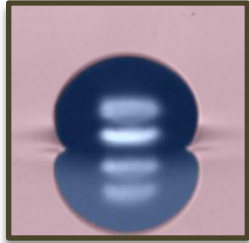


Advanced manufacturing research: A pathway from lab to commercial scale

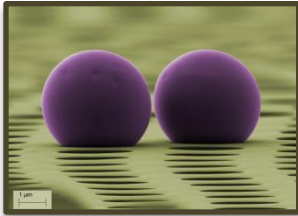
– **Dr. Ronan Daly**
14th May 2015

Introduction

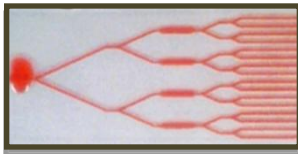
- Fluids in Advanced Manufacturing



1. **Soft Matter Manufacturing Research**



2. **New Digital Manufacturing for Sensor Technologies**



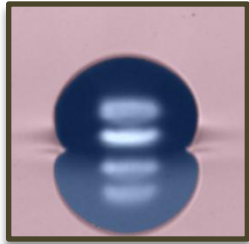
3. **Manufacturing of Devices**



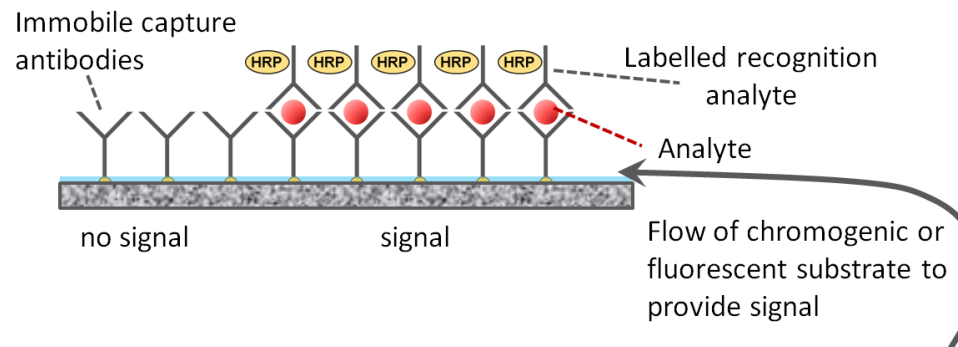
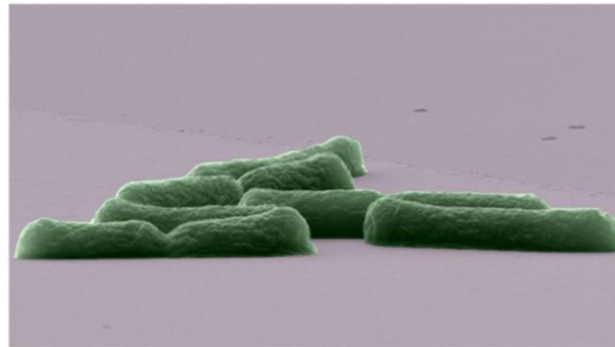
4. **Pathways to Manufacturing and Scale-up**

Introduction

- *Fluids in Advanced Manufacturing*

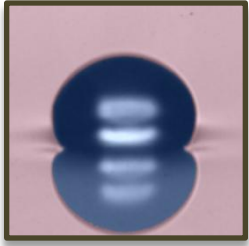


1. Soft Matter Manufacturing Research



Introduction

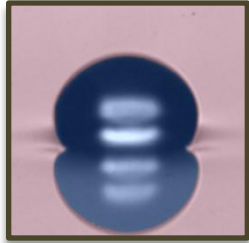
- Fluids in Advanced Manufacturing



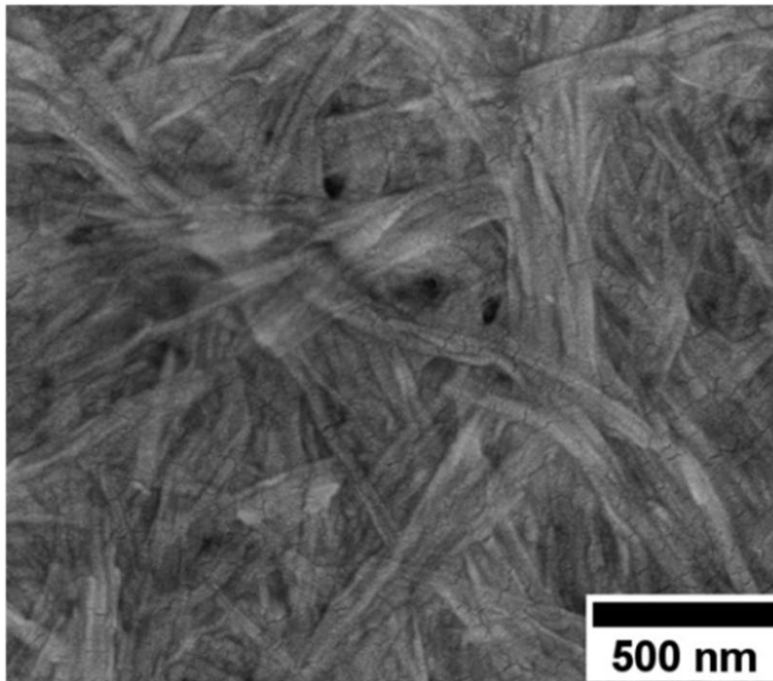
1. **Soft Matter Manufacturing Research**
 - **Supramolecular polymers**
 - **Self-assembling molecules**
 - **Manufacturing challenges**

Introduction

- *Fluids in Advanced Manufacturing*

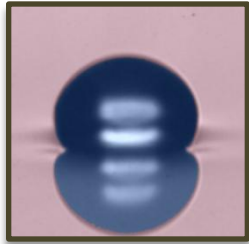


1. Soft Matter Manufacturing Research

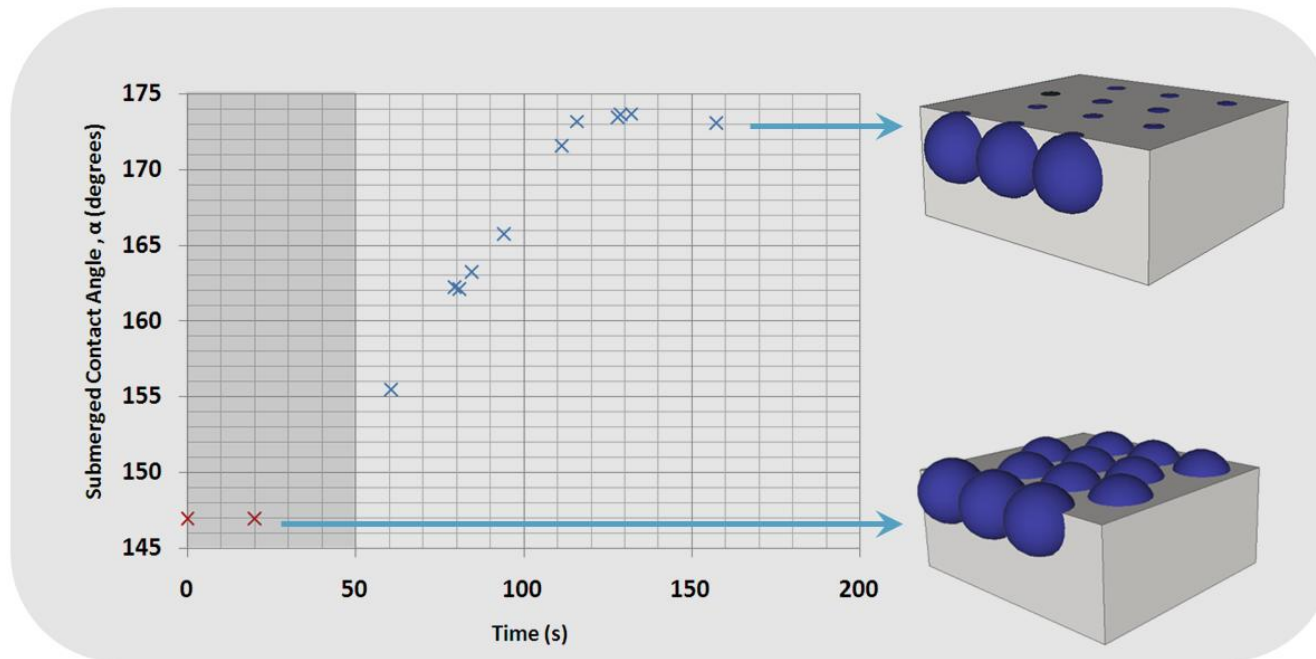


Introduction

- *Fluids in Advanced Manufacturing*

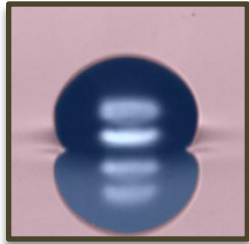


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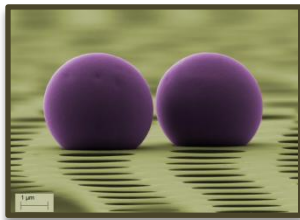


Introduction

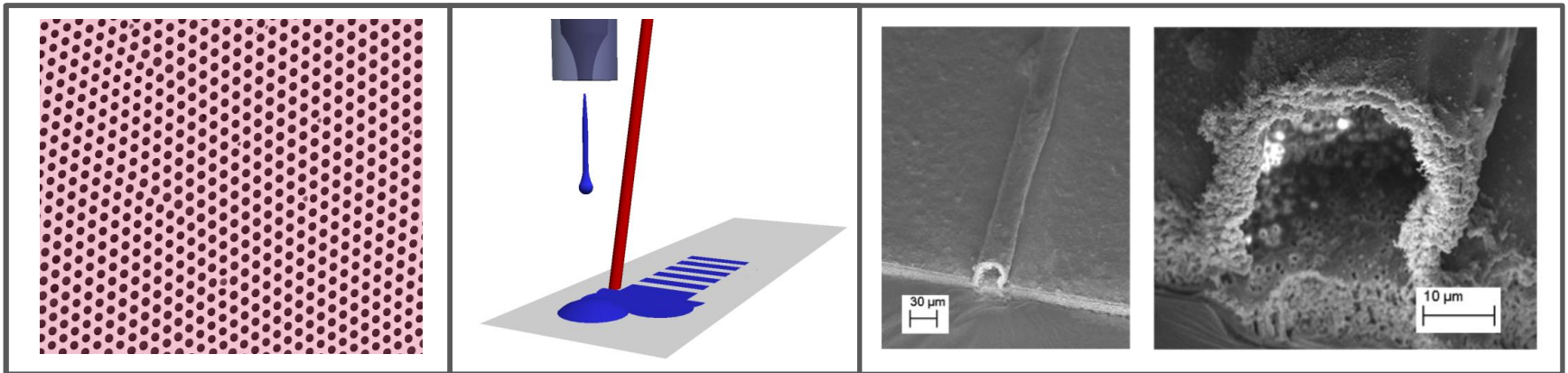
- *Fluids in Advanced Manufacturing*



1. **Soft Matter Manufacturing Research**

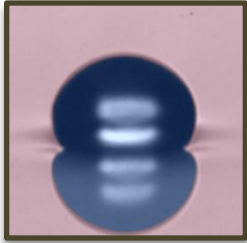


2. **New Digital Manufacturing for Sensor Technologies**

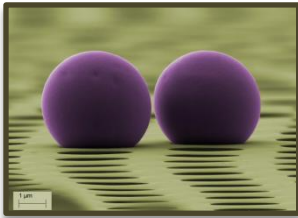


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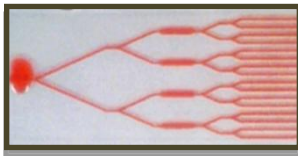
- Fluids in Advanced Manufacturing



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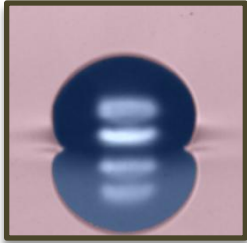
2. **New Digital Manufacturing for Sensor Technologies**



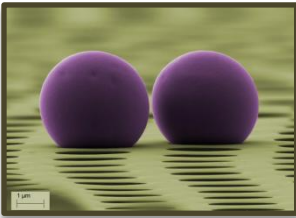
3. **Manufacturing of Devices**

Introduction

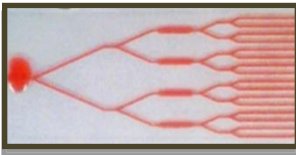
- Fluids in Advanced Manufacturing



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2. **New Digital Manufacturing for Sensor Technologies**

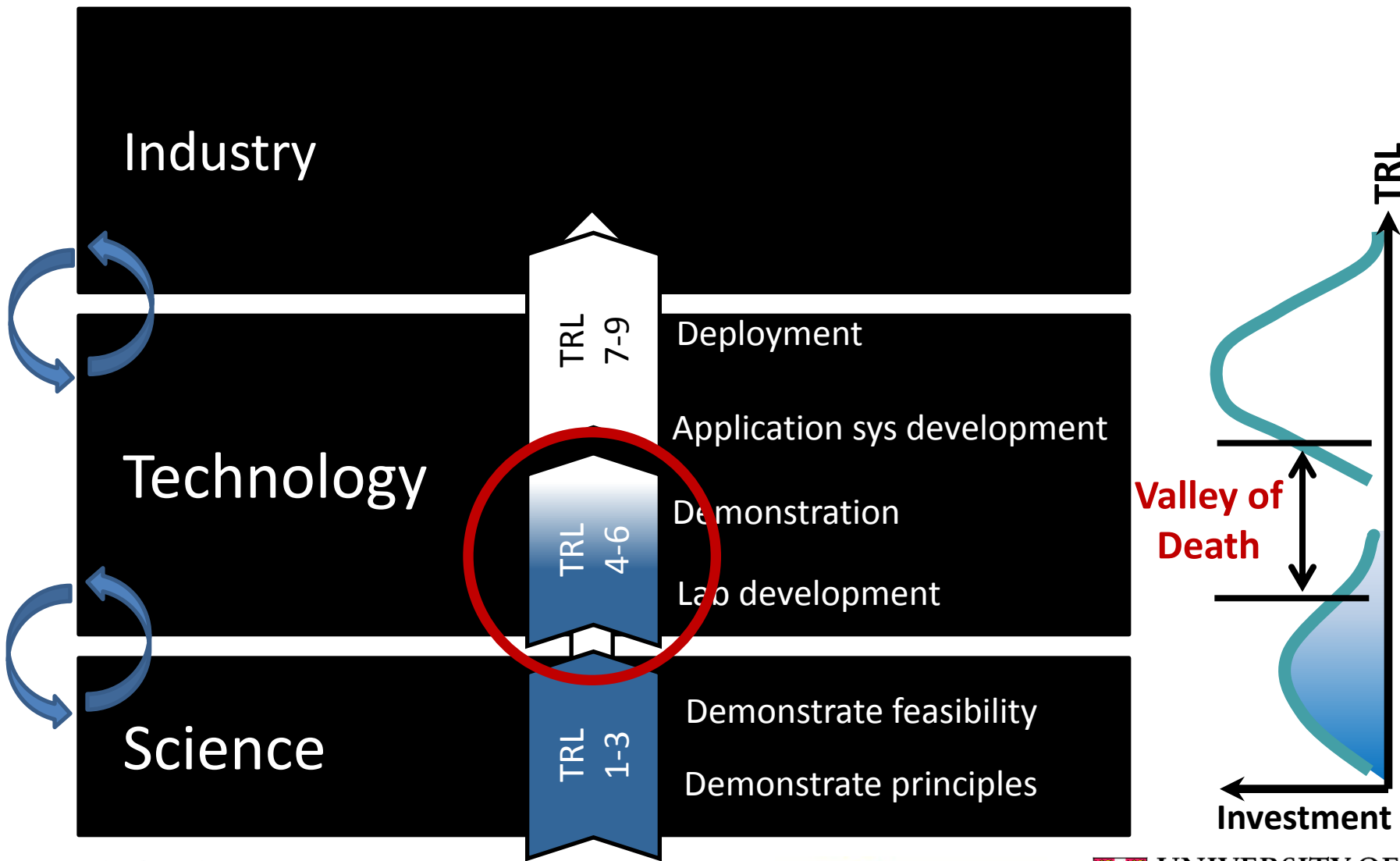


3. **Manufacturing of Devices**



4. **Pathways to Manufacturing and Scale-up**

Pathways to Manufacturing



Pathways to Manufacturing

- Anticipating industrial challenges of emerging technologies

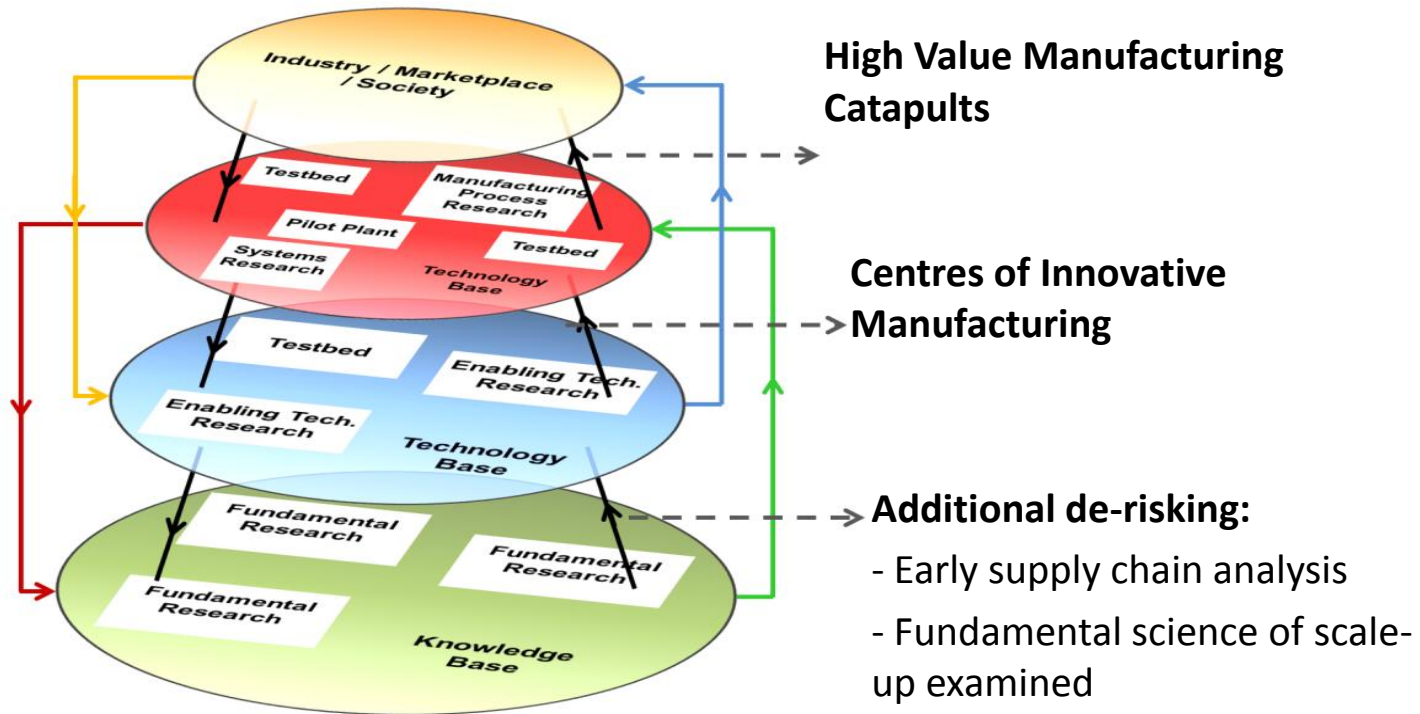
- **De-risking earlier** to enable downstream impact
- Research guided by **downstream demands** at very early stages
- **Fundamental science** to solve manufacturing challenges
- Starting point: Department of Defense, Manufacturing Technology Program.

Manufacturing Readiness Threads

1. Technology and industrial base capabilities
2. Design
3. Cost and funding
4. Materials
5. Process capability and control
6. Quality management
7. Manufacturing personnel
8. Facilities
9. Manufacturing management

Pathways to Manufacturing

- Anticipating industrial challenges of emerging technologies



Pathways to Manufacturing

- Anticipating industrial challenges of emerging technologies

- Learn from **academic and industrial** researchers
- What have you learned to look for?
- What are the first questions you ask?

- Incorporate into project design
- Manufacturing research has to consider downstream implications

E.g.

- *Required advances in measurement*
- *Availability of critical materials*
- *Novel production technology capabilities*
- *Regulatory requirements*
- *Supply chain maturity/stability*

Pathways to Manufacturing

- International focus

Bridging the valley of death: improving the commercialisation of research

- House of Commons Science and Technology Committee, March 2013

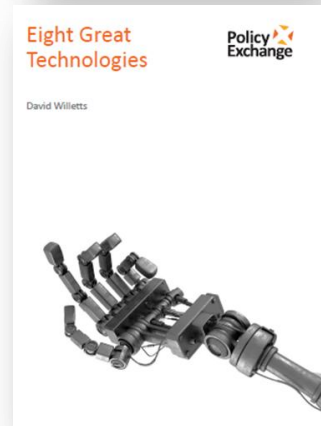
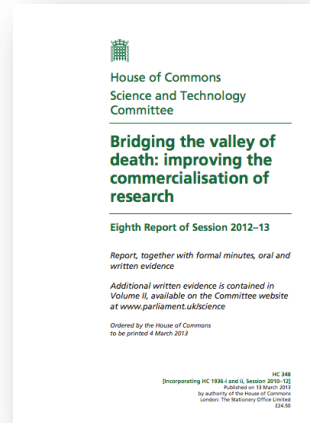
- Success of the UK economy → **translating science base** to generate new businesses
- **No single valley of death**
- Create commercial demand for university engagement
- Engage research base with the innovation agenda

Eight Great Technologies - David Willetts, Policy Exchange, January 2013

- A new impetus for **converting discoveries into commercial opportunities**

High Value Manufacturing Strategy – Technology Strategy Board, 2012-2015

- **Application of technical expertise** to the creation of products, production processes
- Potential to bring sustainable growth and **high economic value to the UK.**



Pathways to Manufacturing

- International focus

A European Strategy for Key Enabling Technologies

– ***A bridge to growth and jobs, European Commission, June 2012***

- KETs: Important role in sustainable competitiveness and growth
- **Combine research and innovation** under Horizon 2020
- Translating research into **economic growth**
- mKET **Pilot Lines** initiative

Report of the MIT Taskforce on Innovation and Production

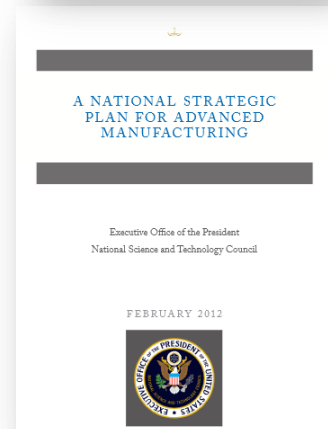
- MIT, February 2013

- Innovation **critical for economic growth** and productive society
- Gains from co-location have not disappeared.
- Linking **innovation to production** → growth of industrial America.

A National Strategic Plan for Advanced Manufacturing

- Executive Office of the President National Science and Technology Council, *February 2012*

- **Acceleration of innovation** for advanced manufacturing → **bridge gap** between R&D activities and domestic production.

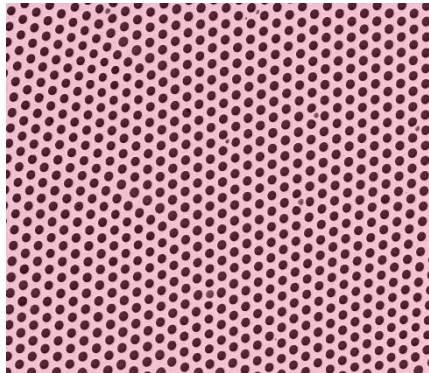


Pathways to Manufacturing

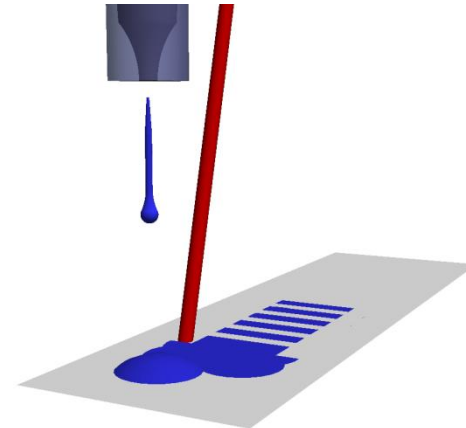
- Link to lab-based manufacturing research

2 Examples

Microengineering by
liquid manipulation



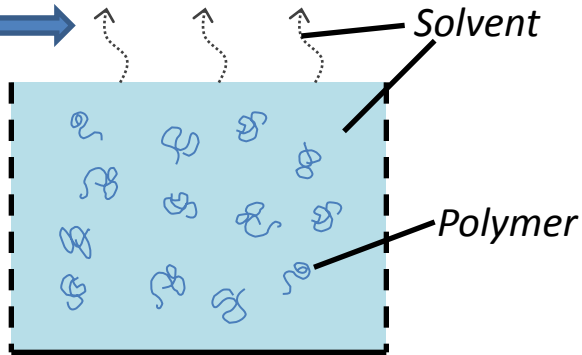
Inkjet and Laser
Engineering



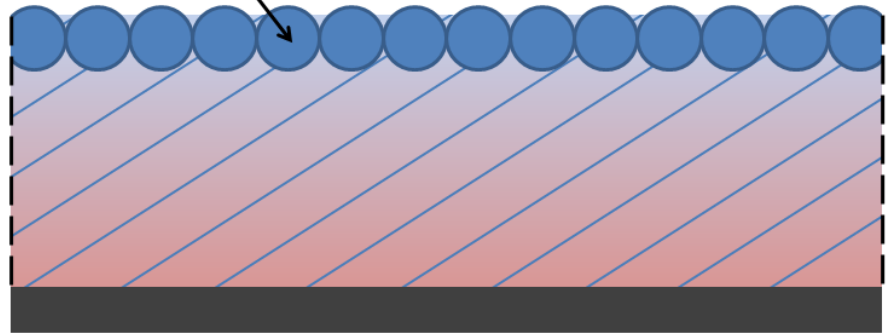
Example 1: Water Droplets

Three Component System

Water



Water condenses onto liquid surface

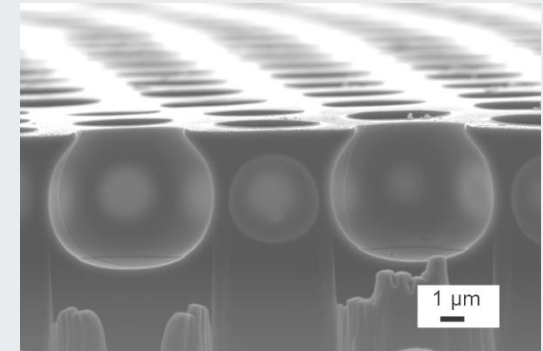


Chloroform, Dichloromethane,
Toluene, Butyl Acetate

3-3.5% w/w polymer in solvent

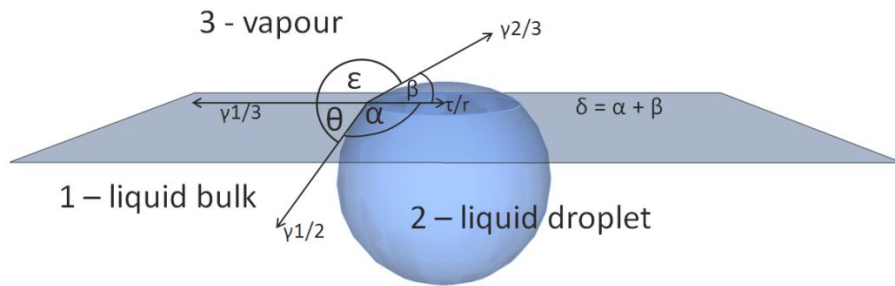


Imprinting Droplet
Shape in Polymer



Example 1: Water Droplets

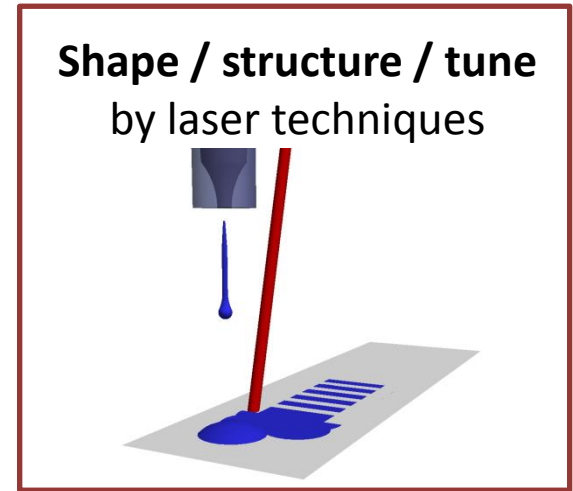
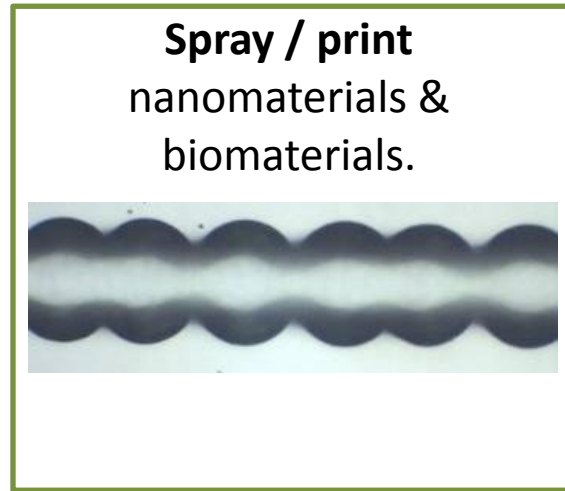
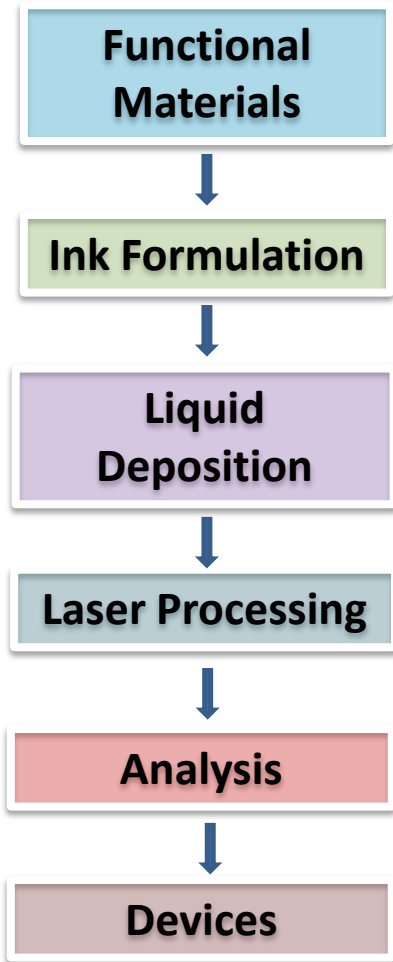
- Water condenses onto solvent
- Droplets are stable due to surface tension balance (with partial mutual solubility / solvent migration)



$$\alpha = \text{ArcCos} \left[\frac{r \left(\gamma_{12}^2 - \gamma_{23}^2 + \left(\gamma_{13} - \frac{\tau}{r} \right)^2 \right)}{2\gamma_{12}(\gamma_{13} \cdot r - \tau)} \right], \quad \beta = \text{ArcCos} \left[\frac{r \left(\gamma_{23}^2 - \gamma_{12}^2 + \left(\gamma_{13} - \frac{\tau}{r} \right)^2 \right)}{2\gamma_{23}(\gamma_{13} \cdot r - \tau)} \right]$$

Moving towards manufacturing
with spray / inkjet technologies

Example 2: Laser & Inkjet Engineering



Summary

- Please join in Pathways to Manufacturing
 - seminars, best practice output shared
 - sign up here or on IfM website

<http://www.ifm.eng.cam.ac.uk/research/cstip/themes/science-technology-industrial-emergence/p2m/>

- New research projects
 - Ronan Daly (*rd439@cam.ac.uk*)

Acknowledgements:

Laser/Inkjet engineering: Yoanna Shams, Dr. Martin Sparkes, Dr. Davor Copic, MSOLV Ltd.

Liquid manipulation: Qingxin Zhang, Prof. Ian Hutchings

Pathways to Manufacturing: Dr. Charles Featherston, Yoanna Shams, Dr. Eoin O'Sullivan

Thank you for listening