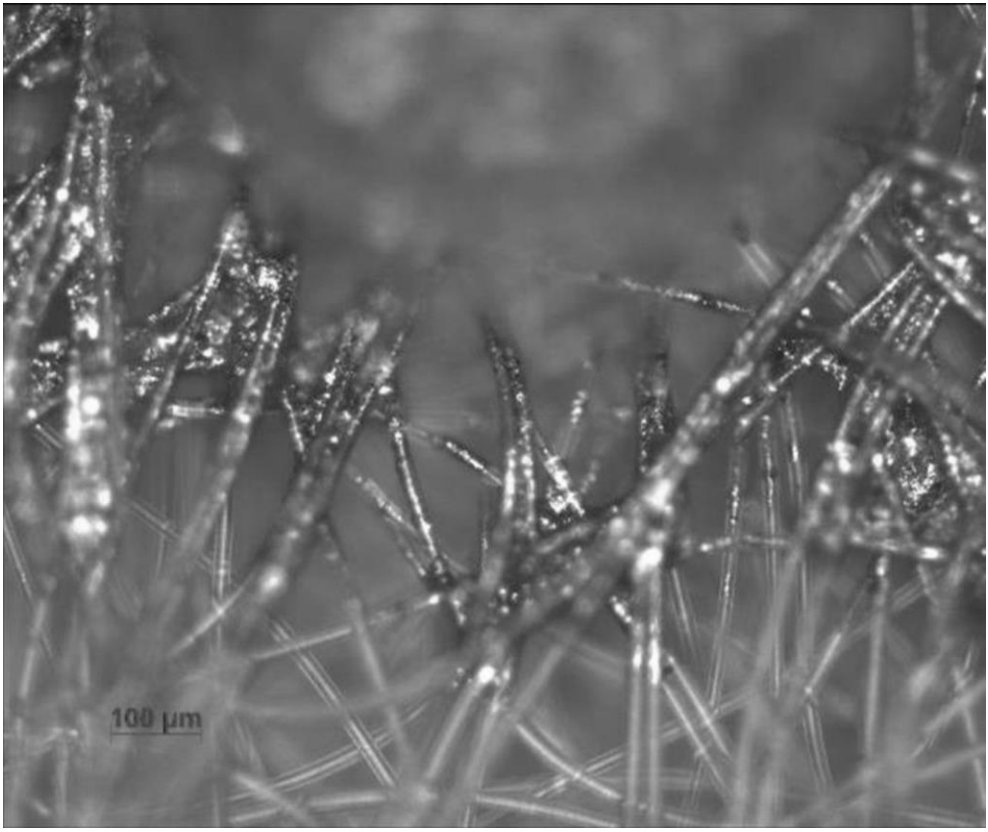
IOP Institute of Physics
Printing and Graphics Science Group

NEWSLETTER **September 2017**

Issue no. 11



http://pgs.iop.org

Cover image: Screen printed silver ink on a non woven open mesh textile with voids and depth. x10 0.3 Numerical Aperture objective lens. Bright Field (specular reflection) polarised light reflection image

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Welcome and Message from the Chair

A warm welcome to the 2017 edition of the PGS Group newsletter.
Our group has been involved in a number of events throughout the year and I would like to thank everyone who was involved in either the organisation or participation. Without you these events would not be possible.
This newsletter reports on events run this year, including the prizes awarded at our student conference “Printing for the Future”. The group also continues in our support of early career researchers through the successful application of Elis Parry to the IOP Research Student Conference Fund for his work on drop-on-demand inkjet printing of liquid crystal and polymer materials.
Details of the groups’ calendar for events during the upcoming year are included in this newsletter, but are also available online on our webpage http://pgs.iop.org. We look forward to seeing you again in the future!
This year has seen a number of changes on the PGS committee. In particular, Anna Fricker has recently stepped down as chair following the successful completion of her PhD, and this year Ian Hutchings will also step down from the committee following many years of service. Special thanks are given to both in this newsletter, but I would also like to thank them both here for their highly valued contribution to the group over many years, and to wish them the best of luck in the future.
I also extend my thanks to Martin Gouch who has taken over the position of honorary secretary, and would like to welcome Feras Alkhalil and James Johnstone who join us as an Ordinary member and co-opted member respectively. Finally, many thanks to Roy Gray for his hard work in putting together this newsletter.

Changes on the Group Committee

Your Group Committee exists to represent your interests, mainly by our conference programme. The Printing and Graphics Science Group Committee maintains a healthy turnover of members to best represent the changing interests of our membership. However, we also rely on the experience of some long standing committee members who over an extended period have made substantial contributions to the Group.
This year will see us lose 2 of our long standing committee members and

it is good to take this opportunity to recognise their contribution to our work. They have brought very different skill sets to the committee, reflecting the fact that they are at different stages of their career paths.

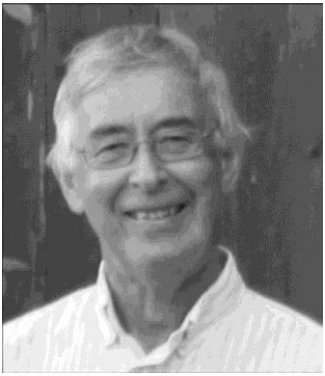
Ms Anna Fricker MInstP

Anna joined the committee 10 years ago whilst working in print research at the London College of Communication, since incorporated into the University of the Arts London. The Materials And The Arts Research Centre (MATAR) there was involved in conservation research on print media and Anna worked on a project funded by the Arts and Humanities Research Council looking at humidity fastness of modern materials. This work was recognised by The Royal Photographic Society with Anna being the recipient of their 2012 Selwyn Award, pictured here.

Anna was part of the group organising the "Preservation and Conservation Issues in Digital Printing and Photography" meeting over a number of years. She served the committee first as a member then as Secretary for 4 years and as Chair since 2014. During that period Anna has successfully completed a PhD in the field of conservation science at Imperial College and now leaves the committee to take up employment at BSI.

Professor Ian Hutchings FInstP

Ian joined the committee in 2010 with a very distinguished background. He is GKN Professor of Manufacturing Engineering at the Institute for Manufacturing at the University of Cambridge and a fellow of St John's College. He founded the Inkjet Research Centre in the Institute for Manufacturing in which he and colleagues investigate the science and technology of inkjet deposition, a field upon which much of Printing and Graphics Science now rests.



This background was used with great effect in a series of annual 1 day meetings on the topic of printing with ink droplets. Starting as the “Dynamics of Printed Drops” it became the "Science of Inkjet and Printed Drops". Through Ian’s leadership this became a highly regarded event held at the Institute of Physics headquarters in London, attracting an international group of speakers.

Ian retires from his University post this year and will at the same time step down from the Group Committee.

On behalf of the Committee and Printing and Graphics Science Group I would like to wish them both well on their future paths.

Emma Talbot

Chair, Printing and Graphics Science Group
September 2017

Committee Membership 2016-2017

Chair
Dr Emma Talbot
University of Cambridge
elt43@cam.ac.uk

Honorary Secretary
Mr Martin Gouch
FFEI Ltd
martingouch@hotmail.com

Treasurer
Dr Leszek Majewski
University of Manchester
leszek.majewski@manchester.ac.uk

Ordinary Members

Dr Feras Alkhalil
Pragmatic Printing

Dr Martyn Cherrington
Knowledge Transfer Network

Dr Davide Deganello
University of Swansea

Mr Roy Gray

Dr Alan Hodgson
Alan Hodgson Consulting Ltd.

Prof. Ian Hutchings (Until September)
University of Cambridge

James Johnstone
CPI

Mr Trevor Lambourne
University of Leeds

Dr Ehab Saleh
University of Nottingham

The group committee should comprise of (normally) not more than nine ordinary members.

Reports from Recent Group Events

Printing for the Future

12 January 2017
Institute of Physics, London, UK

Presentation prize winners were
Morgan Miles, on the subject of "The science behind flexographic printing uniformity".
Tian Carey,on the subject of "Spray coating of thin films on 3-dimensional surfaces for a graphene based capacitive touch device".

Reports from Other Events

Printing for Fabrication 2016

University of Manchester, 12-16 September 2016

Security Printing at Printing for Fabrication.

There were a number of industrial themes covered at the 2016 meeting that have a long history over this conference series. One of these is Security Printing and this also serves to illustrate how these themes evolve over the years in support of industry. These themes enable delegates to explore the technologies in some depth and the conference committee is always open to suggestions for new themes for this meeting.

In common with other IS&T meetings the conference has a short course programme designed to help students and new entrants to a topic learn about the use of printing in that area. Put together by Patrick Smith this year a range of courses were offered, including Security Printing. The aim of this course was to highlight the opportunities for the fabrication of printed features in secure documents from printing technologies, print inspection and verification. This short course attracted an international audience that reflected the wider conference and a similar short course on “Electronic Imaging in secure documents” may be offered at EI 2017. And again the conference committee and short course chairs of both meetings are always open to suggestions for new topics that can further enhance their programs.

Later in the week there was a short session devoted to Security Printing with a series of 3 papers illustrating the wide range of printing for

fabrication topics covered at this meeting. The first covered the use of additive manufacturing techniques to fabricate document features, the second software techniques to embed data into digital print and the third the various printing methods used to produce plastic identity cards. Although this session was small the technologies applicable to this topic also appeared in other parts of Printing for Fabrication. Of particular note this year was the colour characterisation of metallic surfaces and the printing of dichroic colours and optical features such as light guides.

As with previous years the conference also featured a demonstration session. Here delegates have the chance to experience some of the print samples that feature in the presentations. The demonstration session this year was particularly active with patterned and textured surfaces of interest in Security Printing.

One interesting area in these conferences has always been the workshop sessions. This year was no exception with two sessions seeking to connect different parts of the innovation landscape. In “Connections for Innovation in Security Printing “ 20 delegates came together to explore potential ways in which various ends of the supply chain could bring new technologies into the market for security printing. Three hours of interesting discussion resulted and the conclusions were circulated around the delegates. There are now plans for further meetings on this theme.

Security Printing was but one theme explored at Printing for Fabrication 2016. We look forward to exploring many more in 2017 and beyond.

Alan Hodgson
Our thanks to Dr Hodgson for this report.

https://www.imaging.org/site/PDFS/Conferences/NIP_DF/2016P4F_PreliminaryProgramWWW.pdf

Real Substrates for Printed Electronics

2017 International Forum on Wearable Smart Device

Dr Alan Hodgson, Alan Hodgson Consulting Ltd
Visiting Academic – University of Manchester
Chair of IEC TC119 (Printed Electronics)
This is a scripted version of Dr Hodgson's presentation at the 2017 International Forum on Wearable Smart Device in Seoul, South Korea, 26/27 April.

The Scope for IEC TC119 (Printed Electronics) is:-
Standardization of terminology, materials, processes, equipments, products and health/safety/environment in the field of printed electronics.

Taking Printed Electronics into production

There are both Academic questions and Industrial questions
There is a choice of substrates, eg paper, nonwoven and woven textiles so there is potential for wearable devices.
Microscopes are a useful investigation tool.

It is important to ask the right questions
Academics ask
What is the best conductivity you can achieve in Ω□?
What are the smallest features you can achieve?

Industry asks
What connection resistance range can I use?
How much area do I have available? Small size often no issue
HOW CAN I USE MY EXISTING EQUIPMENT?
Can I also use the materials I normally run on that equipment.

Substrates for easy printing of electronics*

Different materials are often classified by Ease of printing

Easy		to		Hard
Polished silicon Glass	PET	Card	Paper	Textile

But industrial relevance is opposite*

Potential production volumes for printed electronics products;-

Low		to		High
Polished silicon Glass	PET	Card	Paper	Textile

So paper and textiles are the worst substrates for printed electronics but commercially may be the most rewarding.
*Adapted from A. Hodgson, “Paper substrates for device manufacture – a technical roadmap”,Proc. IS&T’s Digital Fabrication, pp 674 – 677 (2008)

Paper substrates

Surface and structure not conducive to easy deposition of lengthy continuous paths.

SEM image width 1.25mm**
**A. Fricker, P. Sutherland, “Paper Topographies”, Institute of Physics (2007). ISBN 978-0-9553984-3-8

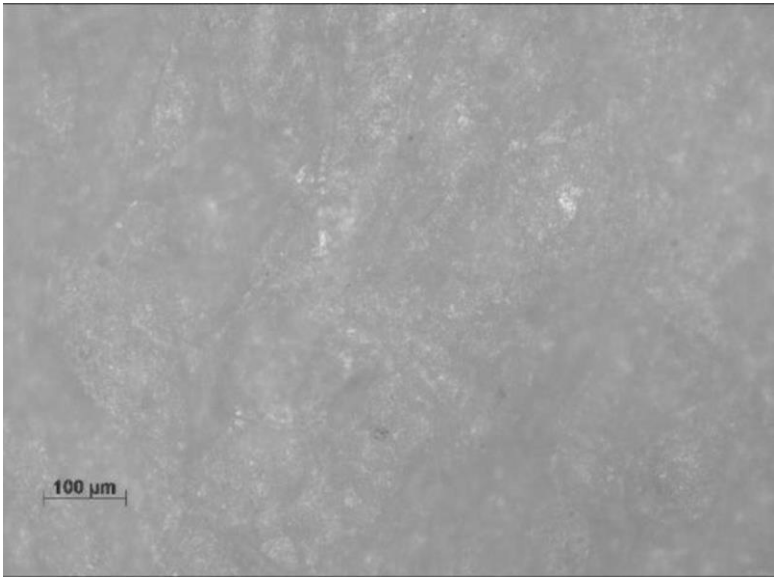
Printed electronics on paper

3 commercial papers are shown as examples in the following surface images
All printed using a Heidelberg GTO offset litho press with a Silver ink and no post treatment***

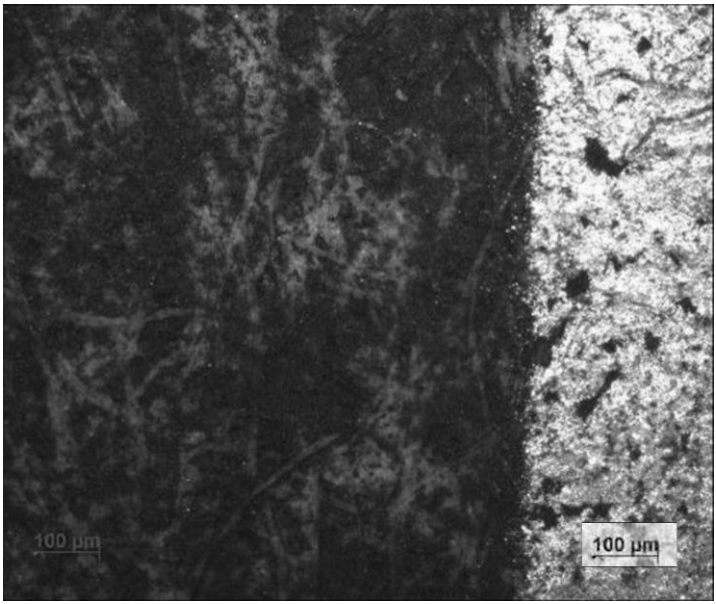
***A Hodgson & C Jones "Offset Printing of Conductive Features onto Paper Substrates" IS&T's Printing for Fabrication 2016 (NIP32), pp143 – 148.

Commercial paper 1 – rough surface

Bright field (specular reflection) polarised x10 0.46 Numerical Aperture objective lens



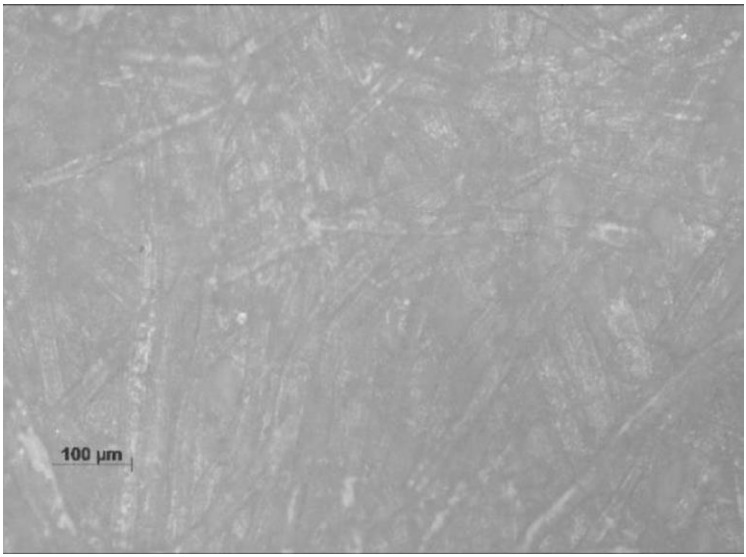
Dark field (scattered light) not polarised x10 0.3NA



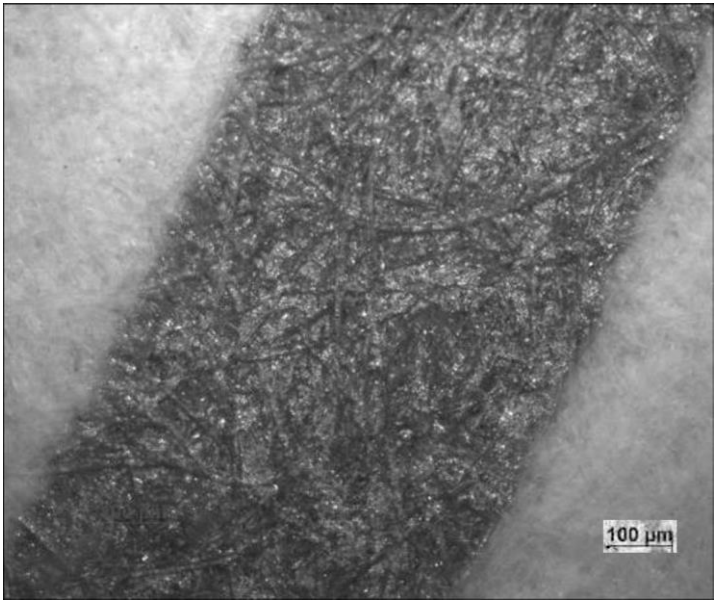
Paper is rough over long length scales (0.1 – 1mm). Inhibits use of printed (thin) conductors.

Commercial colour copier paper 2 – fibre surface smoothed

Bright field (specular reflection) polarised x10 0.46 Numerical Aperture objective lens

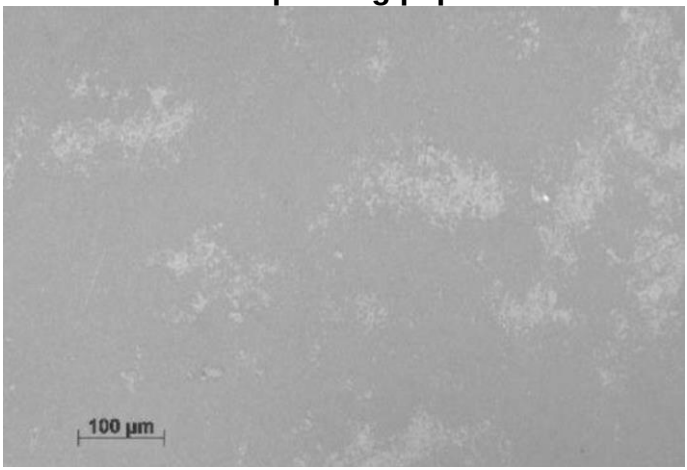


Dark field (scattered light) not polarised x10 0.3 Numerical Aperture objective lens



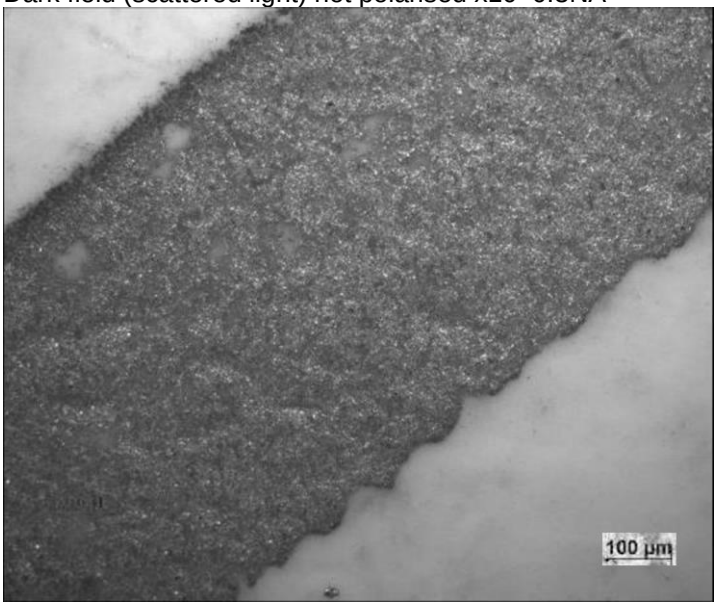
Paper is fibrous over shorter length scales than conductor. The silver ink line is non conducting because the vertical roughness is greater than the ink thickness

Commercial litho printing paper 3 – coated surface



Bright field (specular reflection) polarised x10 0.46 Numerical Aperture objective lens

Dark field (scattered light) not polarised x10 0.3NA



This paper is smooth over length scales of conductor. The printed line is conductive but the ink has wetting issues, hence the wavy edge.

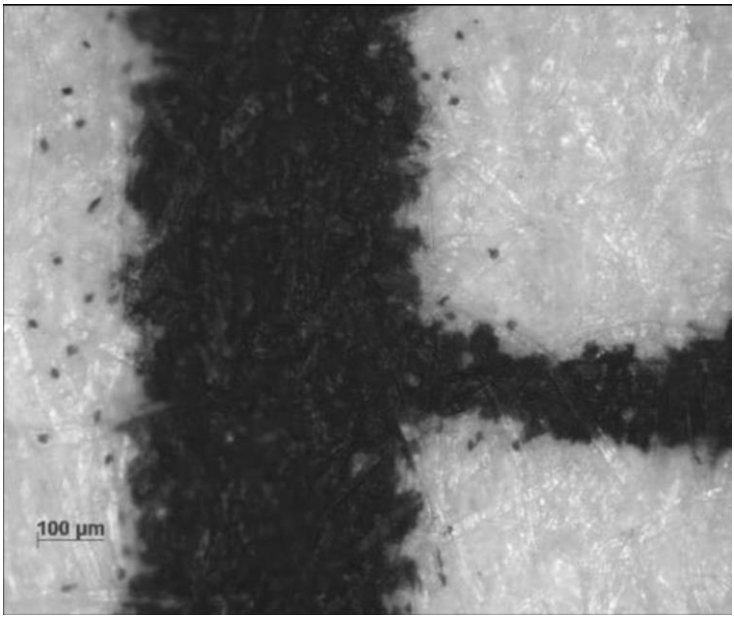
Relevant International Standards

IEC TC119 (Printed Electronics)
Published documents
IEC 62899-201:2016, “Printed electronics - Part 201: Materials – Substrates”.
Under revision to include paper.
IEC 62899-402-1:2017, “Printed electronics - Part 402-1: Printability - Measurement of qualities - Pattern width”
In progress
IEC 62899-402-2 ED1, “Printed Electronics - Part 402-2: Printability - Measurement of qualities - Edge waviness

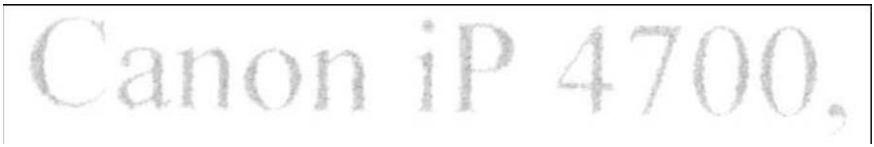
Fibrous substrates – the challenges

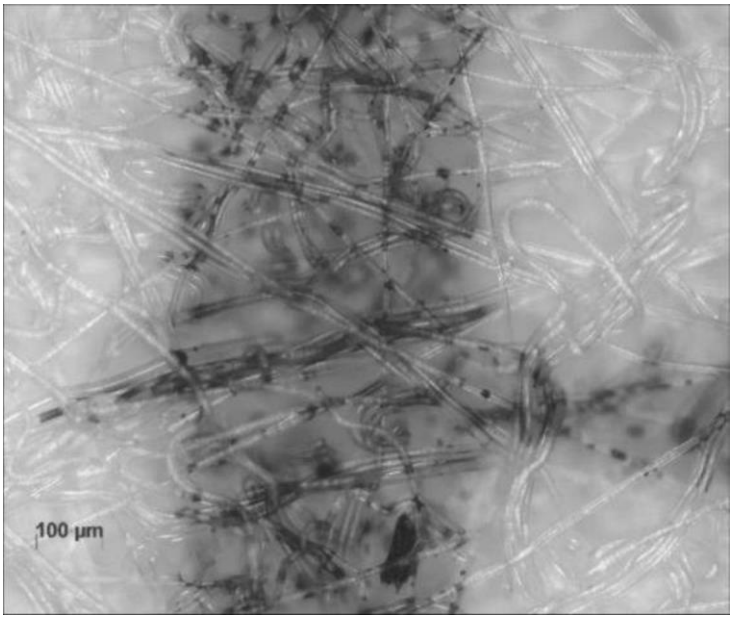
Using the lessons learnt from printing paper
Length scales
Roughness
And some extra ones see below!

Pigment black – paper standard copy & non woven substrate



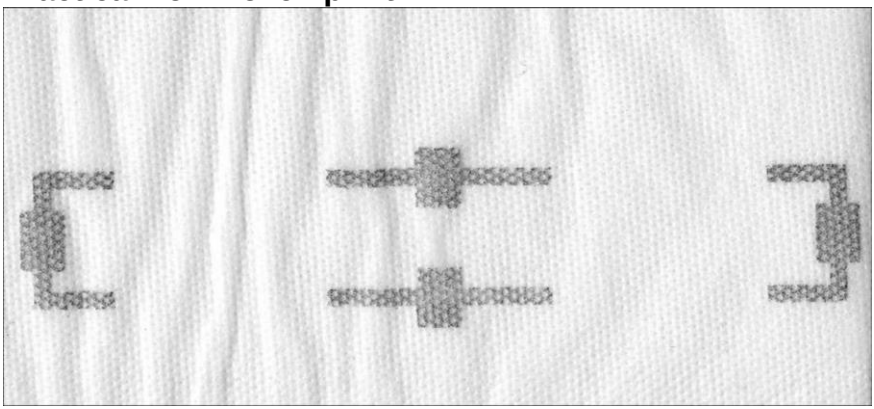
Copier paper substrate.





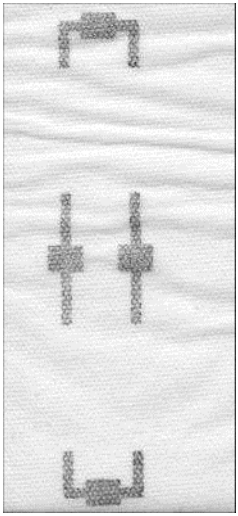
Non-woven textile fibre substrate.

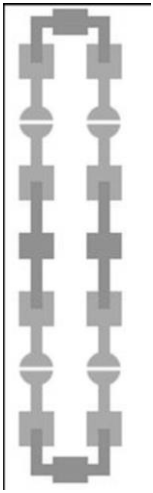
Practical non-woven print

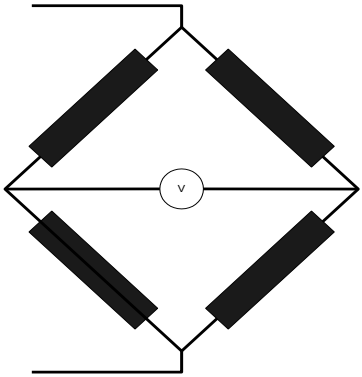


This is 14 cm long sample of printed fibrous non woven textile. It is not flat, has periodic patterns over various length scales. But the print is conductive!

Wearable Wheatstone bridge sensor

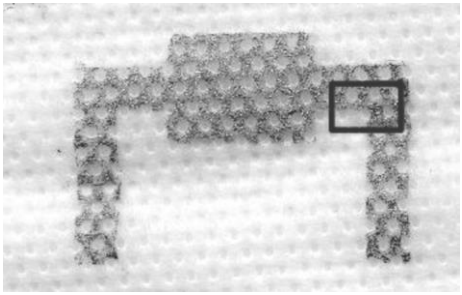




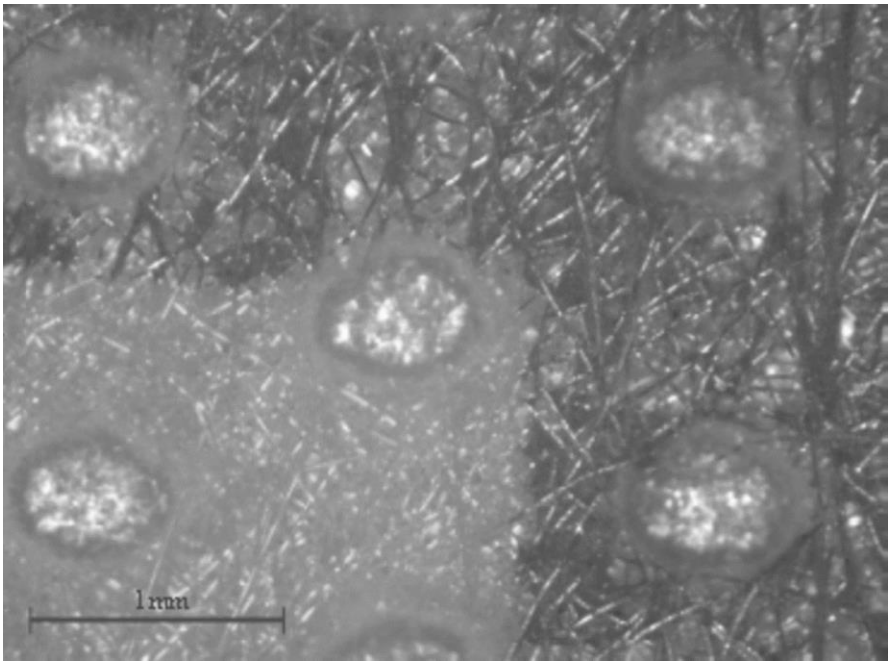


Sensors to be printed over the gaps in these printed connectors.

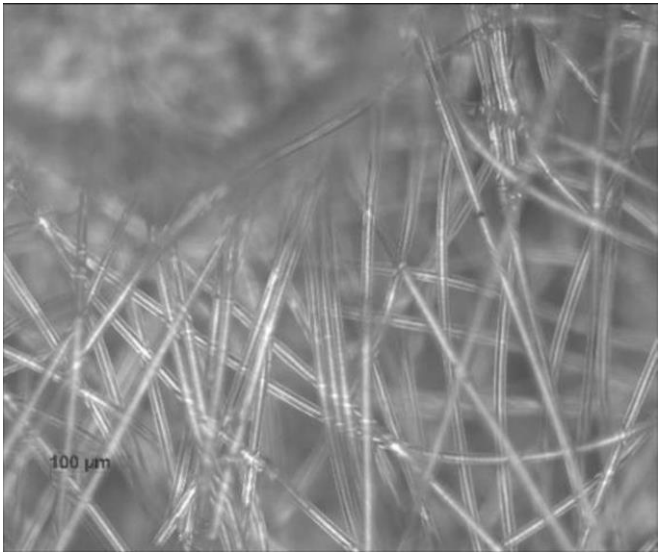
Periodic and random surface detail



The (red) box shows the area in the magnified image next page.

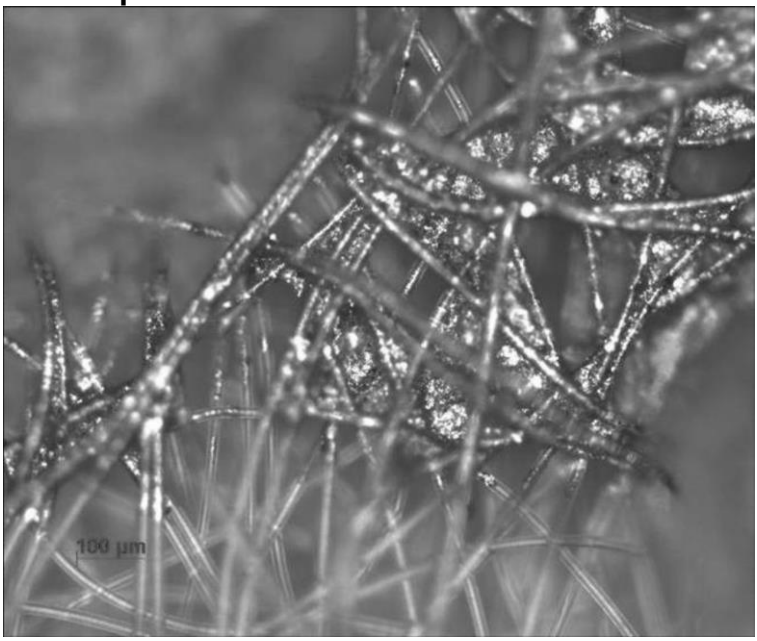


Dark (Red) line length 1 mm
x2.5 0.07 Numerical Aperture objective lens. Bright Field (specular reflection) polarised light reflection image.



Non woven material attributes
x10 0.3 Numerical Aperture objective lens. Bright Field (specular reflection) polarised light reflection image

Screen printed silver ink



Screen printed silver ink on a non woven open mesh textile with voids and depth. x10 0.3 Numerical Aperture Bright Field (specular reflection) polarised light image.

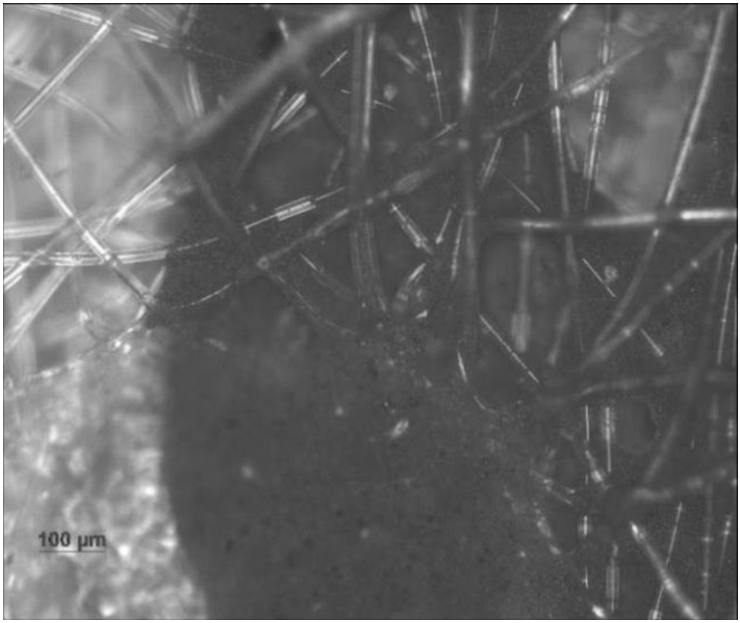


Image of sample screen printed with a ‘normal’ pigmented (red) ink on a non woven open mesh textile with voids and depth. x10 0.3 Numerical Aperture Bright Field (specular reflection) polarised light reflection image.

Relevant International Standards

IEC TC119 (Printed Electronics)
Published documents
IEC 62899-202:2016 Printed electronics - Part 202: Materials - Conductive ink
IEC TR 62899-250:2016 Printed electronics - Part 250: Material technologies required in printed electronics for wearable smart devices
In progress
IEC 62899-201-2 Printed electronics - Part 201-2: Materials - Evaluation method of stretchable substrates

Conclusions

Paper and textiles present real technical challenges but have real industrial relevance
Surface roughness is a significant challenge. Periodic and non periodic detail has to be characterised and hence there is a need for standardised measurement methods to be developed.

Forthcoming Group Events

Student conference; Solution Deposition

18th Jan 2018
University of Nottingham
Organised jointly by the PGS Group and the Knowledge Transfer Network

We will soon be welcoming students to submit abstracts on the broad topic of solution deposition covering anything from ejection at the printhead to drying on the substrate. Keep an eye open for this call on our website and social media pages. This event is a great opportunity for new students to practise their presentation skills to a responsive audience, and for PhD students nearing the end of their research to share it with keen new faces! All with the chance to win a £50 prize for the two best student presentations. We welcome students at any level, with the option of a poster session as well.
If you have suitable student contacts please encourage them to present.

Advances in Photovoltaics

4 October 2017
Institute of Physics, London, UK
Organised by the IOP Energy Group and Ion and Plasma Surface Interactions Group

https://www.iopconferences.org/iop/1027/home

This one day meeting provides a forum to help assess the current state of the art. It brings together a list of distinguished invited speakers whose expertise covers the range of photovoltaic technologies.

The conference programme and registration details are available at the link above.

IS&T Archiving 2018 Conference;

Digitization Preservation, and Access
April 17-20, 2018
National Archives, Washington, DC
http://www.imaging.org/ist/conferences/archiving/
The IS&T Archiving Conference is an annual event aimed at the imaging science and the cultural heritage communities. The conference brings together imaging scientists and technicians with those working in the cultural heritage community (curators, archivists, librarians, etc.), government, industry, and academia to discuss the latest research and issues relating to the digital preservation and stewardship of hardcopy, audio and video.

There may still be time to submit a paper for this conference. The deadline is the **1st November 2016**, please visit the website for further information.

Other Events of Potential Interest

13th Colour Conference

2017. AIC Color 2017, 13th Congress
16-20 October 2017
Jeju Island, Korea
http://www.aic2017.org

Printing for Fabrication 2017

33nd International Conference on Digital Printing Technologies (NIP)
November 5 - 9, 2017
Grand Hyatt, Denver, Colorado, USA.
http://www.imaging.org/site/IST/Conferences/NIP/IST/Conferences/Print4Fab/Printing_for_Fabrication.aspx?

WCPC 13th Annual Technical Conference

Welsh Centre for Printing and Coating
6th & 7th November 2017
Swansea Marriott, Maritime Quarter, Swansea. SA1 3SS

The conference is an opportunity to view the latest WCPC research in printing technology, discuss the findings with researchers and network with like-minded industrial delegates. Each presentation will be a technical paper based on latest results and analysis derived from controlled experiments and numerical models.
https://wcpcswansea.com/events/annual-conference/2017/

SEMICON Europa Conference

Nov 14-17, 2017
Messe München Munich, Germany
http://www.semiconeuropa.org/node/2981

Printed Electronics USA 2017

The Application of Printed, Organic and Flexible Electronics
November 15 - 16, 2017
Santa Clara Convention Center, CA, USA
http://www.idtechex.com/printed-electronics-usa/show/en/

Industry day; The Droplet and flow interactions with bio-inspired and smart surfaces Special Interest Group (SIG)

A UK fluid network SIG
29th November 2017
Nottingham Trent University.

This multidisciplinary SIG focuses on engineered surfaces inspired by nature that alter flow and motion of liquids whether as droplets or in internal flow (channels, pipes, etc) or external flow (past surfaces), utilising multidisciplinary expertise (Chemistry, Chemical Engineering, Micro-engineering, Manufacturing, Materials, Microsystems, Physics)

This free event aims to give industry an opportunity to hear what this SIG has to offer and for its members to discover more about needs of relevant industries and this would hopefully help initiate new projects and collaborations.

https://ukfluids.net/sig/SmartSurfaces

Electronic Imaging 2017

IS&T International Symposium on Electronic Imaging 2018
26 January - 1 February 2018
Burlingame, California, USA

http://www.electronicimaging.org

Large-area, Organic & Printed Electronics Convention (LOPEC)

12-15 March 2018
Munich, Germany

http://www.lopec.com/

Printed Electronics Europe 2018

11 - 12 April 2018
Estrel Convention Center, Berlin, Germany
http://www.idtechex.com/printed-electronics-europe/show/en/

Awards

PGS Group Awards

The PGS Group award two student presentation prizes each year. These prizes are open to all research students currently undertaking work at a university in the UK or Ireland, leading to a PhD or Masters degree, who present their work at the annual Printing and Graphic Science Group Student Conference. The Group will award two prizes of £50 for the best Student Presentations.

All presentations given at the Group's Student Conference are considered for the year's prizes. For more information on this year's conference please see our group calendar.

(Morgan Miles)

The 2016 Student Presentation Prizes were awarded as follows. Anna Fricker presented the first prize to Morgan Miles of Swansea University on “The Science behind flexographic Printing uniformity” (Morgan Miles).

Ms Fricker then presented the second prize to Tian Carey of Cambridge University on “Spray coating of thin films on 3 dimensional surfaces for a graphene based capacitive touch device”

(Tian Carey).

Research Student Conference Fund

http://www.iop.org/about/grants/research_student/page_38808.html

In 2016 the Group sponsored Tom Mitchell-Williams to attend the Applied Superconductivity Conference in Denver, USA. Here is his Conference report on ASC 2016

I attended the 50th anniversary Applied Superconductivity Conference (ASC) in Denver, Colorado between the 4th and 9th September 2016. It was a very successful conference, where I was able to make several new contacts and strengthen existing ones. Specifically, I received a proposal to start a collaboration with a research group in Houston, Texas.

Particular highlights of the programme included two of the plenaries, by Prof. David Larbalestier and Prof. Carmine Sentore. Both of who provided excellent overviews of the historical and recent progress in applied superconductivity. Also a talk by Prof. Wilfried Goldacker on a new cabling technique for superconducting tape provided the welcome news that there are large scale, particle accelerator applications that may require wider superconducting tape. This is particularly relevant for two significant projects in our research group on the use of stacks of superconducting tape as trapped field magnets.

Furthermore, the poster sessions were very valuable with the opportunity to discuss research in detail with a large number of international scientists. A particularly helpful poster provided information about a new open access database on the properties of superconducting wires available from commercial suppliers. Additionally, a paper presented by an Italian research group provided an insight into why some of our chemical solution routes, which we use to produce patterned superconducting films via inkjet printing, have failed and the potential remedy to correct the process. This will be especially important as I finish my PhD within the next six months.

My talk was well received and it was encouraging to hear from academics and commercial superconductor suppliers that they thought the concept I presented, on a new method for producing low AC loss superconducting tapes, was interesting and novel. The work has also strengthened an existing collaboration with both an industrial partner in Russia and academic partners in Slovakia.

The social schedule of the conference was generally very well organised and provided me with the opportunity for more informal networking, which has been important as I reach a critical stage in my academic career. The decision about whether to and then where to apply for post-doc positions has been influenced by the more informal meetings with researchers from different institutions.

After the intense conference schedule, I was able to see some of the “Mile High City” and take a break to explore Colorado further. It was my first trip to the USA and the Rocky Mountain National Park was a spectacular place to be able to spend time hiking after the conference.

Other Information

PGS Group on LinkedIn, Facebook and Twitter

The Group has pages on the LinkedIn, Facebook and Twitter social networking sites which are regularly updated with news items and details of upcoming events. We look forward to seeing you there.

LinkedIn

http://goo.gl/B0mds

We can be found by searching for the 'Printing and Graphics Science' group on LinkedIn or by following the link above. You will need to be a member of LinkedIn to view the page.

Facebook

http://goo.gl/vX0kC

We can be found by searching for the 'Printing and Graphic Science Group' on Facebook or by following the link above. There is no need to be a Facebook member to view the page.

Twitter

https://twitter.com/PGS_IOP

The PGS Group is now on Twitter @PGS_IOP.

This newsletter is also available on the web and in larger print sizes

The contents of this newsletter do not necessarily represent the views or policies of the Institute of Physics, except where explicitly stated.

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Note; There is a print and (soon) E book version of this Newsletter. The (free on Smashwords) E book includes colour images though not all E readers support colour graphics.