Three Dimensional Inkjet Printing for Healthcare Technologies

Dr Jayasheelan Vaithilingam*, Dr Ehab Saleh, Dr Christopher J Tuck, Prof Ricky D. Wildman and Prof Richard J.M. Hague

EPSRC Centre for Innovative Manufacturing in Additive Manufacturing

Additive Manufacturing and 3D Printing Research Group,
School of Engineering, University of Nottingham

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

Background

- Additive manufacturing (AM) is a novel manufacturing method in which parts are usually built upon layers from a three dimensional (3D) model data as opposed to subtractive manufacturing technologies.
- 3D inkjet printing (3DIP) is a technique that recreates a 3D digital image by propelling droplets of ink successively to a substrate.
- 3DIP being a non-contact mode of printing, has numerous advantages including the ability to print complex geometries using multiple materials, low to no cost personalisation and net-shape manufacture.
- These unique benefits offered by 3DIP compared to the traditional manufacturing process has the potential to compliment/improve the existing needs in the healthcare/biomedical sector and possibly open-up new applications.

Aim

- To create 3D multi-functional parts by inkjet printing functional materials for electrical, mechanical, pharmaceutical and biological applications.

Research Areas

- Development of novel inks for inkjet printing.
- Inkjet printing of conductive and dielectrics inks for the electrical and electronics applications.
- Jetting of pharmaceutically relevant biomolecules/additives for solid dosage formulations.
- Jetting of hydrogels, cells, proteins and other biocompatible materials for healthcare/biological applications.
- Advancing inkjet printing to print 3D multi-functional parts with embedded electronics (conductors, semiconductors and dielectrics).

Facilities and Capabilities

- The additive manufacturing and 3D-printing research group has the state-of-the-art laboratory for AM comprising the following equipment.
  - Single Material, dual material and multiple material jetting system.

Fujifilm Dimatix® inkjet printing system (single head)

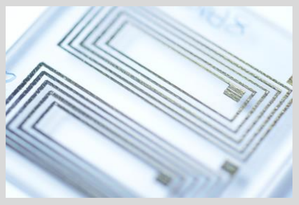
PiXDRO LP50® inkjet printing system (dual head)

JETx® inkjet printing system (six head); print head assemblies and infra-red and ultra-violet curing source

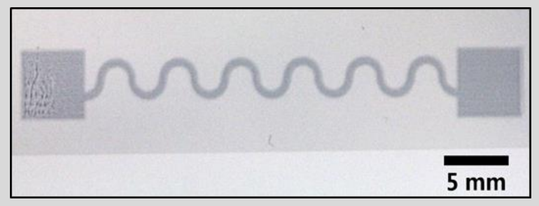
- In-house developed inkjet printing systems.
- Material characterisation equipment to optimise ink properties.

Multi-material/Multi-functional Printing

- Two-dimensional (2D) inkjet printing of conductive inks on 3D-printed dielectric structures and ceramic substrates.

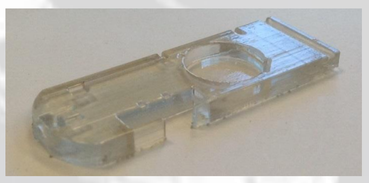


Silver nanoparticles printed and sintered on a dielectric (left) and glass substrate (right)

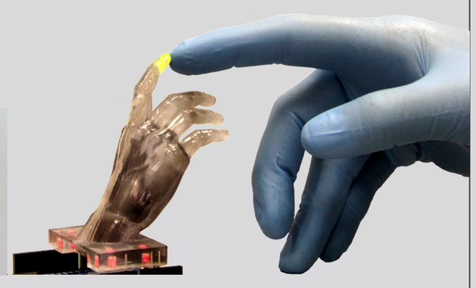


PEDOT:PSS printed and sintered on a glass substrate (right)

- 2D-printing of conductive tracks on printed 3D structures and assembly of electronic components.

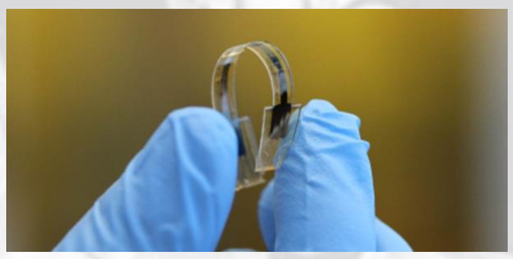


3D-printed part with electronics assembled

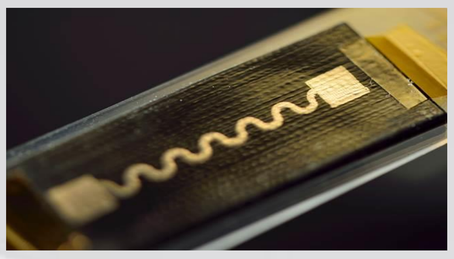


3D-printed capacitive touch sensor

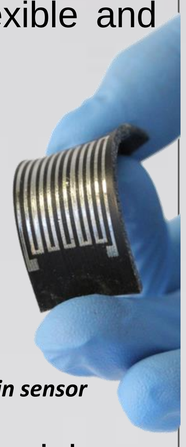
- Printing of conductive inks (metallic and polymeric) on flexible and stretchable 3d-printed substrates.



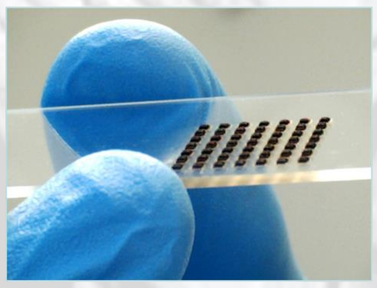
Fully 3D-printed flexible strain sensor



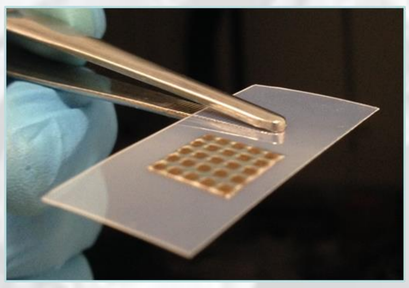
Fully 3D-printed flexible and stretchable strain sensor



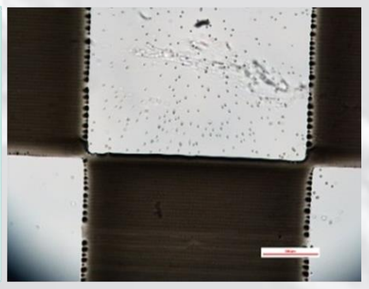
- Synthesis and 3D-printing of electromagnetic (EM) responsive ink.



Printed EM ink with Iron oxide

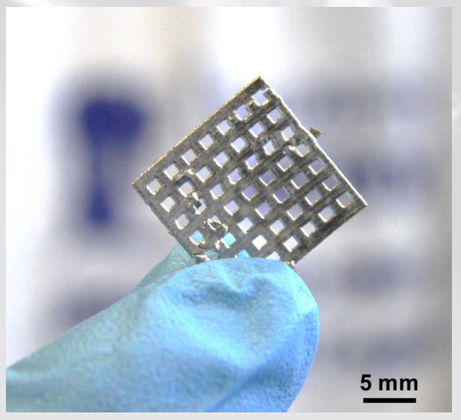


Encapsulated EM ink with Iron oxide within a dielectric material

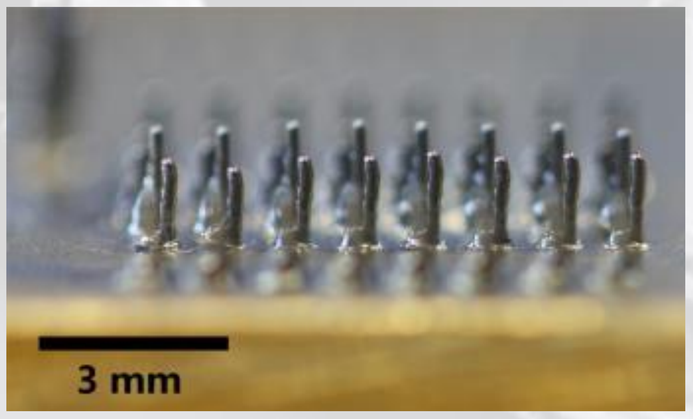


Printed EM responsive ink with carbon black

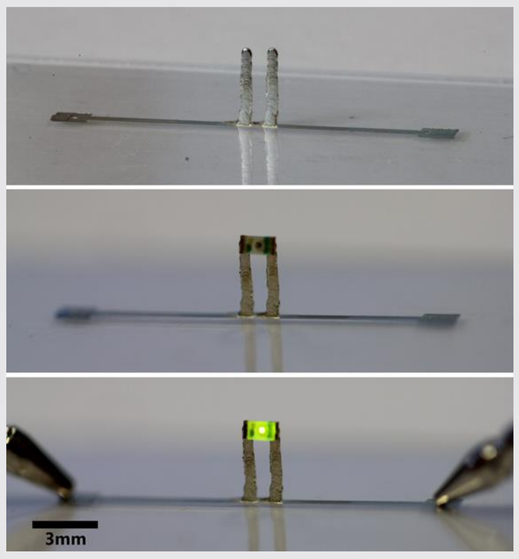
- Single step 3D-inkjet printing and curing of single and dual-materials.



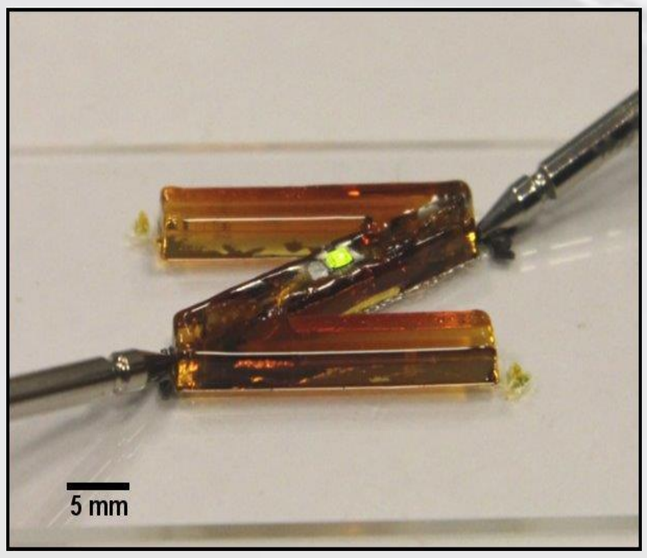
Printed mesh pattern with Silver nanoparticle ink



3D-inkjet printed pillars using silver nanoparticle ink



3D-inkjet printed pillars using silver nanoparticle ink (top); pillars assembled with a light emitting diode (middle); lighting-up of the diode (bottom)



3D-inkjet printed multi-material structure using a dielectric ink and conductive silver ink. The part assembled with a light emitting diode on top lights-up as current is passed from the bottom of the part

Contact: Jayasheelan.Vaithilingam@nottingham.ac.uk