

**Institution: Heriot-Watt University**

**Unit of Assessment: 34 - Art and Design: History, Practice and Theory**

**Title of case study:** Developing technical textile products and processes

**1. Summary of the impact** (indicative maximum 100 words)

Heriot-Watt University (HWU) led the development of a supportive infrastructure for the sustainable advancement of Technical Textiles (the fastest growing textiles sector in an industry worth \$25bn globally and £3bn per year to the UK economy). 452 companies have had their products or processes created or improved. (e.g. patents awarded, new companies established and research and development sustained). The research transformed how Technical Textiles were understood as marketable products in their own right; from purely functional entities to materials that operate at the interface of design and technology. This enabled the development of new technologies that enhance wellbeing and quality of life, e.g. in the health and defence sectors.

**2. Underpinning research** (indicative maximum 500 words)

In 2000 Professor Stylios recognised the potential of the nascent Technical Textiles industry to transform the textiles industry and to support other industry sectors. As lead partner, with universities of Manchester and Leeds and the British Textile Technology Group he won a Faraday Partnership Initiative award (Technitex £7M) to identify and address the research challenges for the embryonic industry and established a UK-wide plan based on collaborative research, training and technology transfer focusing on current and future industrial needs. Through leadership of his own centre RIFLEX (Research Institute for Flexible Material) Stylios also took leadership in key areas of research, particularly manufacture of technical textiles and the modelling and measurement which underpinned the partnership.

There was an increasing appreciation that textiles could be used in a number of industries to provide added value and competitiveness to the UK sector.

A successful bid to EPSRC led to development of a generic platform of scientific foundation for applied research and new product/process development.

Stylios led the manufacturing research programme to identify how the design of the new materials and their compliance in measurement could be realised through manufacturing processes. At the same time research into nano fibres and membranes demonstrated that certain technical characteristics could be achieved at the molecular level upwards. This became the catalyst of the subsequent work on nano fibres, nano yarns and nano membranes. Part of the manufacturing responsibility was to simulate how to coat the fabrics. The theoretical basis of giving functionality to textile products by fabric coating was set in a rheological model that allows companies to predict the optimum process conditions for end users. Research in micro/nano technology has discovered new ways of making materials that have high surface to volume ratio which renders them very strong, super absorbing, and by manipulating the cavities in their structure enables extra functionality such as self-cleaning, odour and water resistance, moisture generation or chemical release.

Subsequent research in RIFleX stemmed from the EPSRC core programme and by an agreed research roadmap with industry led to developing the following areas of TT;

1. SMART Textiles; Shape/colour changing, psychotextiles (mood changing, brain/beauty interactions, photonic fabric systems). This work contributes to developing the capability of textiles to interact with stimulus or their environment.
2. NanoTextiles; conversion of nanofibres into mats regeneration of cashmere by nanoscience nanofibre functionalisation, development and manufacturing processing and nanomembranes (controlled release of biopharmaceuticals for medical applications), along with discovery of converting nanofibres to yarns., Wearable Electronics: the hypothesis that

one day computers would become part of clothing is now becoming a reality. HWU has been designing electronic textiles for comfort and unobtrusiveness along with integration and miniaturisation of IC networks for carrying electronic devices wirelessly.

3. Modelling; fabric behaviour, mechanical measurement (shear, bending, tensile, surface) and high performance including chemical and biological filtration against warfare. The underlying research stems from the fact that fabrics as visco-elastic materials behave in a non-linear way and hence to define their behaviour during manufacture and end use their mechanical properties have to be defined. Camira Fabrics use what is commonly accepted fingerprinting of fabric behaviour to map in their upholstery fabric performance user requirements. Moxon of Huddersfield is using the fingerprinting of their fabrics in identifying their superiority.
4. Measuring Performance; the behaviour of Technical Textiles is important for critical end uses, such as for filtration against Chemical and Biological substances. The FilTex filtration machine was developed from an EPSRC project.

### 3. References to the research (indicative maximum of six references)

1. Rheological Behaviour Of Polymer Solutions During Fabric Coating, Zhao, X., Stylios, G. K. & Christie, R. M. 15 Feb 2008 Journal of Applied Polymer Science. 107, 4, p. 2317-2321 5 p. <http://dx.doi.org/10.1002/app.27289>
2. Applications of Nanotechnology in Medical Practice; G Stylios, Giannoudis, P. V. & Wan, T. 2005, Injury. 36, SUPPL. 4, p. S6-S13 (most cited paper 2005- 2010) <http://dx.doi.org/10.1016/j.injury.2005.10.011>
3. Investigating SMART Membranes And Coatings By In Situ Synthesis Of Iron Oxide Nanoparticles In PVA Hydrogels Stylios, G. K. & Wan, T. Y. 2009 In : Advances in Science and Technology. Smart Textiles 60 , p. 32-37 <http://dx.doi.org/10.4028/www.scientific.net/AST.60.32>
4. The Concept of Mood Changing Garments Made From Luminescent Woven Fabrics and Flexible Photovoltaics "MoodWear", Stylios, G. K. & Yang, D. 2013, Advances in Science and Technology. 80, 22, p. 22-29 8 p.80
5. Prediction Of Post-Buckling Deformation In Fabric Drape, Lin, H. & Stylios, G. K 2009, Journal of The Textile Institute. 100, 1, p. 35-43, <http://dx.doi.org/10.1080/00405000701582547>
6. The Filtration of Technical Fabrics against Chemical and Biological Substances, Stylios, G. K. and Yousef, M. I. 2013, *Polymeric Protective Technical Textiles*, McCarthy, B. (ed.), Smithers Rapra, ISBN 9781847359629, p. 115-138 23

### Funding

#### FARADAY TECHNITEX

- EPSRC Faraday Funding Engineering the performance and functional properties of technical textiles. 2002-2005 (GR/S09203/01, GR/S09210/01 & GR/S09227/01, £1,04M)

#### TSB/DTI Funding

- Novel Micro-Channel Membranes for Controlled Delivery of Biopharmaceuticals, 100327, Total award £650k,(£200k HWU), 2006-2009
- Multi-scale Integrated Modelling for High performance flexible materials, 100256, Total award £1,6M (£275 HWU), 2006-2010

#### EPSRC FUNDING

- Integration of CFD and CAE for design and Performance assessment of protective clothing, DT/E011098/1, £250k, 2007-2010

Other RIFleX work with commercial partners has been fully funded by industry;

- Selex/Es: next generation of soldier clothing with health monitoring; 2010, £60k
- MiroLink Ltd; wireless wearable SMART ECG systems; 2011 £80k
- MiroLink Ltd; 2013 £100k (extension)

**4. Details of the impact** (indicative maximum 750 words)

In the period 2005-2010, the world market for Technical Textiles (TT) increased in value by US\$ 20bn. Today, TT is the fastest growing sector within the global textiles and clothing industry (c. 4% growth per annum, compared to 1% for apparel and home textiles) and in the UK it is worth around £3bn to the economy.

The research led by Stylios through TechniTex has helped more than 450 companies, addressed a range of technical issues through the provision of advice, technical translation and assistance with research and product development.

RIFLeX research has impacted directly in the period on product and process development through direct collaboration with private sector enterprises.

In Modelling collaboration with Moxon of Huddersfield and Camira Fabrics Ltd both use what is commonly accepted fingerprinting of fabric behaviour; Camira to map in their upholstery fabric performance user requirements and in identifying the superiority of their fabrics. Moxon, a manufacturer of luxury worsted and woollen suiting fabrics for tailors such as Chester Barrie established the technical superiority of Moxon textiles in terms of quality, handle and drape, enabling the company to expand its product range and to market its fabrics with a 'certification of conformance' at, for example, Première Vision, the world's leading commercial fabric fair. A senior representative stated "*Moxon is the oldest textile mill established in 1556 and manufactures in Huddersfield the finest cloth in the world. Our Altai Cashmere, Royal Flannel and Vintage Cloth ranges have been technically developed and accredited as "IDEAL CLOTHS" by Prof Stylios's research. Moxon uses these certificates when selling/exhibiting internationally*".

Camira Fabrics Ltd worked with RIFLeX research in the design and prototyping of eight new upholstery fabrics, and their technical compliance in terms of both manufacturing and performance. Camira's sales and turnover increased by 20% (2008-11) and it was awarded the Queen's Award for Enterprise: Sustainable Development 2010. In 2012, RIFLeX assisted Camira with eliminating weaving production problems associated with the skewness of one of its main commercial fabrics. The elimination of the fault has saved in rejects and production time and increased customer satisfaction.

In measuring performance RIFLeX worked with PIL Membranes Ltd to characterise the filtration efficacy of its specialist membranes. Before the collaboration, there had been no reliable measurement of nanofabrics (which burst under traditional measurement), so the project utilised the Institute's unique filtration equipment; FilTex, see Ref 2, developed from an EPSRC-funded research project (TP6/DAM/6/SK3043B). It enabled PIL to assess new products against chemical and biological substances, similar to SARIN which has been used in the Syrian conflict, allowing them to commercialise their products to clients requiring high levels of product efficacy, including the military, emergency services, heavy industry and the medical sector. They confirmed "*Our collaboration with the Heriot Watt team enabled us to gain new knowledge on the filtration behaviour of fabrics and through the new FilTex project apparatus developed, to benchmark and further develop our membrane products*" (a senior technical officer of the company).

In Nanotextiles patents have opened up a new horizon for industry to manufacture new yarns and fabrics for the domestic (fashion, retailing) and technical markets (aerospace, automotive, shipping and civil architecture) and for the nanoengineering of cashmere from guard hair (waste product) by Todd & Duncan. The work culminated in the formation of NanoYarns Ltd, a new company start-up supported by an external consortium of investors, a senior member of the investment group (formerly McNeight & Lawrance) said "*Recognising the importance of the nanotextile innovations by Stylios and his colleagues I have set up an investing group of individuals aiming to prototype the work and go commercial. This work will bring the textile industry back to UK and establish a new sector based on nano products for apparel, medical, automotive, aerospace, shipping and civil engineering*".

In Wearable Electronics development work with MiroLink in healthcare monitoring of 'ECG, Respiration, Temperature' enables wireless monitoring at a distance from the patient.

**Impact case study (REF3b)****5. Sources to corroborate the impact** (indicative maximum of 10 references)

Senior Member of the Investment Group for NanoYarns Ltd, who, recognising the importance of the nanotextile innovations, stated "*I have set up an investing group of individuals aiming to prototype and commercialise the work. This work modernise the textile industry back to UK and establish a new sector based on nano products for apparel, medical, automotive, aerospace, shipping and civil engineering*".

MD Moxon of Huddersfield, who will confirm the impact that the work had on the company.

Department of Trauma and Orthopaedic Surgery, Leeds Royal Infirmary, will confirm that the collaboration in controlling the release of biomedical substances using nanomaterials provided a new development platform for the bone injury community.

Technical Manager, PIL Membranes Ltd

Director, Technitex Faraday Ltd

Data on the world market for Technical Textiles (TT) obtained from EURATEX, [www.euratex.eu](http://www.euratex.eu), the Textile Innovation Knowledge Platform

([www.tikp.co.uk/knowledge/market-sectors](http://www.tikp.co.uk/knowledge/market-sectors)), the EEF

([www.eef.org.uk/blog/post/Technical-Textiles.aspx](http://www.eef.org.uk/blog/post/Technical-Textiles.aspx)) and the Smart Textiles Network

(<http://smarttextiles.co.uk/overview/application/textiles-clothing>).