UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Inkjet Printing: Fundamentals to Applications"

Prof. **Brian Derby**

University of Manchester, UK

Brian.Derby@Manchester.ac.uk

Short Abstract:

Inkjet printing concerns the precise positioning of drops of fluid in the picolitre regime to fabricate 2D and 3D objects. Starting as a tool for graphic output from classical computing it has developed into a ubiquitous digital printing tool with applications in printed and large area electronics, additive manufacturing or 3D printing, precision dosing in pharmaceuticals, and tissue engineering or regenerative medicine. This course will begin with a review of the fundamental fluid physics of the inkjet process, the behavior of drops on substrates, drying or solidification of drops and the design of inks. It will cover the types of inkjet printing and their applications across a range of engineering applications and include a number of case studies across a range of disciplines including: marking and coding, graphics, printed electronics, 2D materials, 3D powder bed printing, 3D additive printing, and printing biological macromolecules and living cells.

Course Contents in brief:

- Review of fluid physics: capillary and advective flow, dimensionless numbers, drop formation, drops in flight and on surfaces, the contact angle.
- A brief history of inkjet printing, practical methods for drop generation, Continuous Inkjet Printing (CIJ) and Drop on Demand Printing (DOD). Introduction to applications.
- Introduction to inks. Inks for marking, coding and 2D graphics. Components of inks, required fluid properties. Drop generation, satellite drops, ink design.
- Drops on surfaces: impact, splashing, spreading and equilibrium. Building objects from drops. The stability of structures on surfaces. advancing and receding contact angles and the stability of a printed line.
- Drop drying and the coffee ring defect. Fluid flow in drops controlling the shape of a drying drop.
- Gelling inks, UV cure inks, hot melt inks.
- Printing on real surfaces, effect of roughness and porosity. Printing on paper and textiles.
- Inkjet 3D printing. Printing on a powder bed. Drop infiltration: Washburn equation. Binderjet printing, high speed sintering. Direct 3D printing.

- Inkjet printing for large area electronics, printing conducting tracks, limits to resolution, filling wells and drop drying.
- Inkjet bioprinting, printing biomacromolecules, printing cells.

Total # of hours of lecture: 16 Hours

References:

1. Inkjet printing of functional and structural materials - fluid property requirements, feature stability and resolution, **B. Derby**, *Ann. Rev. Mater. Res.* **40**, 395-414 (2010).
2. Inkjet printing ceramics: from drops to solid, **B. Derby**, *J. Europ. Ceram. Soc.* **31**, 2543-50 (2011).
3. Printing and Prototyping Tissues and Scaffolds. **B. Derby**, *Science,* **338**(6109), 921-6 (2012).

CV of the Teacher

See the attached CV

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – time

Day2 – time

Day3 – time