



UNIVERSITY of
BRADFORD

Faculty of Engineering
& Informatics

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZON 2020



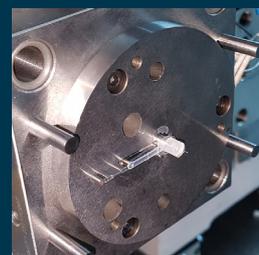
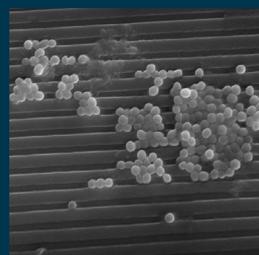
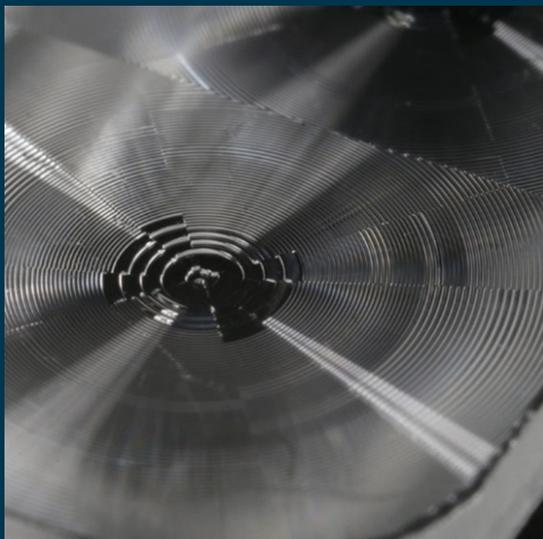
μ MAN

Process Fingerprint for Zero-defect
Net-shape MICROMANufacturing

Micro Injection Moulding Workshop

*13 -17 March
2017*

*Richmond WB19
Polymer MNT
University of Bradford*



Welcome

We hope you enjoy our new-look workshop where we have combined seminar presentations from leading experts with unique hands-on sessions in our laboratories.

We will provide you with the theoretical background to understand key mechanisms for micro-manufacturing processes using polymer melts.

You will then get the chance to test your skills and expertise by using our state of the art equipment to configure processes for real measurements and manufacturing processes.

This is also an opportunity to meet, share ideas and socialise, so we hope you enjoy our exciting away day and enjoy networking with the other ESRs.

Above all, have fun!



WiFi access

You can access the internet throughout our facilities using two methods:

1. Using eduroam (simply use your institutional login to get online)
2. Using a guest login on _The Cloud wireless network

If you have trouble, let one of the Bradford team know!

Fire alarms

There is one fire alarm test on Thursday 16 March at 08.45.

There will be short bursts of the alarm and you do not need to take action.

However, if the alarm sounds continuously at this, or any other time, please follow us to the nearest exit and assembly point.



ESR Attendees:

Ajeet Singh Rajput	TU Chemnitz	Grp 1
Antonio Luca	LFM Bremen	Grp 1
Emanuele Cannella	IPU	Grp 1
Federico Baruffi	Denmark TU	Grp 1
Mattia Bellotti	KU Leuven	Grp 1
Sandeep Kuriakose	Politecnico di Milano	Grp 1
Teguh Santoso	University of Nottingham	Grp 2
Matin Yahyavi	TU Chemnitz	Grp 2
Yukui Cai	University of Strathclyde	Grp 2
Krishna Saxena	KU Leuven	Grp 2
Pablo Fook	LFM Bremen	Grp 2
Soufian Ben Achour	Denmark TU	Grp 2
Mert Gulcur	University of Bradford	Grp 2

Health and Safety

Whilst we want you to learn by actively using our equipment, your safety is important to us, so please help us to avoid accidents by:

- Wearing appropriate laboratory clothing
- Listening carefully and following instructions
- Asking if in doubt

Day 1: Tuesday 14 March

9.00 -11.00 Microman general meeting

12.00 Lunch

13.15 Workshop Welcome – Prof PD Coates, Dr B Whiteside

13.30 Micro-extrusion and die drawing lecture – Dr A L Kelly,

14.30 Micro-extrusion hands-on workshop

15.30 Coffee break

16.00 Micro die drawing hands-on workshop

17.00 Close

Day 2: Wednesday 15 March

09.00 Micromoulding - Dr B Whiteside

10.00 Coffee

10.30 Micromoulding hands-on workshop

11.30 Ultrasonic moulding hands-on workshop

12.30 Lunch

13.30 Polymer Rheology - Dr T Gough

14.30 Capillary rheometry hands on workshop

15.30 Coffee

16.00 Rotational rheometry hands-on workshop

17.00 Close

Day 3: Thursday 16 March

08.30 Polymer crystallisation – Dr T Gough

09.30 Coffee

09.45 Small Angle X-ray scattering hands-on workshop

10.45 Thermal Analysis hands-on workshop

11.45 Travel to Coniston Hotel

12.30 Lunch at Coniston Hotel

14.00 Clay Pigeon Shooting

15.00 4x4 Experience

17.00 Return to Bradford

Day 4: Friday 17 March

09.00 Polymer physical properties – Prof John Sweeney

09.30 Coffee

10.00 Small scale tensile testing hands-on workshop

11.00 Nanoindenting hands-on workshop

12.00 Lunch (optional)

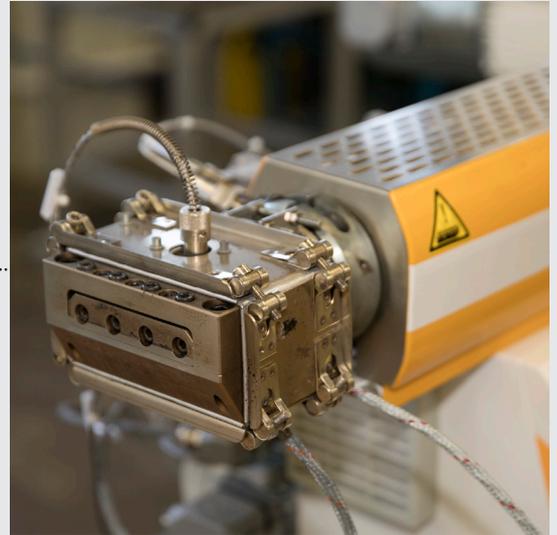
13.00 Close and depart for home

Session 1 - Microextrusion and Die Drawing

Seminar (1 hour):

Extrusion is a widely used process for the production of polymeric products such as pipe, tube and film, and can also be used as an intermediate process to mix polymers with other additives (compounding). Recently, there has been an increased requirement for small scale extrusion processes, driven by developments in the medical and pharmaceutical industries. Here, the basic principles of extrusion and the mechanisms involved in melting, forming and solidifying the product will be discussed. The importance of screw design and set operating conditions will be highlighted.

Die drawing is a form of solid phase orientation used to improve the properties of polymeric materials which involves pulling solid polymers at temperatures above their glass transition but below their melting point through converging dies. Controlled oriented structures can be produced; physical properties such as strength and stiffness increase with draw ratio. Here, the principles of die drawing will be discussed in relation to small scale products.



Speaker:

Dr Adrian Kelly
PhD
CEng MIMechE

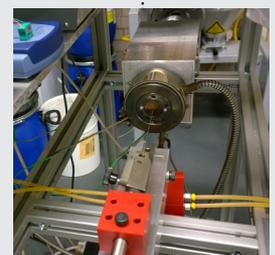
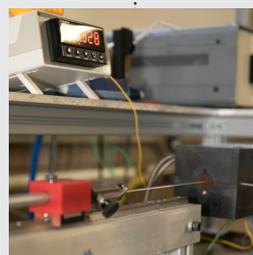
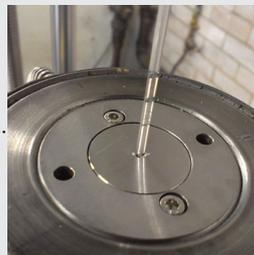


Hands-on workshop 1.2 Micro die drawing (1 hour)

- Basic operation of die drawing apparatus.
- Optimising drawing parameters to achieve the required properties.
- Measurement of specimens to determine outcomes.

Hands-on workshop 1.1 Micro-extrusion (1 hour)

- Basic operation of a small scale single screw extruder.
- Optimisation of extrusion parameters for production of small diameter tube.
- Analysis of residence time.



Session 2 - Micro-injection Moulding

Seminar (1 hour):

Microinjection moulding (micromoulding) is a process developed for high volume manufacturing of products using thermoplastic, thermoset and ceramic/metal power materials. While it has similar characteristics, is not directly comparable with conventional injection moulding. The product dimensions can be extremely small (weights of approximately 1 milligram are typical), and the surface area to volume ratio of the components can be significantly high. The factors can result in flow and cooling/solidification behaviours that pose significant challenges for process development and control.

The critical aspects of the process are discussed and it is shown how they can significantly affect the resulting physical properties of the component. Process measurement is an essential tool to understand these mechanisms, and some state of the art methods used in our laboratories will be described, and the use of this data to improve process simulation tools will be demonstrated.

Key topics:

- Micromoulding process environment
- Machine parameters
- Process data measurement
- Simulation tools
- Component examples



Speaker:

Dr Ben Whiteside
PhD
CEng MIMechE

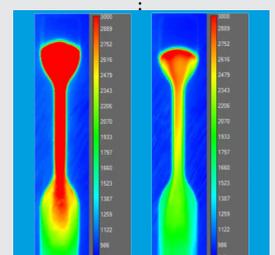
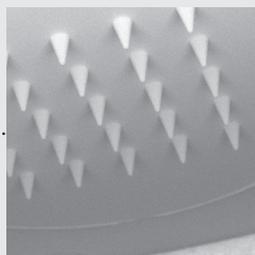


Hands-on workshop 2.2 Ultrasonic moulding (1 hour)

- Basic operation of an ultrasonic micromoulding machine.
- Thermal imaging for process quality assessment.
- Optimising the moulding parameters for production of a micro tensile test specimen.

Hands-on workshop 2.1 Micro-injection moulding (1 hour)

- Basic operation of a micro-injection moulding machine.
- Optimisation of moulding parameters for production of a microneedle device.
- Quality assessment using an automated image analysis system.



Session 3 - Polymer Rheology

Seminar (1 hour):

Rheology is the science of flow and deformation; flow behaviour is important in many industries such as polymers, paints, food processing and personal healthcare. Understanding of polymer rheology is a key requirement to the design, optimisation and control of polymer processing operations. Polymer melts are complex viscoelastic materials and their flow behaviour is dependent upon temperature, flow rate, pressure and polymer type. Many polymeric materials contain additives such as fillers which add further complexity to their rheology.

Here, the basic principles of rheology will be discussed and related to polymer processing operations such as extrusion, injection moulding and micromoulding. Rheological characterisation techniques will be highlighted with relevant case studies.

Key topics:

- Principles of rheology
- Rheological behaviour of polymer melts
- Measurement of polymer rheology

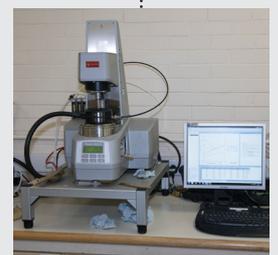


Hands-on workshop 3.2 Rotational Rheometry (1 hour)

- Basic operation of an oscillatory rheometer.
- Set up of standard rheological tests.
- Analysis of viscosity, storage and loss moduli.

Hands-on workshop 3.1 Capillary Rheometry (1 hour)

- Basic operation of a capillary rheometer.
- Set up of standard rheological tests.
- Analysis of shear and extensional viscosity.



Session 4 - Polymer Crystallisation

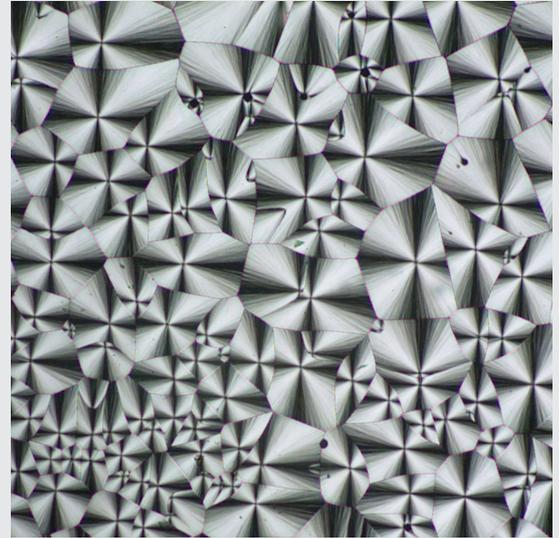
Seminar (1 hour):

The majority of commodity (and more novel) polymers are semi-crystalline materials being composed, in the solid phase, of crystals in an amorphous matrix. Crystallinity confers a range of properties onto final product morphologies and macroscale behaviour including mechanical strength, wear profiles and optical clarity. Cooling rates, polymorphism and the effects of flow upon crystallisation during processing provide further complexity but also an opportunity for tuning end product properties allowing novel material and product development.

Critical aspects of crystallinity and its measurement and control will be explored chiefly through the 'off-line' techniques of x-ray diffraction (SAXS/WAXD) and Differential Scanning Calorimetry (DSC). A brief summary of suitable in-line techniques allowing real-time control of crystallinity will also be provided.

Key topics:

- Morphology development in polymers
- Morphology characterisation techniques



Speaker:

Dr Tim Gough
PhD
CEng MIMechE

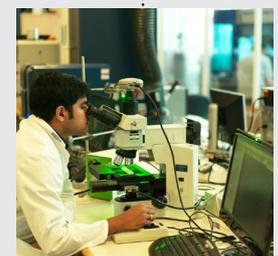
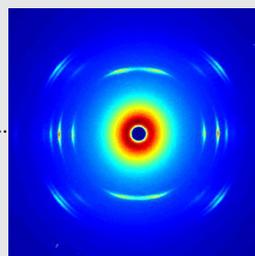


Hands-on workshop 4.2 DSC (1 hour)

- Preparation of DSC samples.
- Performing a DSC heat-cool-heat test.
- Interpretation of results to determine specimen morphology.

Hands-on workshop 4.1 SAXS/WAXS (1 hour)

- Mounting of specimens in the SAXS/WAXS apparatus.
- Performing SAXS and WAXS experiments.
- Interpretation of results to determine internal structures.

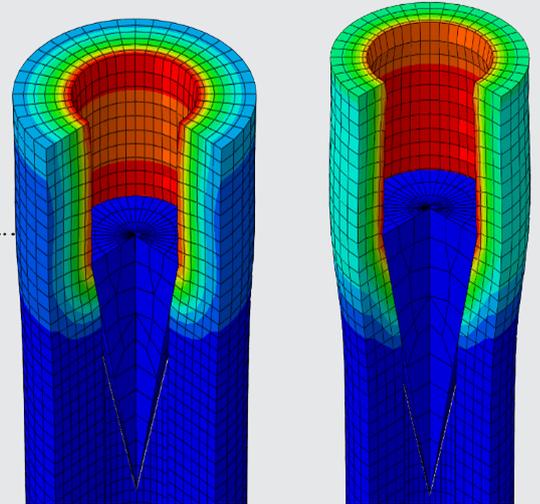


Session 5 - Polymer Physical Properties

Seminar (1 hour):

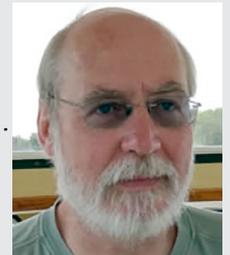
The physical properties of polymers, such as crystallinity and molecular orientation, are closely linked with their mechanical properties. They are complex in comparison with other engineering materials, being inelastic in most circumstances because of time dependence (viscoelasticity) and plasticity. However, there is always a limited range of strain for which behaviour is elastic, which is a source of essential properties that define polymer behaviour in an engineering context. In the case of oriented polymer, even within the elastic range, there are different elastic constants for straining in different modes and directions.

Nanoindentation is now an established method for measuring elasticity, as tests can be analysed to extract elastic constants from the results. However, the conventional analysis is based on the assumption that the elasticity of the material is isotropic and the same in compression as in tension. For oriented polymer, neither of these assumptions is valid. In this presentation experimental procedures and numerical methods are presented that enable the detailed analysis of nanoindentation of oriented polymer.



Speaker:

Prof John Sweeney
PhD, CEng, CSci,
MIMMM

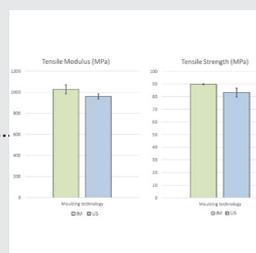


Hands-on workshop 5.2 Nano-indenting (1 hour)

- Basic operation of nanoindenting equipment.
- Performing nanoindenting tests on polymer samples.
- Results analysis to determine key mechanical properties.

Hands-on workshop 5.1 Micro tensile testing (1 hour)

- Mounting micro tensile specimens.
- Performing micro tensile test measurements.
- Results analysis and identification of key mechanical properties.



Away Day - Coniston Hotel

Logistics

- 11.45 Coach leaves Bradford
- 12.30 Lunch served
- 14.00 Clay pigeon shooting (50 clays)
- 15.30 Off road adventure
- 17.00 Coach leaves Coniston Hotel
- 18.00 Return to Bradford



Lunch Menu

- Lamb Koftas served with Pitta Cajun Chicken Skewers
- Herb Crusted Salmon Goats Cheese Tart with Caramelised Red Onion Stuffed Mushroom (V)
- Mixed Salad
- Coleslaw
- Hand Cut Potato Wedges
- Vegetable Rice
- Selection of Breads & Rolls
- Warm Chocolate Brownie with Chocolate Sauce & Ice Cream

Tips

- Don't miss the coach!
- Wear suitable clothes (no suits)
- Wear sturdy shoes with good grip
- Listen carefully to the instructors



Visualisation of Experiments

All

of our seminars and hands-on workshops will be recorded live using state of the art cameras



“Interactive scientific dissemination will be achieved by pursuing publications in the Journal of Visualized Experiments - JoVE Applied Physics where peer reviewed scientific articles are published along with videos of the methods applied in the research”

“D6.3 Videos from selected technological workshops”

D6.3

requires us to record and archive footage from the workshops and publish data

Join in

Use your camera phones to record activities during the hands-on workshops

1. Record video using your phone
2. Choose your best videos
3. Upload to YouTube or similar
4. Keep the originals safe
5. Email the links to Mert Gulcur using the contact details across the page

Contacts

Support

Event management
Travel arrangements
Dietary requirements
Technical questions
Other information

Dr Cristina Tuinea-Bobe
Senior RKT Development Officer



+447511 064815



c.tuinea-bobe@bradford.ac.uk



Support

Event management
Travel arrangements
Technical questions
Visualisation submissions

Mert Gulcur
Early Stage Researcher



+441274 234583



m.gulcur@bradford.ac.uk



Support

Event management
Travel arrangements
Technical questions
Visualisation submissions

Dr Ben Whiteside
Director - Polymer MNT



+441274 231958



b.r.whiteside@bradford.ac.uk





UNIVERSITY of
BRADFORD

.....
Faculty of Engineering
& Informatics