Additive Manufacture for Tissue Engineering

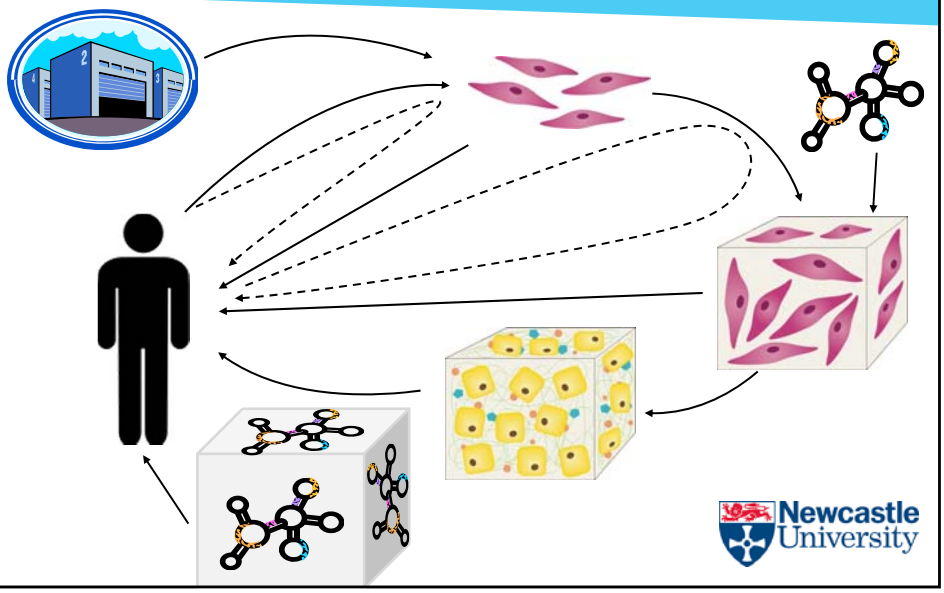
Professor Kenny Dalgarno
School of Mechanical and Systems Engineering
Newcastle University

Overview

- Tissue engineering and scaffolds
- Additive manufacture
- Additive manufacture of scaffolds
- Future work

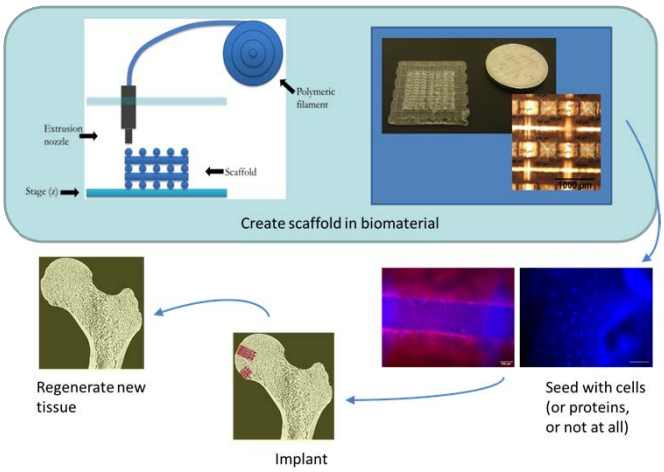
Newcastle University

A range of possibilities for how tissue engineering might work



Newcastle University

A simpler picture



Newcastle University

Resorbable Scaffolds

- Needs:
  - Bioactive: able to resorb at a similar rate to that at which the natural tissue grows
    - bioceramics, biopolymers, and polymer-ceramic biocomposites the starting materials
  - Defined topology
    - generally highly porous to support tissue integration, cell transport, nutrient supply
  - Appropriate surface properties and surface chemistry
  - Appropriate mechanical properties

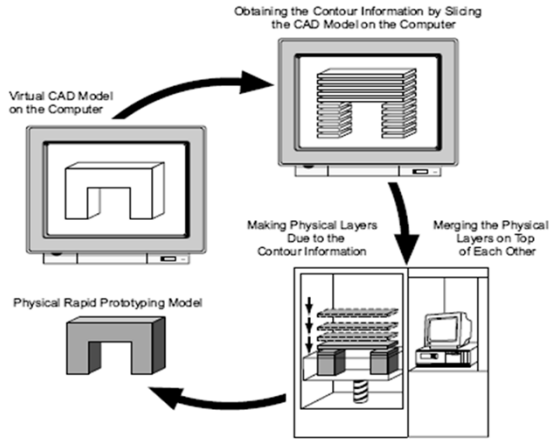
Newcastle University

Additive Manufacture

- Make what you want, where you want, when you want
- aka 3D printing, rapid prototyping, layer manufacturing
- Automated manufacture of low volume or one-off components direct from CAD, normally using a layer manufacture technique

Newcastle University

Additive Manufacture



Newcastle University

Commercial Additive Manufacture Machines

- High end
  > £200k
- Mid-moderate
  £20k – £200k
- Low cost
  £1k - £20k

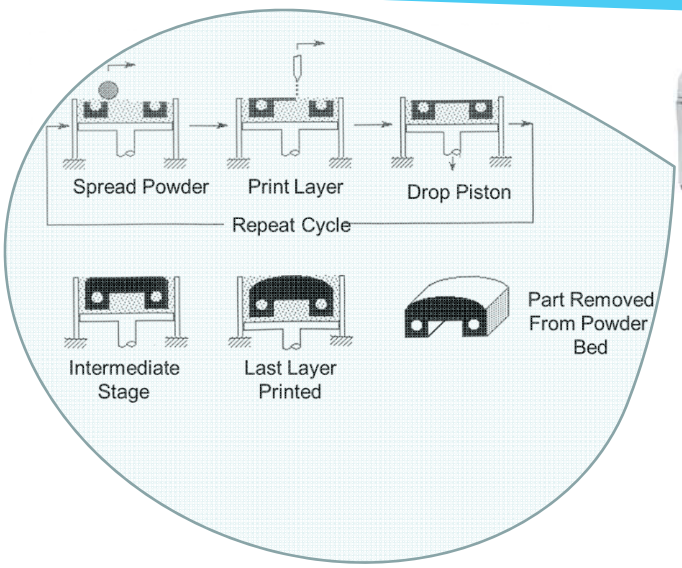
Newcastle University

Personalised Rapid Manufacture

Made by Layerwise in Belgium, implanted in the Netherlands

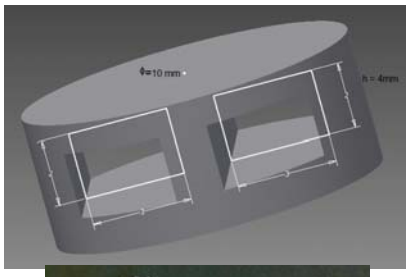
Newcastle University

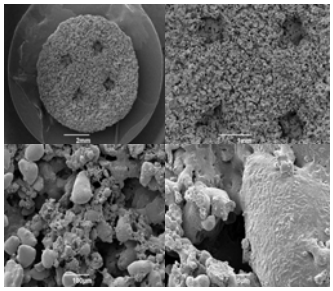
Z Corp 3D Printing

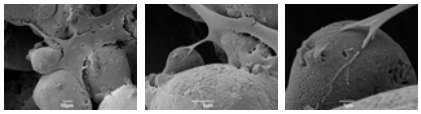


Newcastle University

Combined Macro and Micro Porosity in AW Bioceramic

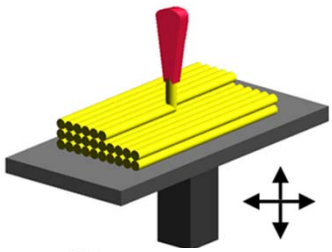


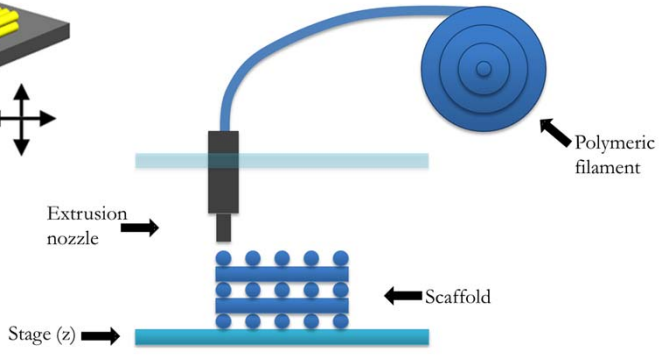




Newcastle University

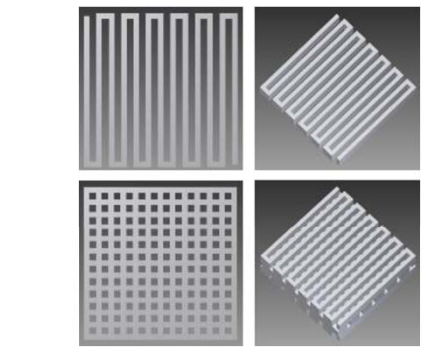
Fused Deposition Machine (FDM)

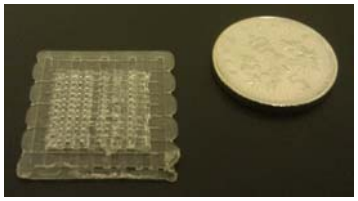


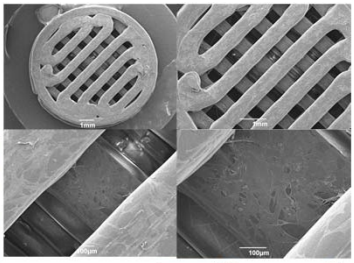


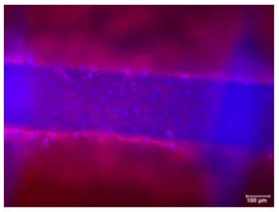
Newcastle University

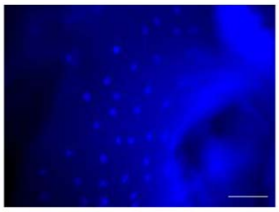
FDM of PLA





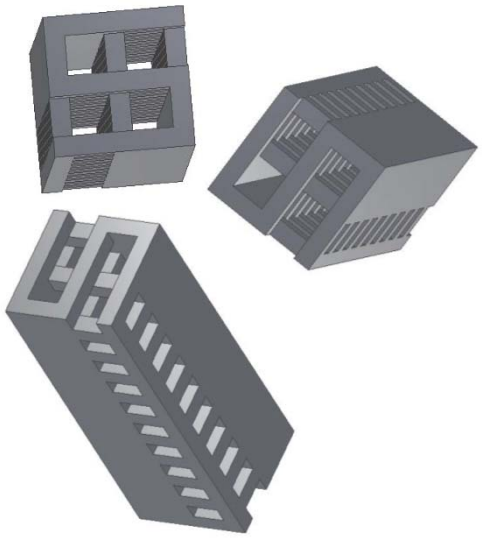


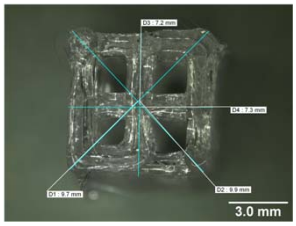


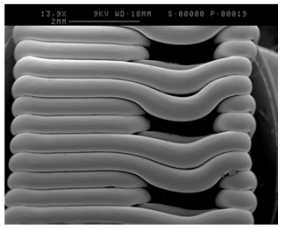


Newcastle University

FDM of PLA Cores for Macroscale Porosity in Sintered AW Bioceramic Scaffolds

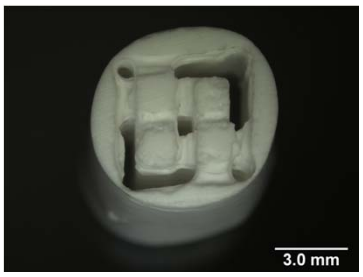


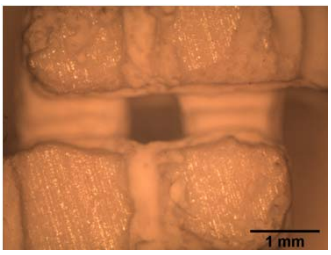


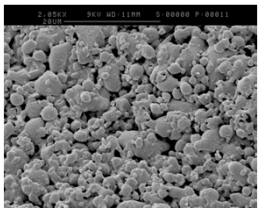


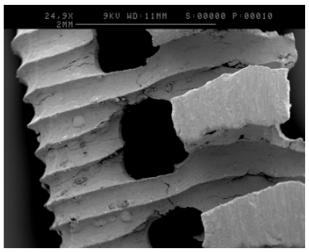
Newcastle University

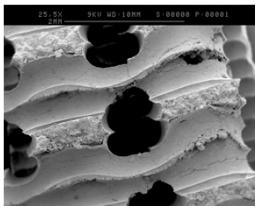
FDM of PLA Cores for Macroscale Porosity in Sintered AW Bioceramic Scaffolds





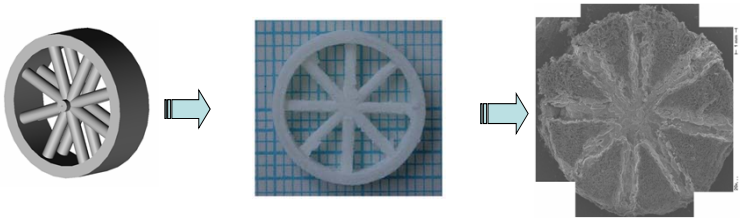






Newcastle University

FDM Moulds for Collagen



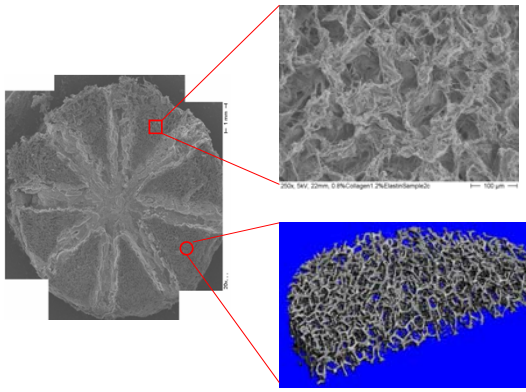
CAD Design	Negative Mould	Scaffold

Features:

- **Pre-defined channels; with highly porous structured matrix;**
- **With suitable chemistry for tissue growth – Collagen+ HA**
- **Controlled degradation rate;**
- **No toxic solvent involved.**

Newcastle University

FDM Moulds for Collagen

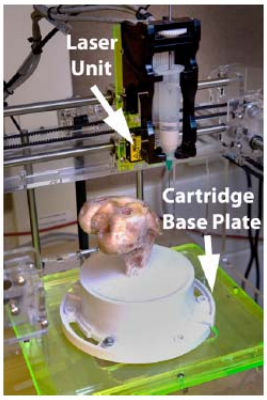


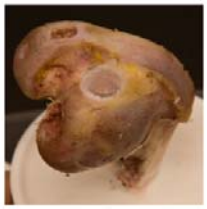
SEM Examination

Micro-CT

Newcastle University

Future possibilities: in situ repair

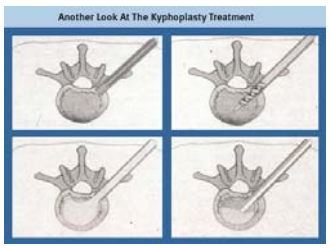




Additive manufacturing for *in situ* repair of osteochondral defects

Daniel L Cohen[1], Jeffrey I Lipton[1], Lawrence J Bonassar[1,2] and Hod Lipson[1,3,4]

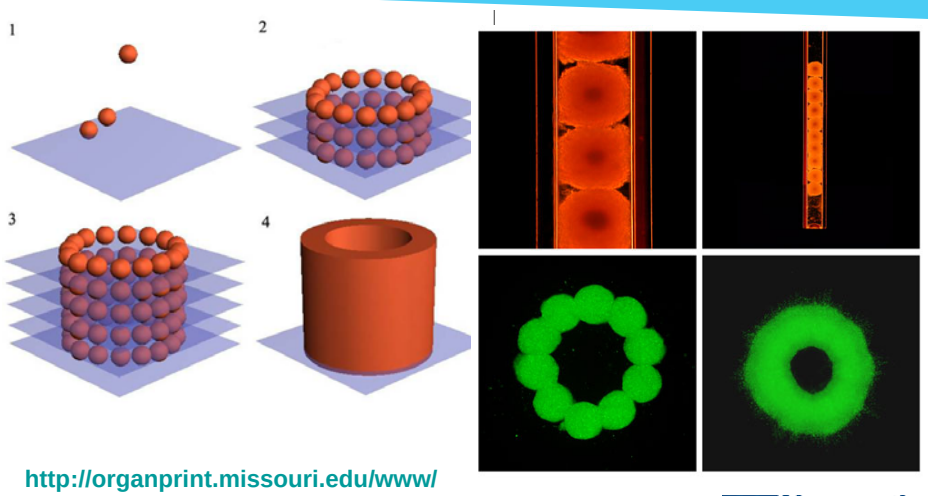
[1] Cornell University, Mechanical and Aerospace Engineering, Ithaca, NY, USA
[2] Cornell University, Biomedical Engineering, Ithaca, NY, USA
[3] Cornell University, Faculty of Computing and Information Science, Ithaca, NY, USA



http://www.spinefracture.org/procedure.html

Newcastle University

Future possibilities: cell and material co-processing



http://organprint.missouri.edu/www/

Newcastle University

Conclusions

- We can make nearly any shape in nearly any material
- 3D printing techniques can make it easier to make the right shapes, from the right materials, that we need for scaffolds
- Also opens up novel cell/material co-processing and in situ defect repair possibilities

Newcastle University

Future Work

Arthritis Research UK Tissue Engineering Centre

Arthritis Research UK

Providing answers today and tomorrow

Newcastle University · University of Aberdeen · Keele University · The University of York · The Robert Jones and Agnes Hunt Orthopaedic Hospital NHS

Developing subchondral and osteochondral scaffolds for tissue engineering

Newcastle University

Future Work

RETORATION

Resorbable Ceramic Biocomposites for Orthopaedic and Maxillofacial Applications

FP7 Grant Agreement 280575

- Developing subchondral and osteochondral scaffolds and maxillofacial bone repair products
- Also specifically evaluating in-clinic production routes

Newcastle University

Future Work

MeDe Innovation
EPSRC Centre for Innovative Manufacturing in Medical Devices

- New Centre for Innovative Manufacture in Medical Devices, led by John Fisher at Leeds, in collaboration with Newcastle, Sheffield, Nottingham, Bradford
- Newcastle lead on personalised ‘near patient’ manufacturing processes for implantable musculoskeletal devices

Newcastle University

Acknowledgements

Naif Alharbi
Sotiria Toumpaniari
Yeo Tai
Matt Benning
Oana Bretcanu
Mark Birch
Chaozong Liu, UCL
Andrew McCaskie, Cambridge

Newcastle University


Questions?