CHT Centre for Healthcare Technologies

Additive Manufacturing & 3D-Printing for Healthcare

Dr Ruth Goodridge – Faculty of Engineering

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

CHEATA

Nottingham University Hospitals NHS
NHS Trust

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Additive Manufacturing & 3D-Printing Research Group

- 100 academics, researchers and technicians dedicated solely to AM & 3DP research
- £10 million additive manufacturing laboratories, supported by state-of-the-art testing facilities.

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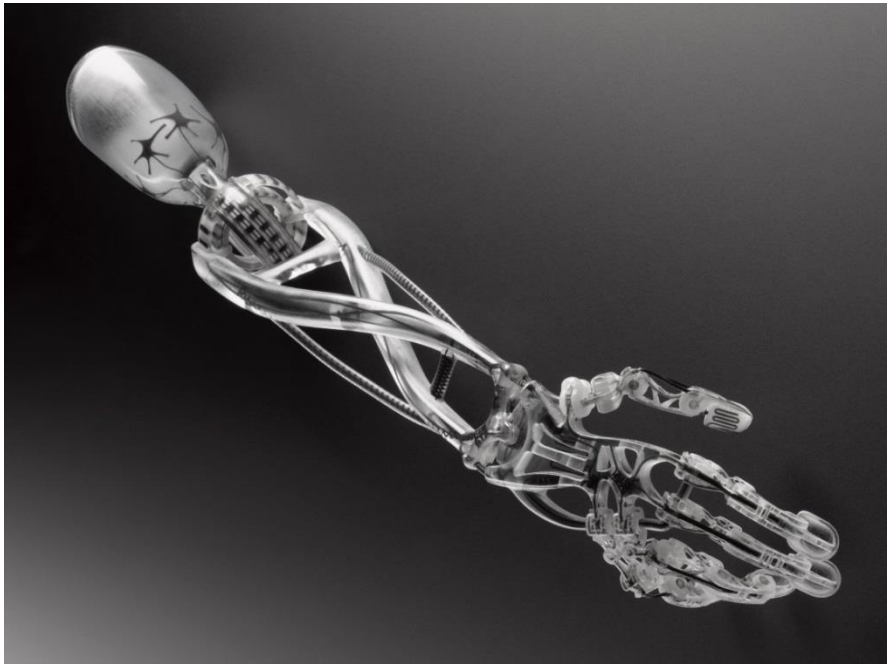
EPSRC Centre for Innovative Manufacturing in Additive Manufacturing



Produced for the Science Museum exhibition 3D: printing the future

Aim: To create multifunctional active devices & components in a single manufacturing step

Complex, multi-component parts without assembly.

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EPSRC Centre for Doctoral Training in Additive Manufacturing & 3D-Printing

- Materials, Processes, Design, Applications (inc. medical)

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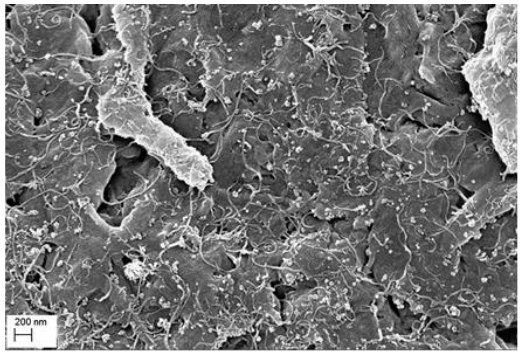
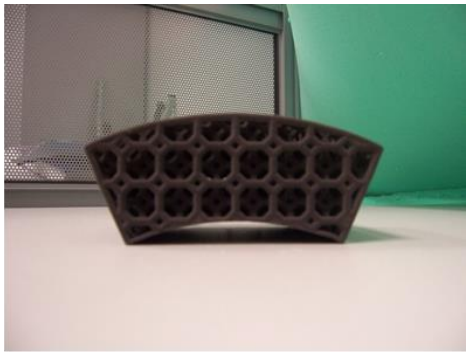
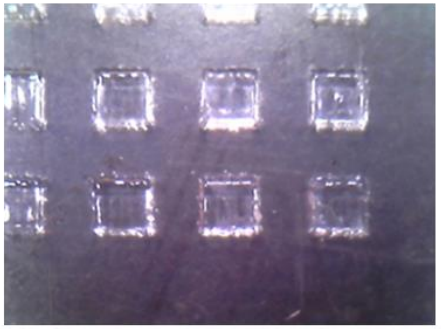
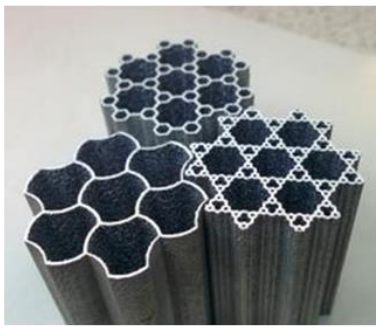
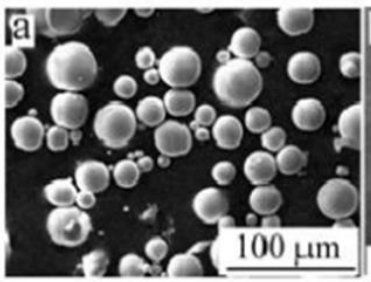
General Research Areas: **Materials**

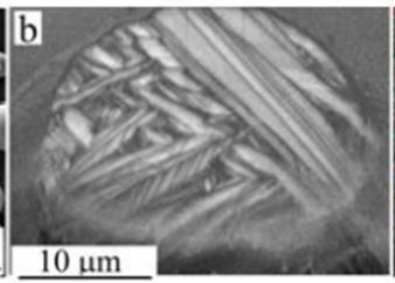


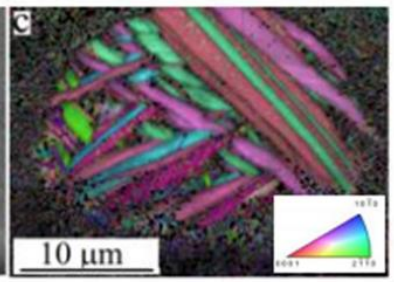


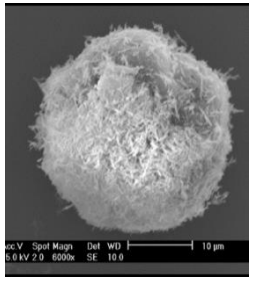












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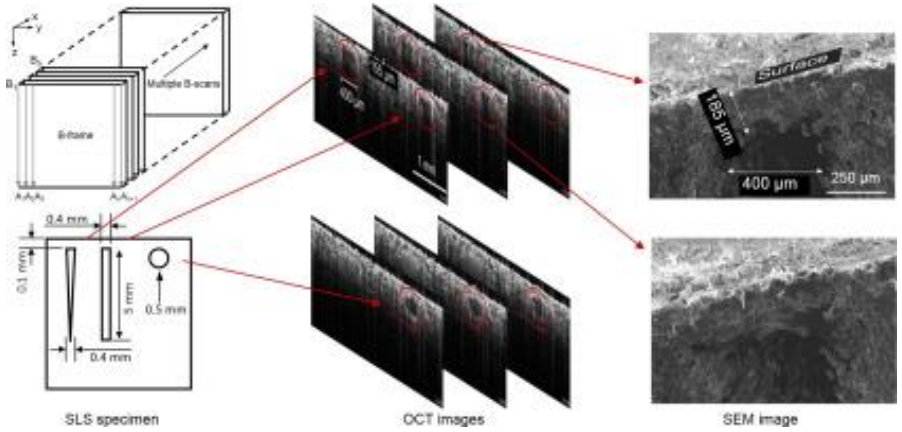
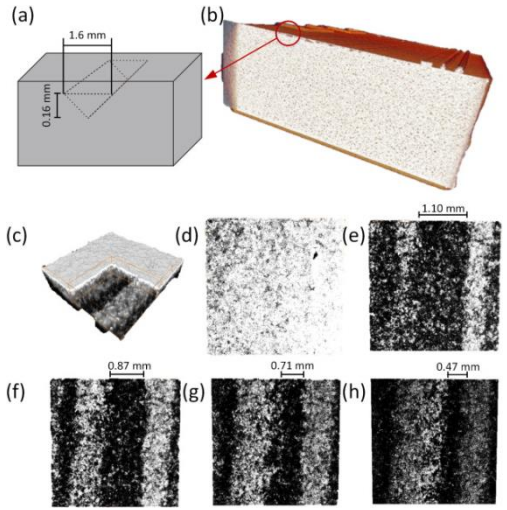
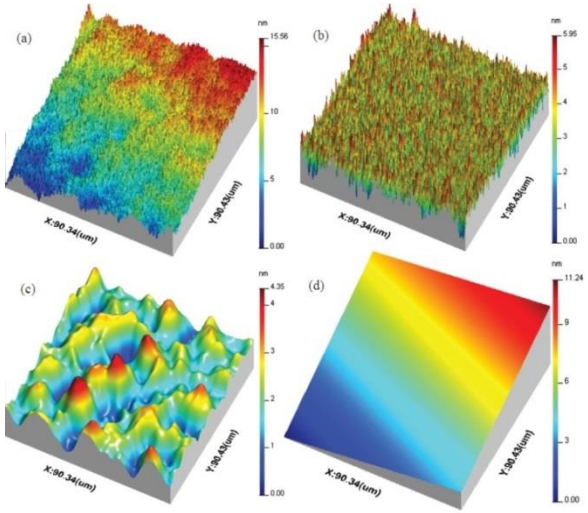
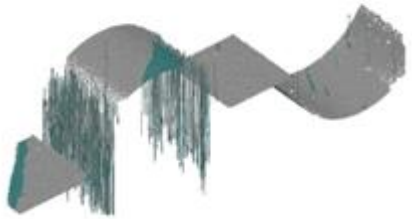
General Research Areas: **New Processes, Machine Design, System Control**

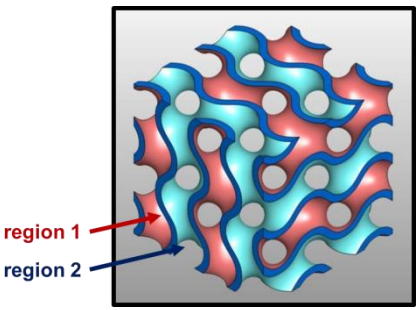


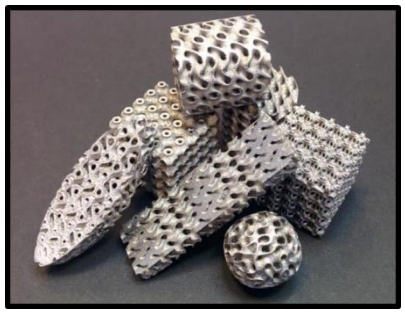


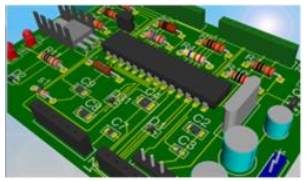


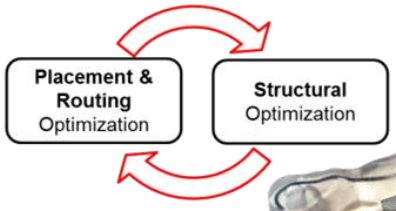


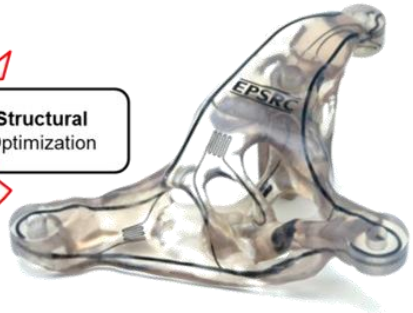
General Research Areas: **Design Tools**



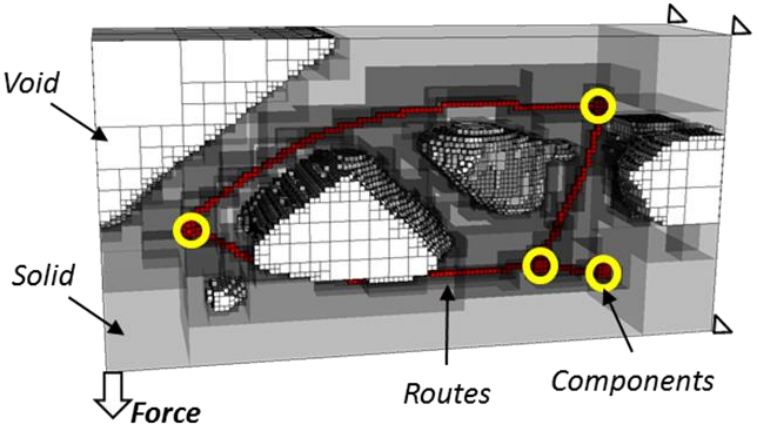




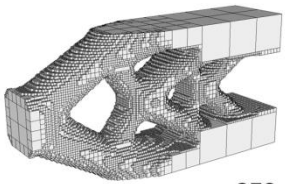




Functional density grading



Adaptive Meshing



Utilising topologically optimised solutions

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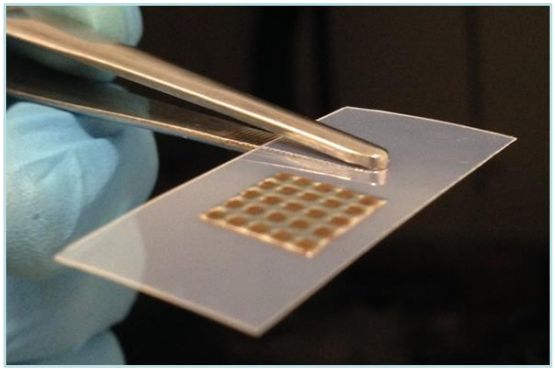
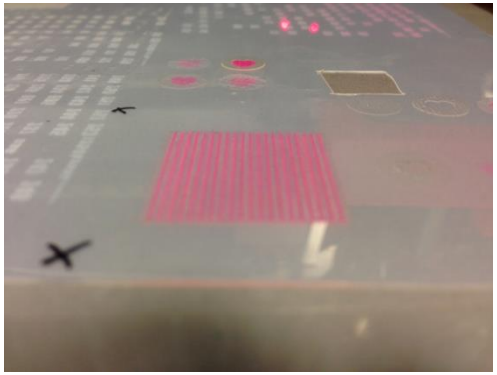
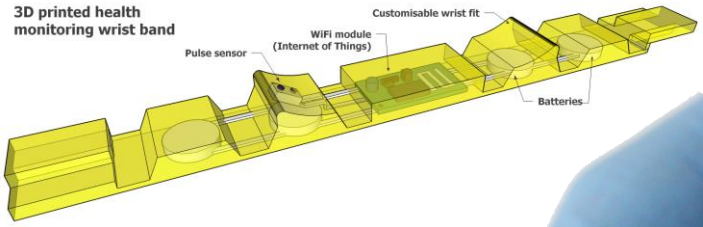
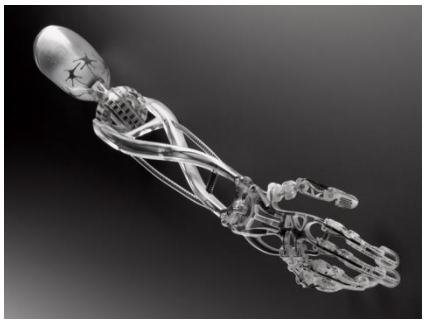
Multimaterial & Multifunctional AM

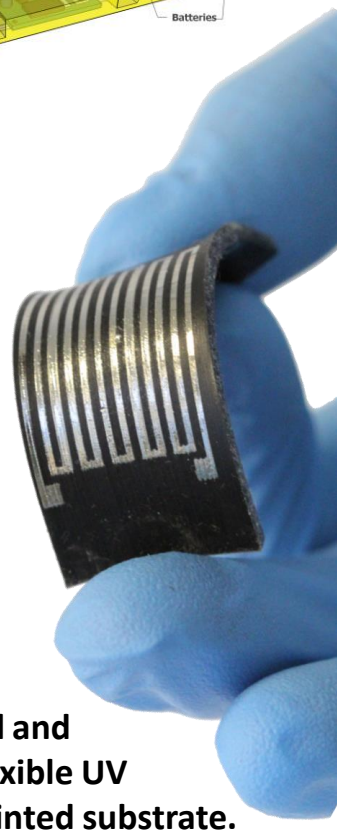




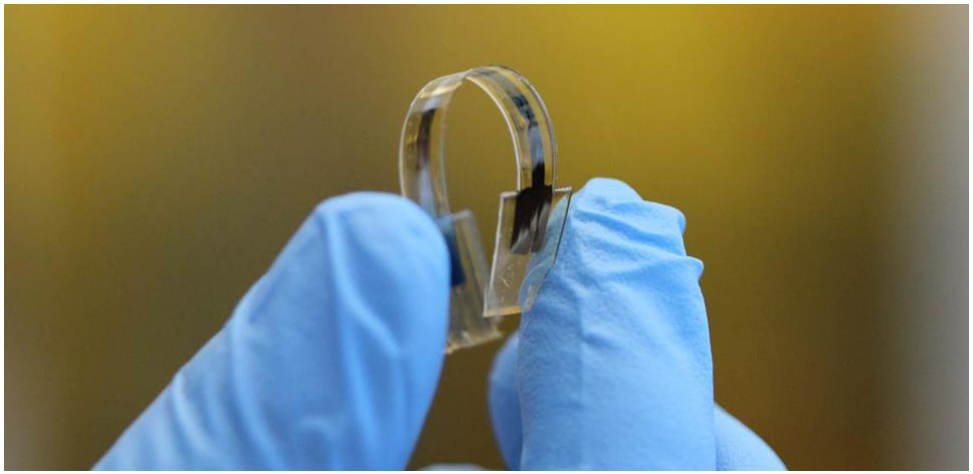
Electromagnetic responsive ink printed alongside SunChemical dielectric ink using LP50 printer.







Silver ink printed and sintered on a flexible UV curable inkjet printed substrate.



Flexible conductive track printed in a single process using silver and dielectric inks.

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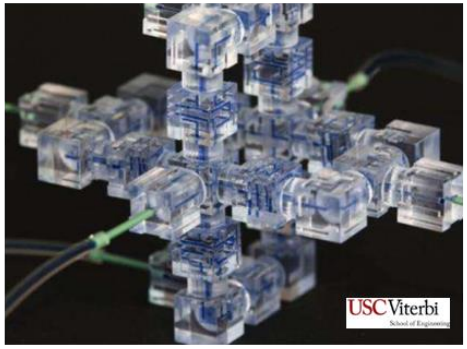
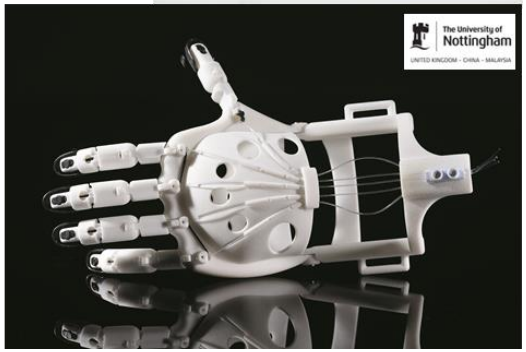
AM for Healthcare

- Increased Design Freedom – customised internal & external geometry
- Economic low volume production
- Patient-specific devices that can be modified as the user grows or treatment requirements change
- Manufacture at point of need
- Accelerated product development
- Integration of additional functionality
- Weight reduction & increased patient comfort





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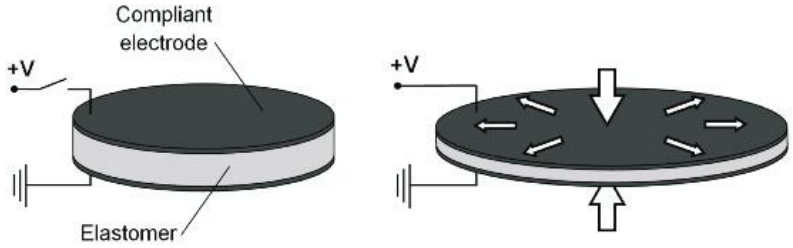
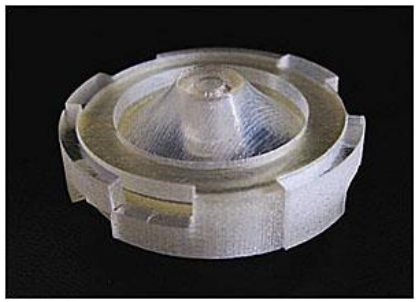
Project: **Wearable Soft Robotics for Independent Living** (EPSRC)

Ruth Goodridge, Asish Malas (UoN) + Universities of Bristol, Leeds, Strathclyde, Southampton, Loughborough, UWE



- Print multi-layer actuators using multimaterial AM
- Sequence of conductive/dielectric layers
- Very thin and consistent layers to increase EAP performance
- Focused on lower limb devices



Artificial muscle unit produced by AM

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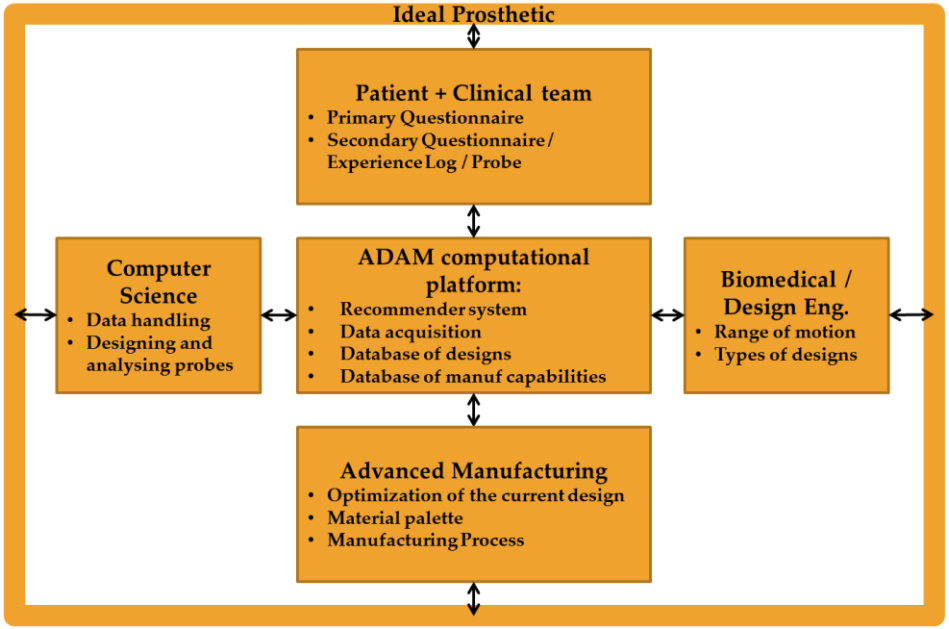
Project: **ADAM: Anthropomorphic Design using Advanced Manufacturing (EPSRC)**

Ajit Panesar, Ian Ashcroft, Ruth Goodridge, Stefan Egglestone, Steve Benford, Michael Valstar, Joe Marshall, Jon Garibaldi (UoN) and Amit Pujari (NUH)

Partners: University of Strathclyde, The Royal National Orthopaedic Hospital

- Identify the key (common) elements that will enable in the higher acceptance rates of adoption for a prosthesis.
- Employ learning algorithms and to mine vast amounts of data to extract meaningful information that will enable in a patients' need-specific device to be made.



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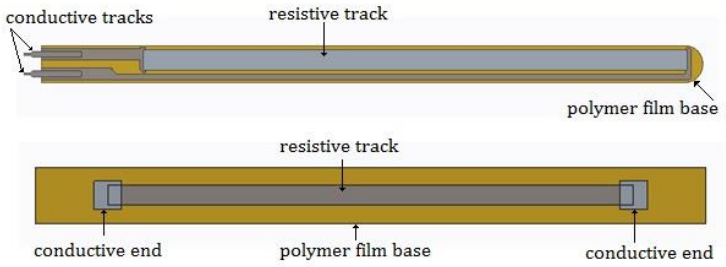
Project: **Multi-material AM Sensors for adding functionality to Upper Limb prostheses (UoN Studentship)**

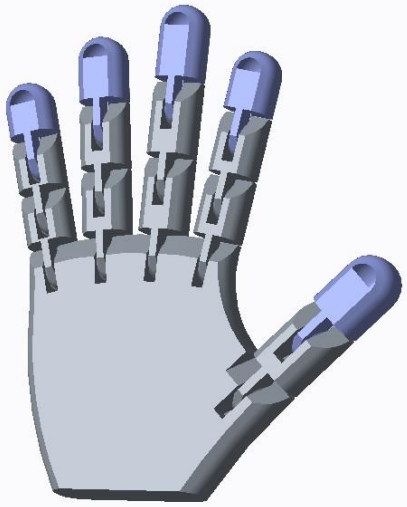
Trang Ngo Thuy, Ian Ashcroft, Ruth Goodridge, Ajit Panesar

Design and manufacture of sensors using multimaterial Additive Manufacturing processes, with the purpose of customisation and enhancing functionality of upper limb prosthesis.



Project's current focus:

- Design and manufacture of flex sensors and capacitive touch sensors by jetting.
- Bridging the gap between concept designs and the process' capabilities.
- Development of suitable experimental procedures for the characterisation of these sensors.



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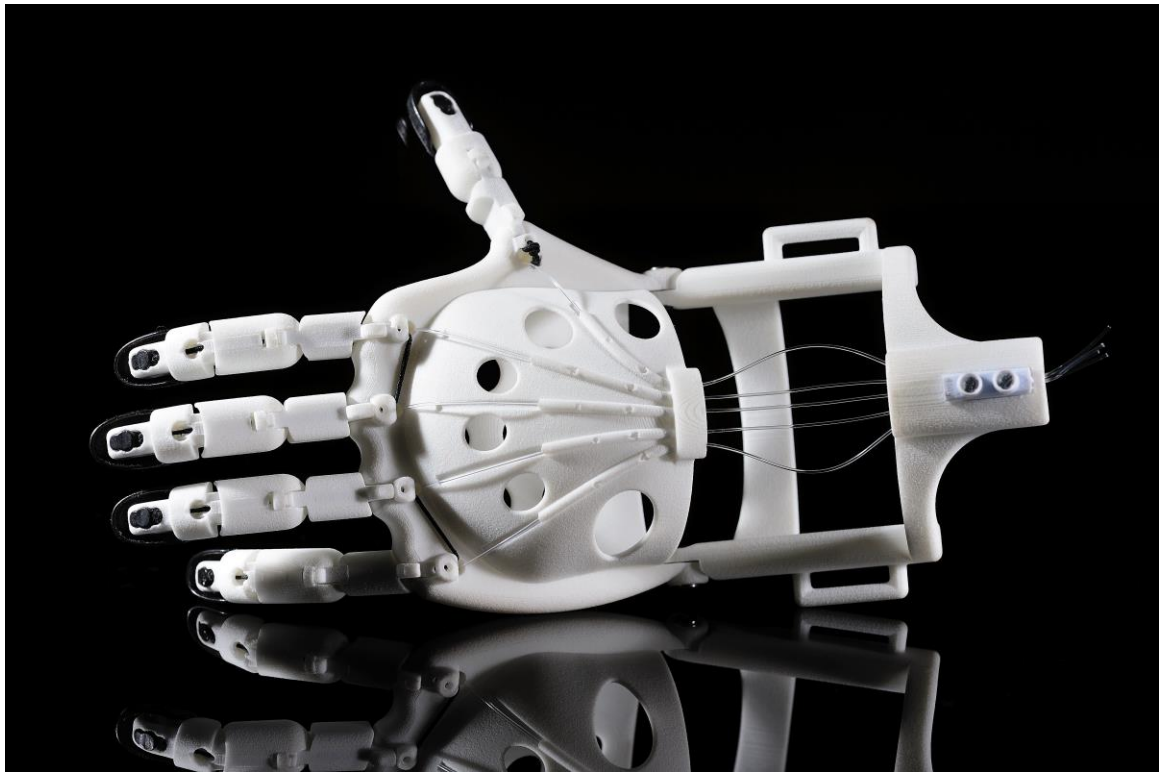
Project: **Outreach: Modified Robohand** **(EPSRC CIM in AM)**

Joe White, Mark East, Ruth Goodridge (UoN); Mark Croysdale (Royal National Orthopeadic Hospital)



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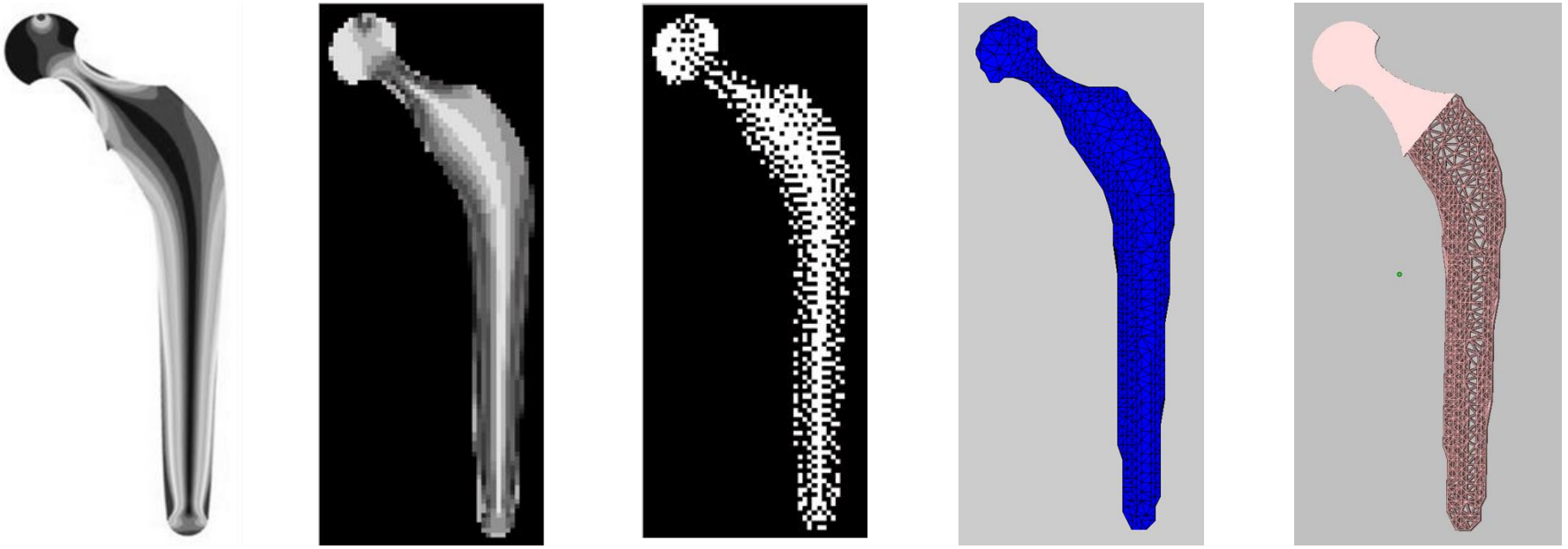
Project: **Selective Laser Melting of Functionally Graded Lattice structures with Intelligently Distributed Material Density for Biomedical Applications (EPSRC CDT in AM&3DP)**

Duncan Hickman, Ruth Goodridge, Ian Ashcroft, Richard Hague (UoN) + Materialise



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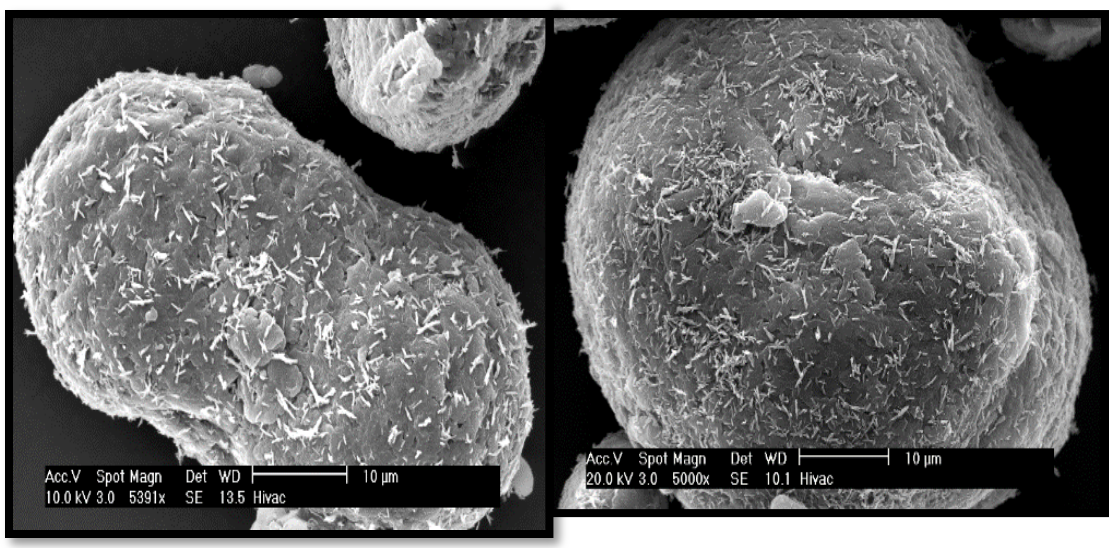
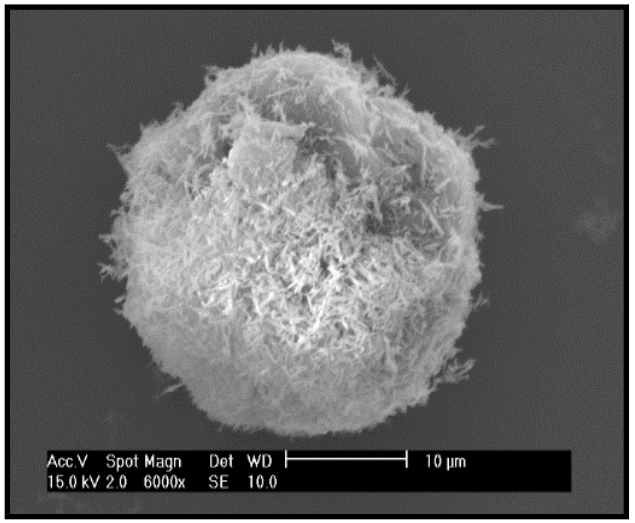
Project: **Producing osteoconductive scaffolds via laser sintering from polyamide powders coated with nano-hydroxyapatite (UoN Studentship)**

Dominic Hui, Ruth Goodridge, David Grant, Colin Scotchford



4wt% nano HA



20wt% nano HA

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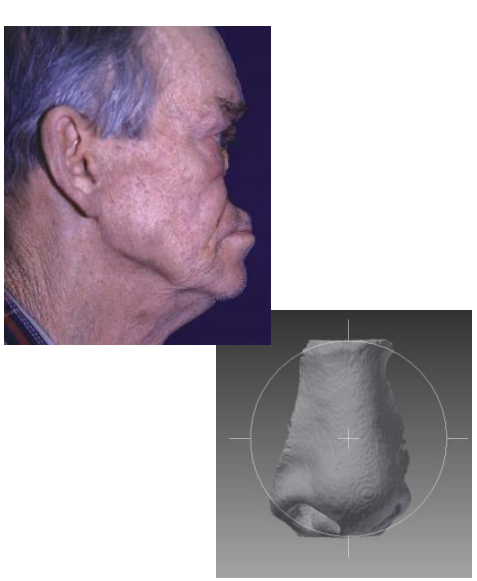
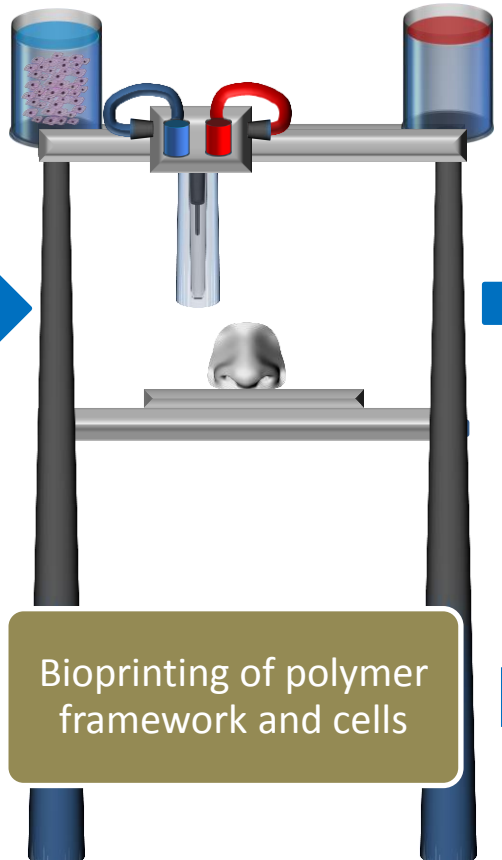
Project: Bio-printing personalised scaffolds for nasal reconstruction

(EPSRC Centre for Innovative Manufacturing in Regenerative Medicine)

Laura Ruiz Cantu, Andy Gleadall, Jing Yang, Callum Faris (NHS), Joel Segal, Kevin Shakesheff



Surgical assessment of patient and CT scan



Bioprinting of polymer framework and cells

Surgical implantation of personalised nose

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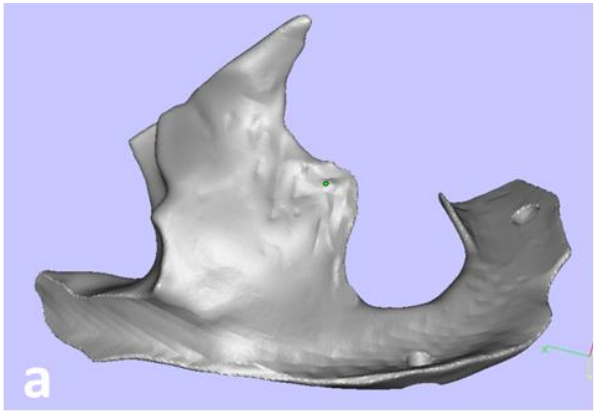
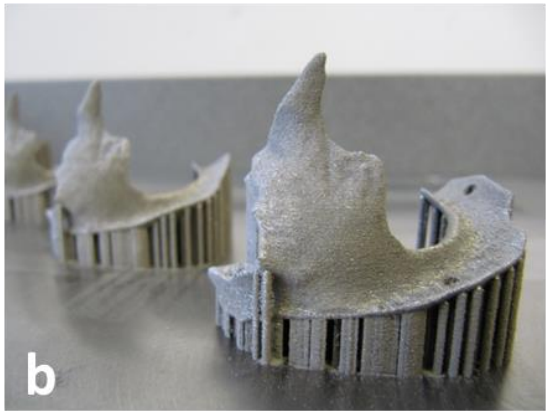
Project: **Additive Manufacturing and Surface Functionalisation of Biomedical Implants using Self-assembled Monolayers (SAMs)**

(UoN Studentship)

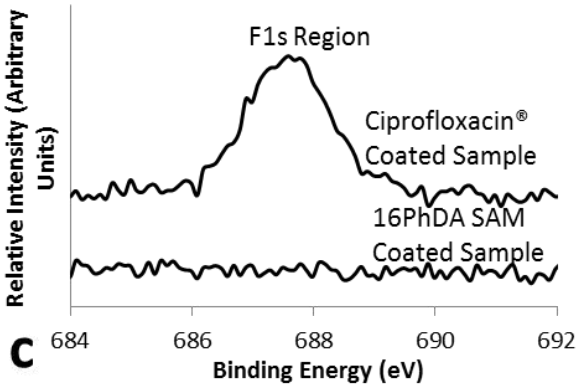
Jayasheelan Vaithilingam, Ruth Goodridge, Richard Hague, Steven Christie (Lboro), Steve Edmondson (Manchester)



Three dimensional (3D) model



3D model built using a selective laser melting (SLM) machine



Drug attached to self-assembled monolayers (SAMs)

Produce parts in SLM a machine → **Analyse the surface chemistry and chemically attach SAMs** → **Surface functionalisation with an antibacterial drug *via* SAMs**

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Project: **Metrology for Additively Manufactured Medical Implants (EMPIR)**

Donal McNally

- The overall objective of this project is to provide a comprehensive basis for a safe and cost efficient use of additive manufacturing products within the medical sector.

- £1.4 million EMPIR funding (Jun 2016 - Aug 2018)
  - 7 National Measurement Institutes
  - 9 Academic Partners
  - 4 Industrial Partners

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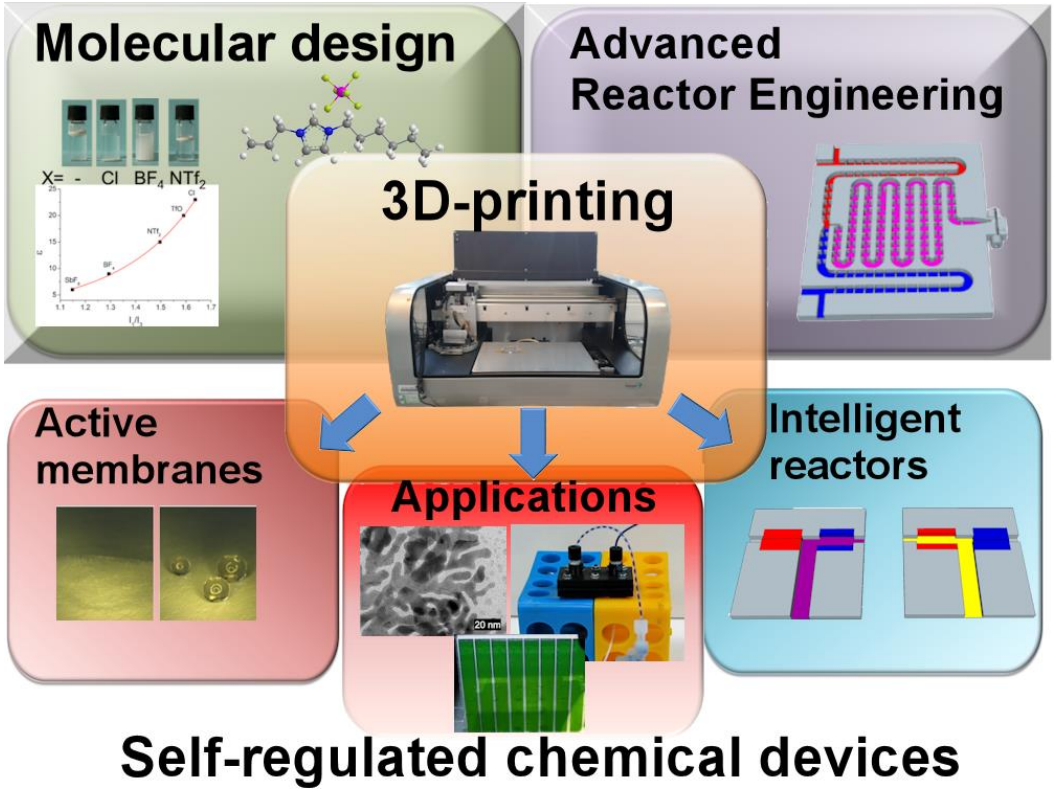
Project: **Complex Fluidic Architectures for synthesis, diagnostics and analytics**

Victor Sans Sangorrin, Ruth Goodridge, Erno Karjalainen, Jairton Dupont, Peter Licence, Darren Walsh



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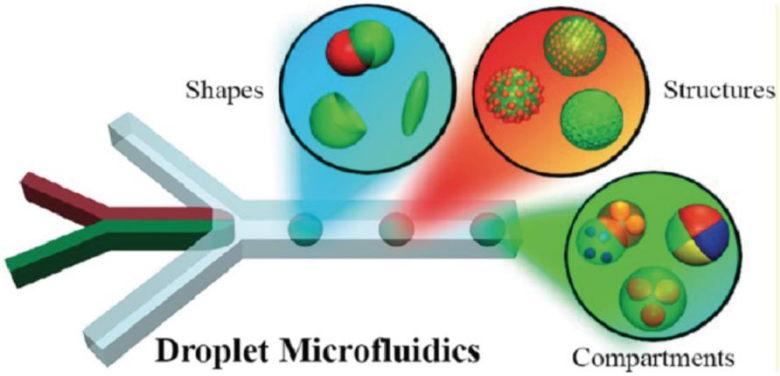
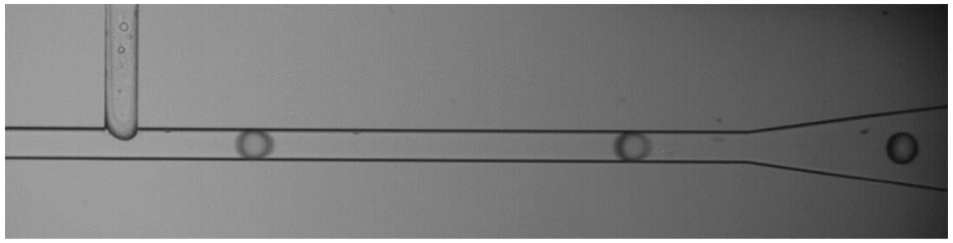
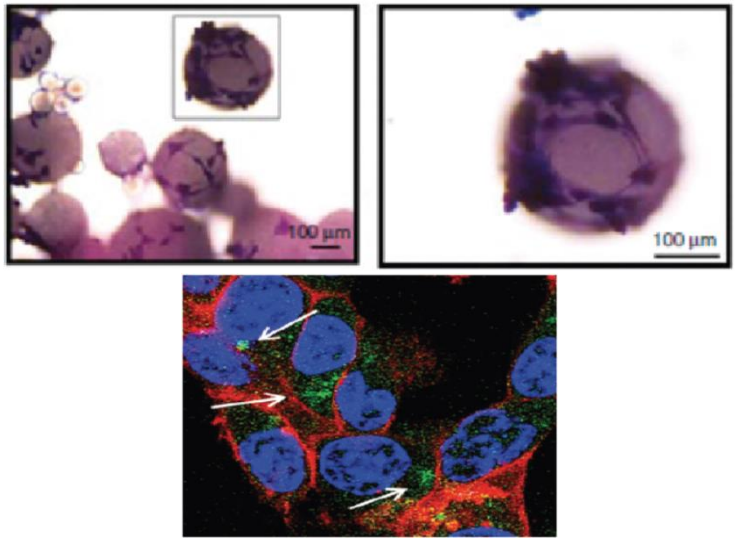
Project: **3D particulate libraries with microfluidics**
(EPSRC Next Generation Biomaterials Discovery)

Simon Haas, Amanda Hüsler, Derek Irvine, Ricky Wildman, Richard Hague, Morgan Alexander







Spherical particles with varying size and chemical composition

Variation of particles geometry for the best performing compositions

Influence of size, shape and composition of particles in biomedical applications?

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Project: **3D-Printed Tablets** (EPSRC, GSK, UoN, Astra Zeneca)

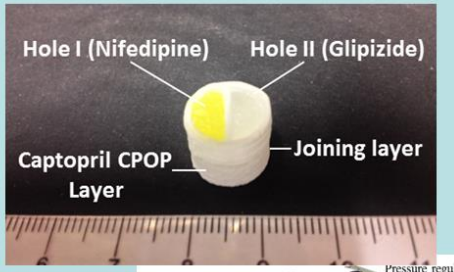
Ricky Wildman, Clive Roberts, Morgan Alexander, Chris Tuck, Richard Hague

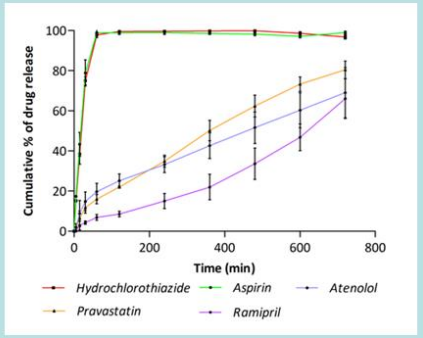
Printing the drug(s), the dose & the matrix to release when and where it is needed

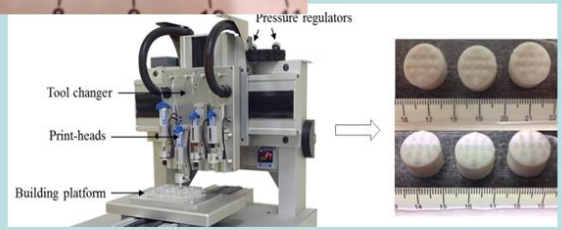
A FLEXIBLE SINGLE PLATFORM FOR DOSAGE FORM INNOVATION AND MANUFACTURE.

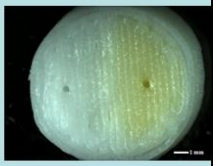
Fast disintegrating tablet

NEW GEOMETRIES,
NEW OPPORTINTIES.
THE POLYPILL MADE REAL.









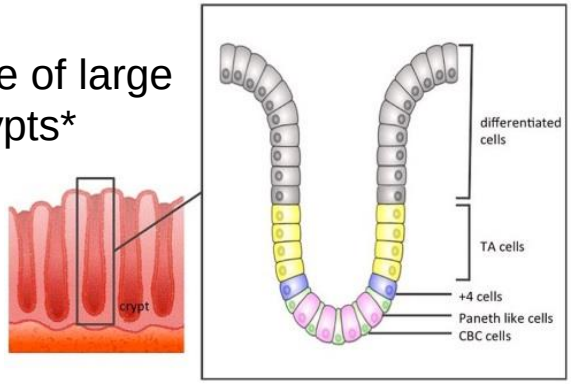
FACILITATING INNOVATION AND CHANGE IN DEVICE DESIGN.

CHT Centre for Healthcare Technologies

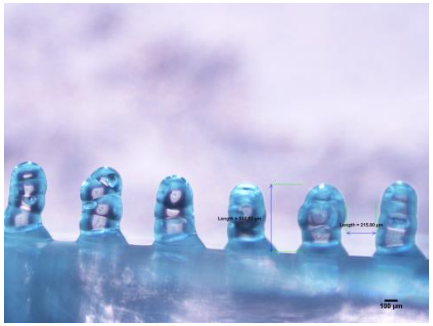
Project: **3D-Printing of Gelatine based structures for biomimetic applications (EPSRC CDT in Regenerative Medicine)**

Hagit Gilon, Rehma Chandaria, Elisabetta Prina, Felicity Rose, Ricky Wildman

The structure of large intestinal crypts*



A one-step rapid method for fabricating crypts scaffolds for exploring cells growth in culture



A side view optical microscope image of crypts scaffolds

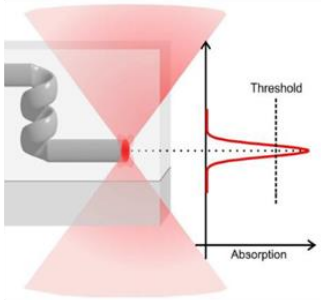
PicoDot LV (Nordson EFD) jetting valve

3D printing system

* M. Fujii and T. Sato. *Alterations of Epigenetics and MicroRNAs in Cancer and Cancer Stem Cell* (2014): 6-10

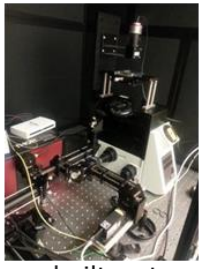
CHT Centre for Healthcare Technologies

Project: **3D micro/nano fabrication by multi-photon lithography (EPSRC, EOARD-USAF)** *Qin Hu, Richard Hague, Ricky Wildman, Chris Tuck*

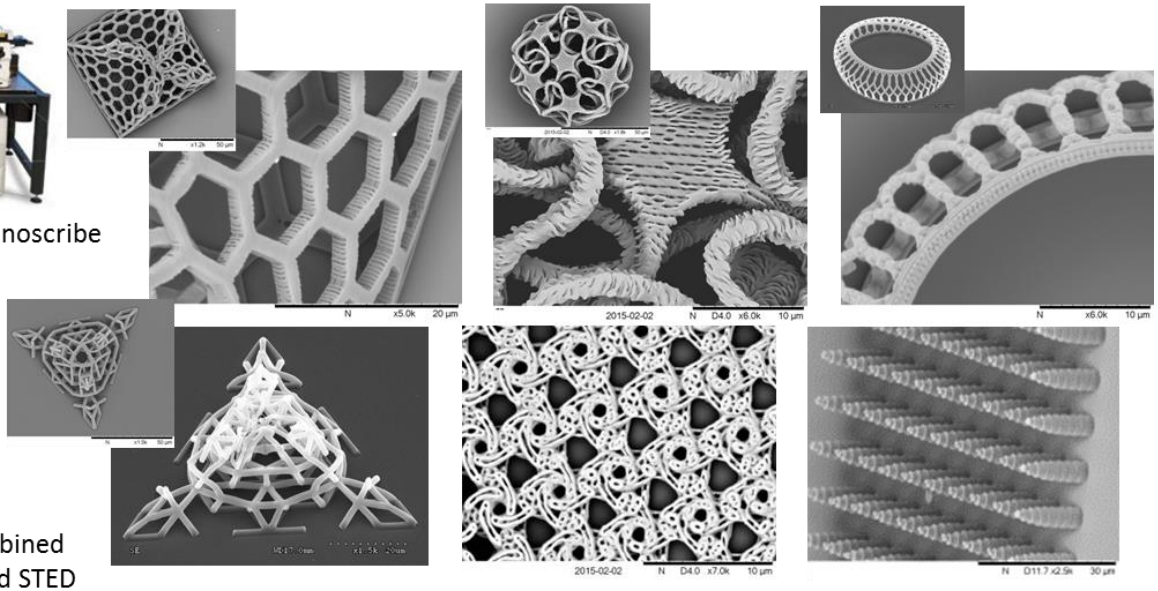


- Fabricate arbitrary 3D structures without a mask
- Feature size: ≤ 0.2 µm
- Overall dimensions: up to 100 x 100 x 1 mm^3
- Fabrication speed: up to 10 mm/s
- Materials: polymers, ceramics, metals & hybrid
- Bio-applications: scaffolds for cell culture, micro-needle for drug delivery, microfludics, biomimetics, …

Commercial system: Nanoscribe



Home-built system: combined with optical tweezers and STED

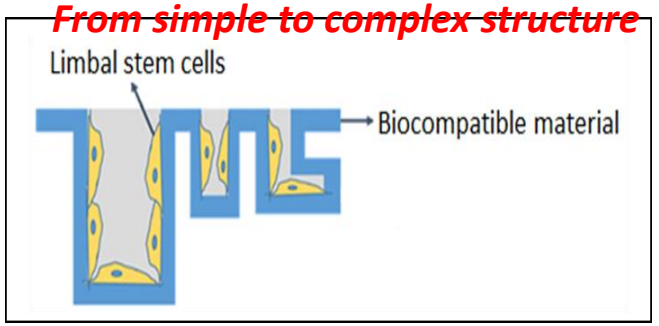


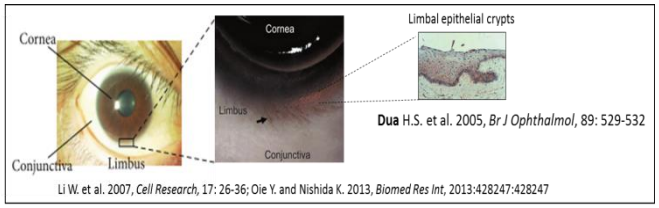
Centre for Healthcare Technologies

Project: **Laser Fabrication of 3D Limbal Epithelial Crypts: a first step towards cornea regeneration** (EPSRC, Innovate UK)

Elisabetta Prina, Laura Sidney, Jing Yang, Felicity Rose, Ricky Wildman

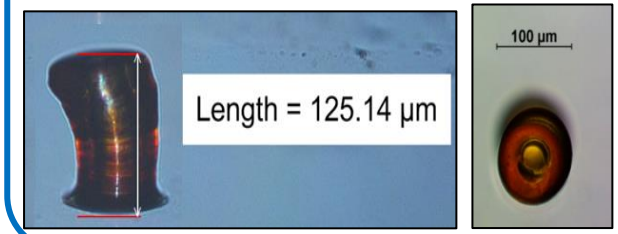
~~***From simple to complex structure***~~



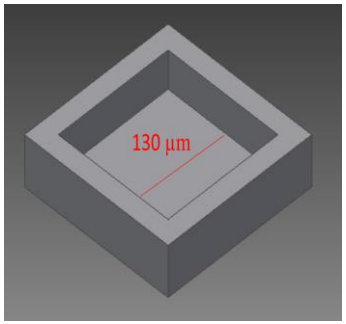


Technology:
Two Photon Polymerization system

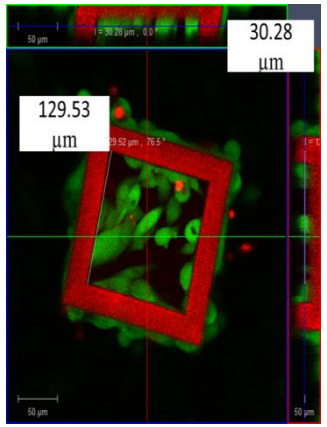
3D structures



CAD file



After cells seeding:
Live/dead staining



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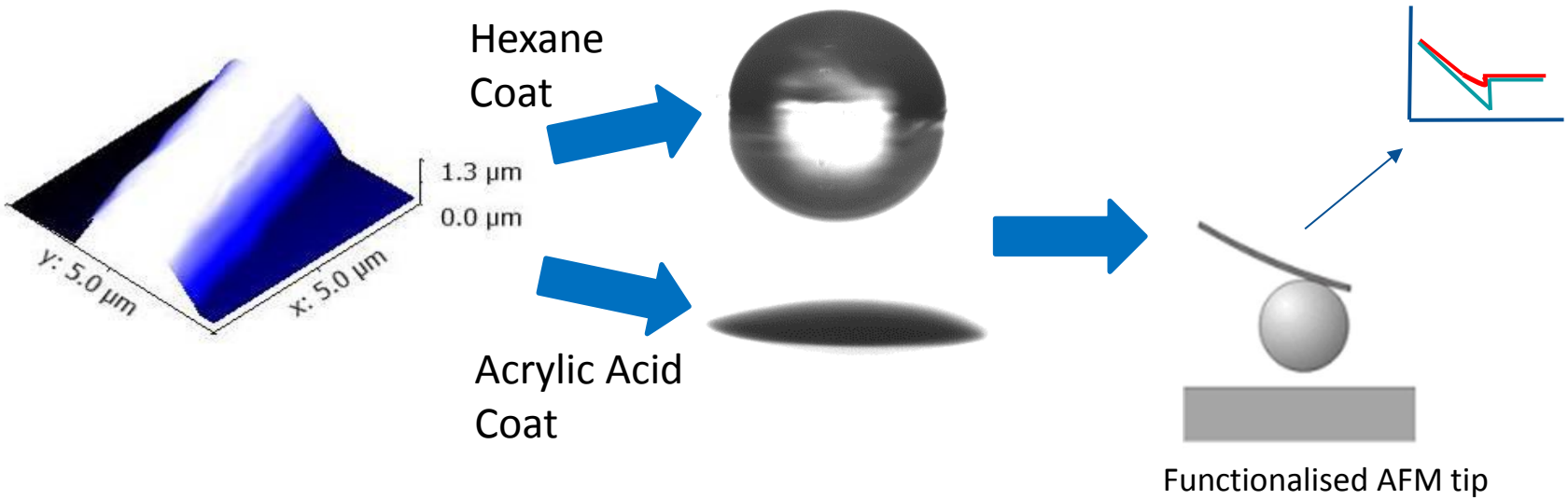
Project: **Powder Interaction: Surface Morphology or Chemistry?**
(EPSRC CDT in Targeted Therapeutics, Astra Zeneca)

Georgina Marsh, Clive Roberts, Morgan Alexander, Ricky Wildman, Matt Bunker



Produce + coat 3D printed surface → Produce surfaces with altered morphology or surface chemistry → Compare adhesion measurements

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Medilink Special Interest Group in 3D-Printing & Additive Manufacturing for Healthcare

"The 3D-Printing and Additive Manufacturing for Healthcare Special Interest Group (SIG) brings together researchers, healthcare professionals, industrialists and scientists to develop and explore the application of these technologies to relevant clinical need."

CHT Centre for Healthcare Technologies

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www.nottingham.ac.uk/research/groups/3dprg/

www.3dp-research.com/

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