including an award winning article in Materials World (IOM3). Over the last ten years Prof Greenhalgh has given a training module on fractography as part of the Composites MSc at Imperial College London. In addition, he has given courses on polymer composite fractography at NASA Langley (US), Air Accident Investigation Branch (UK) and Rolls-Royce (UK), as well as giving bespoke fractographic training to researchers from the Brazilian Airforce (Brazil) and FFA (Sweden). Finally, Prof Greenhalgh has provided an independent assessment and audit of the Rolls Royce composites fractographic capability.

**Material Property and Toughness Testing:** Prof Greenhalgh has considerable experience in basic material tests, such as tension, compression, ILSS, flexure, etc. on a range of composite materials for aerospace, automotive and marine components. He has been involved in international groups such as ESIS and ASTM in test

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standard development. In particular, he has extensive knowledge of pure and mixed-mode methods (ENF, DCB and MMB), and delamination failure criteria for composite materials such as unidirectional, multidirectional, woven and sandwich configurations. More recently, he has led development of a novel mixed-mode II/III test method under industrial funding.

**Delamination, Impact Damage and Energy Absorption:** Prof Greenhalgh is an expert in understanding, characterising and defining modelling methodologies for delamination growth in composites. This has entailed planning, testing, analysis and reporting of coupon and structural tests (plain and stringer-stiffened panels) on specimens containing delaminations. He has experience in low and medium velocity impact testing on components such as CAI coupons, sandwich panels, skin-stringer panels and wingbox structures. He has extensive knowledge of impact damage mechanisms and processes in both coupons and structures. In addition, he has experience with high-speed impact, blast, ballistic and hydraulic shock type failures. He has extensive knowledge of impact threats and design requirements for damage tolerant structures; in particular issues relevant to certification of aircraft structures, but this expertise has been extended to other platforms, such as damage tolerant design of naval components. He has particular knowledge on the mechanisms and modelling of runway debris and the subsequent impact on structures, which was chosen as an impact case for the 2013 REF assessment at Imperial College London. Finally, he has experience of energy absorbing structures for Formula One, both through testing and failure analysis, which ultimately led to improved designs.

**Environmental and Fatigue Testing:** Prof Greenhalgh has led planning, conditioning, testing, analysis and reporting of tests under environmental sequencing and fatigue testing. This has entailed testing of notched coupons, both dry and containing moisture, under cyclic loading whilst sequencing temperature. He has undertaken analysis to glean a detailed understanding of the damage mechanisms around the notches and bearing failures through the use of X-radiography and fractography. He has also studied delamination growth (coupons and structures) under cyclic loading. Finally, recently he has led the Imperial College contribution to a joint government/industrially funded project (CTi) into time/temperature/moisture characterisation and modelling of highly toughened aerospace composites.

**Structural Testing:** Prof Greenhalgh has extensive experience in mechanical testing of composite structures such as I-beams, sandwich panels, skin/spar joints, stringer-stiffened panels and wingbox structures under monotonic and cyclic loading. This has entailed planning, rig design, instrumentation, testing, inspection (NDI), analysis and reporting. He also has considerable experience in interpretation of strain gauge and other instrumentation techniques such as Moiré interferometry, Digital Image Correlation and Acoustic Emission. His research includes characterising skin/stringer joint strength, damage in marine sandwich structures, and assessing different advanced concepts such as Z-pinning for improving structural performance. He led a £1.2M grant (EPSRC/dstl) into a four year programme on crack arrest and self-healing of composite structures (CRASHCOMPS). This was aimed at developing structural (such as geometric features) and materials (such as active materials) for arresting rapidly growing cracks in stiffened composite structures, and then self-healing the crack and the associated damage.

**International Programmes:** Prof Greenhalgh has considerable experience in European and UK Working groups on damage growth and fractographic analysis of composite structures. He has a wide network of contacts throughout most of the major aerospace industries and research organisations in Europe, particularly in Sweden, Spain and Holland, as well as contacts within other industries such as marine and Formula One. He has initiated a number of CEC funded programmes. He was Task Leader (Structural Testing) for a 7M€ programme (EDAVCOS), as well as involved in earlier programmes (e.g. DAMTOS, ADCOMP, ADSTREFF). He was Programme Coordinator for a 6.5M€ programme (FALCOM) on non-crimp fabric composites involving twenty partners from nine countries. He led inception, setting-up and management of a trinational programme (DAMOCLES) on impact in composite structures between institutes in the UK (QINETIQ), Holland (NLR) and Sweden (FOI). He led a £600K (MoD) programme on structural power materials for military aircraft and led a €2.7M FP7 programme (€900K for Imperial College) on structural power materials for hybrid cars (STORAGE). He currently leads a €1.6M Clean Sky 2 (SORCERER), £1.1M EPSRC and \$1.3M USAF projects on structural power.

**Nanocomposites and Hierarchical Composites:** He has been one of a team of three academics on the development of 'hierarchical' composites; thermoset and thermoplastic polymer composites with both micron and nano-level reinforcement. He has focussed on tailoring these materials for improved compression strength and delamination toughness. This research has led to development of novel synthesis methods for ensuring the nanoreinforcement is homogeneously distributed, has controlled alignment and good interfacial adhesion. More recently this research has led to the development of carbon aerogel reinforced composites which offer a step change in mechanical, physical and multifunctional properties of polymer composites.

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**Multifunctional Composites:** Prof Greenhalgh leads the team at Imperial College London on structural power materials; the team is one of the leading groups worldwide in this field and are the leading group in structural supercapacitors. These are materials which simultaneously store (and deliver) electrical energy and carry mechanical loads. The research has led to leadership of the EU programme (STORAGE) on the development of these materials for automotive applications and several research programmes for MoD. The research has led to considerable publicity, including articles in popular and professional publications such as *New Scientist*, *Professional Engineer*, *The Economist*, *New York Times*, *Automotive Design* and *Materials World (IOM3)*. The [Youtube video](#) has had about 82000 hits, and is still one of the most popular Imperial College videos. There have been numerous invited talks, such as a keynote at Supercapacitors Europe 2015, Berlin Germany, 25th Anniversary Conference at SICOMP, Sweden in 2014 and keynote (and session organiser) at ICCM20 in Copenhagen (2015). The research has been very successful, culminating in demonstrator components, and a patent being granted on structural power materials.

## **Teaching**

Prof Greenhalgh gives lectures and tutorials on undergraduate and post-graduate courses, on topics including Mechanics, Structural Analysis, Materials, Materials Modelling, Laminate Theory, Composite Testing and Fractographic Analysis of Composites. He also supervises Composite Design studies, Group Design Projects and Final Year Projects in composites and aerospace materials. He is Director of the Composites MSc at Imperial College and is a keen advocate of promoting materials education and enhancing the student's knowledge of the state of art in this field. He was an External examiner on the Aerospace Engineering BSc at Farnborough Technical College and is currently the External examiner for Perth College (Scotland). Finally, he has considerable experience in supervising PhD and EngD students, as well as examining PhD Vivas both in the UK (Imperial College, University of Bristol, University of Manchester and QMW) and Europe (University of Lulea and KTH).

## **Professional Activities (IOM<sup>3</sup>) and External Visibility**

**General:** Prof Greenhalgh has extensive experience in presenting research at conferences, symposia and meetings, both in the UK and abroad. He has been invited to chair sessions and be involved in the executive committees of several international conferences. He has trained a large number of researchers in failure analysis and fractography of composites, and operation of equipment such as scanning electron microscopes. He has regularly been invited to give presentations on fractography of composites.

**Publications;** To date Prof Greenhalgh has published fifty five journal papers, about seventy conference papers, fifty one technical reports, four patents and two books. In 2002, he was awarded the Sir Vernon Brown Prize for the best paper on aircraft maintenance by the Royal Aeronautical Society. In 2007, his PhD student (Sang Nguyen) won the National SAMPE/IOM<sup>3</sup> student lecture competition. In 2012, he was awarded the Materials World award for the article 'Cracking Under Pressure'. Finally, he regularly referee papers for *Composite A*, *Carbon*, *Composite Structures* and *Composites Science and Technology* Journals (typically about fifteen papers per year).

**IOM<sup>3</sup>:** Prof Greenhalgh was chair of the London Materials Society (LMS) in 2008/9, having sat on the board for the previous five years. During his chairmanship he assembled a series of the talks and chaired meetings focused on composites which had been very successful, with a significant increase in the numbers attending these events as compared to previous years. Many of these events were jointly held with other regional institutes such as the London branch of the IMechE. He was the past chair of the Meetings and Marketing Committee (CMMC) in the IOM<sup>3</sup>, a subcommittee of the British Composites Society (BCS). He is currently a member of the BCS board who are UK Composite leaders from academia, industry and research organisations. The focus of his role is twofold; (a) initiation and development of workshops and conferences to promote the IOM<sup>3</sup> and UK composites, and (b) promote and raise awareness of UK composites. Finally, last year he led the UK bid to host the European Conference on Composite Materials in 2020.

**International Visibility:** Prof Greenhalgh sat on the council of the ESCM (European Society of Composite Materials) from 2009 to 2015, which is an overarching European organisation with the aims of promoting European cooperation on composites and encouraging education in composite materials. The Council organises the biannual European Conference on Composite Materials (ECCM). At the European Conference on Composite Materials (ECCM13) held in Stockholm in June 2008, he gave the opening plenary entitled '*Fractography of Polymer Composites; Current Status and Future Issues*'. At ICCM16 in Kyoto Japan in 2007 he gave a keynote lecture entitled '*Fractographic Observations of Delamination Growth Mechanisms*'. At ECCM15 (Venice) in June 2012, he organised a session on structural power materials as well as co-authored a keynote presentation. At the ICCM19 (Montreal) in July 2013, he organised and co-chaired the Session on structural power. Finally, at ICCM20 in Copenhagen in 2015 he gave a keynote lecture entitled '*Recent Developments in Structural Power Materials*'.

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As detailed in the previous Section, he has had considerable outreach through publicity of research into structural power materials, including invited to attend Foreign and Commonwealth Office (FCO) missions to Montreal (2011) and Singapore (2010) to present on this field.

## Management and Administration

**Consultancy:** Over the last ten years he has been responsible for managing the mechanical testing and fractographic work undertaken in the Aeronautics Department for industry. This has entailed costing of the programmes, liaising with customers, managing the running of the programmes and timely reporting of the results. In addition, he has undertaken consultancy (composite failure characterisation) for a number of other companies such as Dowty, dstl (MoD), SICOMP (Sweden), Kongsburg (Norway), GE, Rolls Royce, Airbus and Corac.

**Facilities:** Prof Greenhalgh has initiated purchase and commissioned several scanning electron microscopes and subsequently run the composites microscopy facilities at QinetiQ and Imperial College. He has recently initiated and commissioned a new facility for multifunctional materials development at Imperial College, as well as involved in the commissioning of digital image correlation and ultrasonic inspection equipment.

**Administrative Roles:** Prof Greenhalgh was Careers Officer for Aeronautics at Imperial College between October 2005 and December 2006, which entailed organising presentations from employers and distributing details of graduate opportunities. He was Admissions Tutor for the Department from 2006 to 2011, with the aim of meeting targets for Home (and EU) and Overseas students. As well as developing the strategy for admitting students to the undergraduate courses, this role was the first point of contact for new applicants who apply to Imperial College, process the UCAS forms, field ad-hoc enquires, organise the Admissions Days and the Open Day in June, and make offers to the applicants. Since Oct 2014 he has been Director of the Composites MSc, leading admission to the course, running the day to day management and chairing the Examination committee.

## Publications

### **Refereed Publications – Journal Papers**

1. Greenhalgh, E.S. & Cox, P.C., *A Method to Determine Propagation Direction of Compression Fracture in Carbon-Fibre Composites*, **Composite Structures**, 21, (1991), 1-7.
2. Greenhalgh, E.S., *Delamination Growth in Carbon-Fibre Composite Structures*, **Composite Structures**, 23, (1993), 165-175.
3. Greenhalgh, E.S., Bishop, S., Bray, D., Hughes, D., Lahiff, S. & Millson, B., *Characterisation of Impact Damage in Skin-Stringer Composite Structures*, **Composites Structures**, 36, (1997), 187-207.
4. Ireman, T., Thesken, J., Greenhalgh, E.S., Sharp, R., Gadke, M., Maison, S., Ousset, Y., Roudolff, F., La Barbera, A., *Damage Propagation in Composite Structural Elements - Coupon Experiments and Analyses*, **Composites Structures**, 36, (1997), 173-186.
5. Wigenraad, J., Greenhalgh, E.S., Gadke, M., Maison, S., Ousset, Y., Roudolff, F., La Barbera, A., *Damage Propagation in Composite Structural Elements - Structural Experiments and Analyses*, **Composites Structures**, 36, (1997), 209-220.
6. Singh, S., Greenhalgh, E.S., *Micromechanisms of Interlaminar Fracture in Carbon-Fibre Reinforced Plastics at Multidirectional Ply Interfaces Under Static and Cyclic Loading*, **Plastics, Rubber and Composites Processing and Applications**, 27, (1998), 220-226.
7. Greenhalgh, E.S., Singh, S., Hughes, D. & Roberts, D., *Impact Damage Resistance and Tolerance of Stringer-Stiffened Composite Structures*, **Plastics, Rubber and Composites**, 28 (5), (1999), 228-251.
8. Asp, L., Sjogren, A. & Greenhalgh, E.S., *Delamination Growth and Thresholds in a Carbon/Epoxy Composite under Fatigue Loading*, **Journal of Composites Technology and Research**, 23(2), (2001), 55-68.
9. Falzon, B., Davies G., Greenhalgh E., *Failure of Thick-Skinned Stiffener Runout Sections Loaded in Uniaxial Compression*, **Composite Structures**, 53, (2001), 223-233,
10. Greenhalgh, E.S., Chichester, G., Mew, A., Slade, M., Bowen, R., *Characterisation of the Realistic Threat from Runway Debris*, **The Aeronautical Journal**, (2001), 557-570<sup>†</sup>.
11. Greenhalgh, E.S., Hiley, M.J., *The Assessment of Novel Materials and Processes for the Impact Tolerant Design of Stiffened Composite Aerospace Structures*, **Composites A**, 34(2), (2003), 151-161.

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<sup>†</sup> Awarded the Sir Vernon Brown Prize for the best paper on aircraft maintenance

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12. Greenhalgh, E.S., Meeks, C.B., Clarke, A.B., Thatcher, J.E., *The Effect of Defects on the Performance of Post-Buckled CFRP Stringer-Stiffened Panels*, **Composites A**, 34, (2003), 623-633.
13. Greenhalgh, E.S., Huertas Garcia, M, *Fracture Mechanisms And Failure Processes At Stiffener Run-Outs In Polymer Matrix Composite Stiffened Elements*, **Composites A**, 35, (2004), 1447-1458.
14. Meeks, C.B., Greenhalgh, E.S., Falzon, B.G., *Stiffener Debonding Mechanisms in Post-Buckled CFRP Aerospace Panels*, **Composites A**, 36, (2005), 934-946.
15. Greenhalgh, E.S., Lewis, A., Bowen, R., Grassi, M., *Evaluation of Toughening Concepts at Structural Features in CFRP – Part I; Stiffener Pull-Off*, **Composites A**, 37, (2006), 1521 – 1535
16. Shaik Dawood, M.S.I, Iannucci, L., Greenhalgh, E.S., *Three-dimensional static shape control analysis of composite plates using distributed piezoelectric actuators*, **Smart Materials and Structures**, 17, (2008)
17. Nguyen, S.N., Greenhalgh, E.S., Olsson, R., Iannucci, L., *Modeling the Lofting of Runway Debris by Aircraft Tires*, **Journal of Aircraft**, 45 (5), (2008), 1701 – 1714.
18. Qian, H., Bismarck, A., Greenhalgh, E.S., Shaffer, M., *Hierarchical composites reinforced with carbon nanotube grafted fibers: The potential assessed at the single fiber level*, **Chemistry of Materials**, 20, (2008), 1862 – 1869.
19. Nguyen S.N., Greenhalgh E.S., Olsson R., Iannucci L., Curtis P.T., *Improved Models for Runway Debris Lofting Simulations*. **The Aeronautical Journal**, 13, (2009).
20. Greenhalgh, E.S., Rogers, C.B., Robinson, P., *Fractographic Observations on Delamination Growth Mechanisms*, **Composites Science and Technology**, 69(14), (2009), 2345–2351.
21. Qian H, Bismarck A, Greenhalgh ES, Shaffer MSP, *Synthesis and characterisation of carbon nanotubes grown on silica fibres by injection CVD*, **Carbon**, 48, (2010), 277-286.
22. Nguyen, S., Greenhalgh, E.S., Olsson, R., Iannucci, L., *Parametric analysis of runway stone lofting mechanisms*, **International Journal of Impact Engineering**, 37, (2010), 502-514.
23. Qian H., Greenhalgh E.S., Shaffer M.S.P., Bismarck A., *Carbon nanotube-based hierarchical composites: a review*, **Journal of Materials Chemistry**, 20, (2010), 4751-4762.
24. Qian H., Bismarck A., Greenhalgh E.S., Shaffer MSP, *Carbon nanotube grafted silica fibres: Characterising the interface at the single fibre level*, **Composites Science and Technology**, 70, (2010), 393-399.
25. Qian H., Bismarck A, Greenhalgh ES, Shaffer, M.S.P., *Carbon nanotube grafted carbon fibres: A study of wetting and fibre fragmentation*, **Composites Part A**, 41, (2010), 1107-1114.
26. Ho K.K.C., Kollopoulos A., Lamoriniere S., Greenhalgh E.S., Bismarck, A., *Atmospheric Plasma Fluorination as Means to Improve the Mechanical Properties of Short Carbon Fibre Reinforced Poly (Vinylidene Fluoride)*, **Composites Part A: Applied Science and Manufacturing**, 41(9), (2010), 1115–1122.
27. Greenhalgh E.S., *Storage solutions*, **Materials World**, 19, (2011), 24-26.
28. Qian H., Kalinka G., Chan K.L., Kazarian S.G., Greenhalgh E.S., Bismarck A., Shaffer M.S., *Mapping local microstructure and mechanical performance around carbon nanotube grafted silica fibres: methodologies for hierarchical composites*, **Nanoscale**, 3, (2011), 4759-4767.
29. Nguyen S.N., Greenhalgh E.S., Olsson R., Iannucci L., Curtis P., Longstaff S. *Experimental Characterisation of Tire Indentation by Simulated Runway Debris*, **Strain: An International Journal for Experimental Mechanics**, 47 (4), (2011), 343–350.
30. Nguyen S.N., Greenhalgh E.S., Olsson R., *Analytical Modeling of Runway Stone Lofting*, **Journal of Aircraft**, 48, (2011), 1412-1421.
31. Tsampas, S.A., Greenhalgh, E.S., Ankersen, J., Curtis, P.T., *On Compressive Failure of Multidirectional Fibre-Reinforced Composites: A Fractographic Study*, **Composites Part A: Applied Science and Manufacturing**, 43(3), (2012), 454-468.
32. Yasae M, Bond I.P., Trask R.S., Greenhalgh E.S., *Mode II interfacial toughening through discontinuous interleaves for damage suppression and control*, **Composites Part A: Applied Science and Manufacturing**, 43, (2012), 121-128.

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33. Yasae M, Bond I.P., Trask R.S., Greenhalgh E.S., *Mode I interfacial toughening through discontinuous interleaves for damage suppression and control*, **Composites Part A: Applied Science and Manufacturing**, 43, (2012), 198-207.
34. Ariffin, A.K., Shaik Dawood, M.S.I., Iannucci, L., Greenhalgh, E. *Low Velocity Impact Induced Delamination Control Using MFC Actuator*, **Applied Mechanics and Materials** 165, (2012), 346-351.
35. Yasae M, Bond I.P., Trask R.S., Greenhalgh E.S., *Damage control using discrete thermoplastic film inserts*, **Composites Part A: Applied Science and Manufacturing**, 43, (2012), 978-989.
36. Greenhalgh E.S., *Cracking under pressure*, **Materials World**, 20, (2012), pp28-31<sup>1</sup>.
37. Shirshova, N., Qian, H., Shaffer, M.S.P., Steinke, J.H.G, Greenhalgh, E.S., Curtis, P.T., Kucernak, A., Bismarck, A., *Structural Composite Supercapacitors*, **Composites Part A: Applied Science and Manufacturing** 46, (2013), 96-107.
38. Greenhalgh E.S., Bloodworth V.M., Iannucci L., Pope D, *Fractographic observations on Dyneema composites under ballistic impact*, **Composites Part A: Applied Science and Manufacturing** 44, (2013), 51-62.
39. Qian, H., Diao, H., Shirshova, N., Greenhalgh, E.S., Steinke, J.G.H., Shaffer, M.S.P., Bismarck, A., *Activation of Structural Carbon Fibres for Potential Applications in Multifunctional Structural Supercapacitors*, **Journal of Colloid and Interface Science** 395, (2013), 241-248.
40. Qian, H., Kucernak A.R.J., Greenhalgh, E.S., Bismarck, A., Shaffer, M.S.P., *Multifunctional Structural Supercapacitor Composites Based on Carbon Aerogel Modified High Performance Carbon Fibre Fabric*, **ACS Applied Materials & Interfaces** 5(13), (2013), 6113-6122.
41. Javid, A., Ho, K.K.C., Bismarck, A., Shaffer, M.S.P., Steinke, J.H.G., Greenhalgh, E.S., *Multifunctional Structural Supercapacitors for Electrical Energy Storage Applications*, **Journal of Composite Materials** 47(22), (2013).
42. Canturri, C., Greenhalgh, E.S., Pinho, S.T., Ankersen, J. *Delamination Growth Directionality and the Subsequent Migration Processes - The Key to Damage Tolerant Design*, **Composites Part A: Applied Science and Manufacturing**, 54, (2013), 79–87.
43. Shirshova, N., Bismarck, A., Carreyette, S., Fontana, Q.P.V., Greenhalgh, E.S., Jacobsson, P., Johansson, P., Marczewski, M.J., Scheers, J., Kalinka, G., Kucernak, A., Shaffer, M.S.P., Steinke, J.H.G., Wienrich, M., *Structural Electrolytes for Supercapacitors Based on Ionic Liquid Doped Epoxy Resins*, **Journal of Materials Chemistry**, A 1(48):15300-15309 01 Jan 2013.
44. Nguyen, S., Greenhalgh, E.S., Graham, J.M.R., Francis, A. Olsson, R., *Runway Debris Impact Threat Maps for Transport Aircraft*, **Aeronautical Journal**, 118(1201):229-266 01 Mar 2014.
45. Shirshova, N., Qian H., Houllé, M., Steinke, J., Kucernak, A., Fontana, Q., Greenhalgh, E.S., Bismarck, A., Shaffer, M., *Multifunctional Structural Energy Storage Composite Supercapacitors*, **Faraday Discussions**, RSC, DOI: 10.1039/b000000x, 2014.
46. Shirshova, N., Bismarck, A., Greenhalgh, E., Johansson, P., Kalinka, G., Marczewski, M., Shaffer, M. & Wienrich, M. *Composition as a Means to Control Morphology and Properties of Epoxy Based Dual-Phase Structural Electrolytes*. **The Journal of Physical Chemistry C** 118(49): 28377–28387, 2014.
47. Asp L.E., Greenhalgh E.S., *Structural Power Composites*, **Composites Science and Technology**, 101, ISSN:0266-3538, Pages:41-61, 2014.
48. Canturri C, Greenhalgh ES, Pinho ST, *The relationship between mixed-mode II/III delamination and delamination migration in composite laminates*, **Composites Science and Technology**, 105, Pages: 102-109, (2014).
49. Greenhalgh, E.S., Ankersen, J., Bismarck, A., Kucernak, A., Nguyen, S., Steinke, J., Shirshova, N., Wienrich, M., Kalinka, G., Asp, L.A., Nilsson, S., Fontana, Q., Houllé, M., *Mechanical, Electrical and Microstructural Characterisation of Multifunctional Structural Power Composites*, **Journal of Composite Materials**, 49 (15), pp1823-1834, (2015).

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<sup>1</sup> Awarded best paper in Materials World, IOM3 (2012)

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50. Tsampas, S.A., Greenhalgh, E.S., Ankersen, J., Curtis, P.T., *Compressive failure of hybrid multidirectional fibre-reinforced composites*, **Composites Part A: Applied Science and Manufacturing**, 71, pp40-58, (2015).
51. Javaid, A, Ho, K, Bismarck, A., Steinke, J., Shaffer M, Greenhalgh E.S., *Carbon fibre reinforced poly(ethylene glycol) diglycidylether based multifunctional structural supercapacitor composites for electrical energy storage applications*, **Journal of Composite Materials**, 50(16), 2155-2163, (2015).
52. Herceg, T., Shaffer, M., Greenhalgh, E.S., Bismarck, A., Zainol Abidin, M., Davison, J., *Thermosetting nanocomposites with high carbon nanotube loadings processed by a scalable powder based method*, **Composites Science and Technology**, 127, 62-70, (2016).
53. Herceg, T., Shaffer, M., Greenhalgh, E.S., Bismarck, A., Zainol Abidin, M., Davison, J., *Thermosetting hierarchical composites with high carbon nanotube loadings: En route to high performance*, **Composites Science and Technology**, 127, 134-141, (2016).
54. Bismarck, A., Blaker, J., Anthony, D., Qian, H, Maples, H., Robinson, P., Shaffer, M., Greenhalgh, E., *Development of novel composites through fibre and interface/interphase modification*, **IOP Conference Series: Materials Science and Engineering**, 139 (1), (2016).
55. Jollivet, T., Greenhalgh, E.S., *Fractography, a Powerful Tool for Identifying and Understanding Fatigue in Composite Materials*, **Procedia Engineering** 133, 171-178, (2016).

## **Refereed Publications - Patents**

1. Shaffer, M., Greenhalgh, E.S., Bismarck, A., Patent WO 2007/125282 A2, 2007, *Energy Storage Device*.
2. Bismarck A., Greenhalgh, E.S., Lamorinere, S., Menzel, R., Shaffer M. S. P., Tran, M.Q., Menner, A., Patent WO2010001123-A1, 2010, *Production of functionalized carbon (nano)material e.g. for polyamide or epoxy system, by heating carbon (nano)material in inert atmosphere or vacuum, and incubating surface-activated carbon (nano)material with reactive chemical species*.
3. Bismarck A., Greenhalgh, E.S., Lamorinere, S., Menzel, R., Shaffer M. S. P., Tran, M.Q., WO2010081821-A1, 2010, *Manufacture of composite involves impregnating fiber tow with suspension comprising nanocomposite particles and non-solvent liquid phase, or emulsion comprising droplets of nanocomposite in non-solvent liquid phase*.
4. Bismarck A., Shirshova, N., Greenhalgh, E.S., Steinke, J.H.G., Shaffer M. S. P., Patent WO2010/010363, 2010, *Electrolyte comprising continuous meso or nanoporous component and electrolyte phase*.

## **Refereed Publications - Books**

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