Micro-processing of polymer parts for life sciences applications

Choudhury, N.; de Grandpré, C.; Mir, H.; Bardetti, A.; Thibault, F.; DiRaddo, R.

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CompMed
Symposium on Computer Simulation in Medicine
May 16-18, 2007

Micro-Processing of Polymer Parts for Life Sciences Applications

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May 17th, 2007

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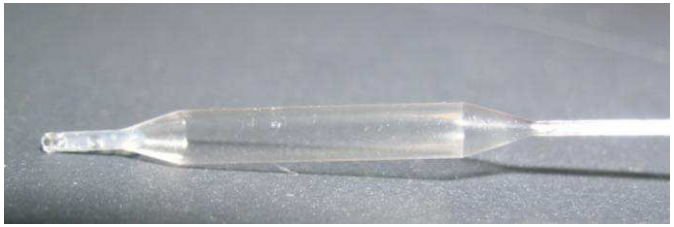
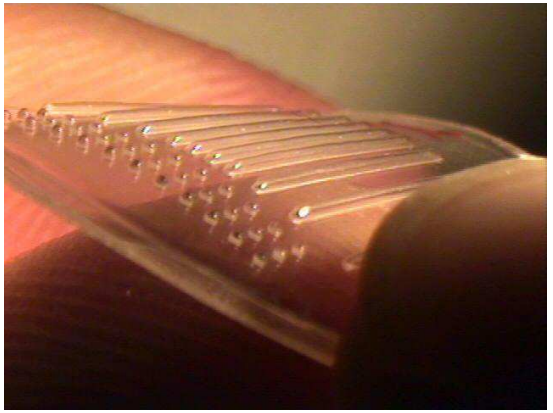
Micro-Fabrication

- Micro-scale (range from µm to mm)
- Miniaturization technologies found in many areas
  - Optics, electronics, medicine, bio-technology, communications, and avionics
  - Wide range of engineering materials, three-dimensional features, and high relative accuracies
- New processes and manufacturing equipment being developed





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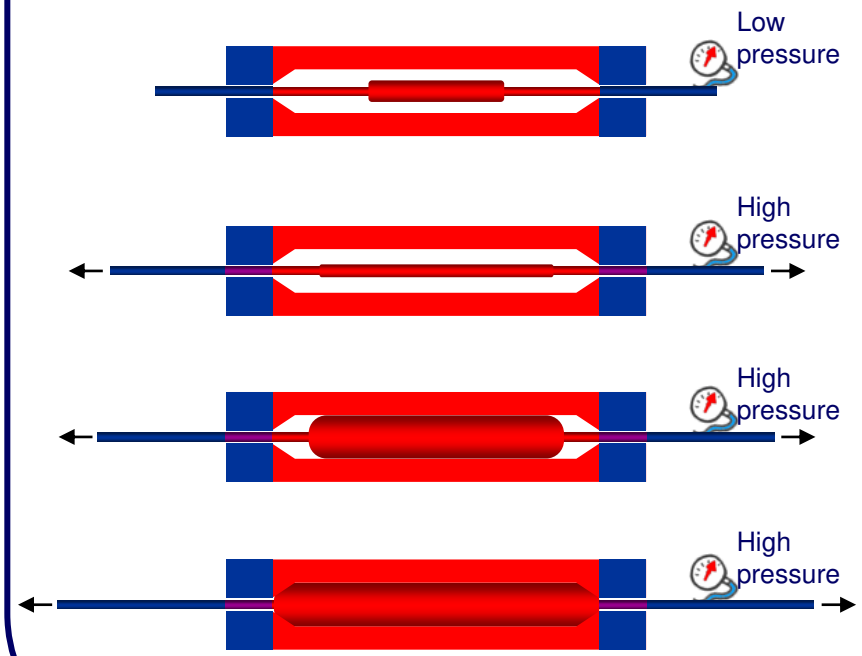
Process Descriptions

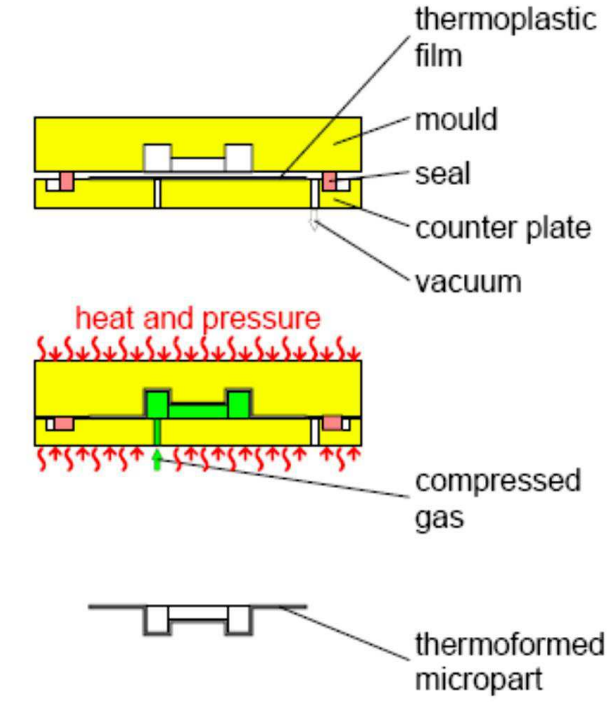
Blow moulding

Used to form hollow parts



Thermoforming

Used to form thin walled parts with high surface area



R. Truckenmüller, Forschungszentrum Karlsruhe, 5th European Thermoforming Conference 2006

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Micro-Blow Moulding

Medical Balloon Products

Driven by increase in minimally invasive procedures and localized drug delivery

- Interventional cardiology
- Minimally invasive spinal therapy (kyphoplasty)
- Neurology
- Interventional gastro-enterology (stone extractors)

www.mghp.com/women/osteo/balloons.shtml

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Micro-Blow Moulding

IMI Infrastructure

Tube Fabrication

Extruder

Tube Preparation

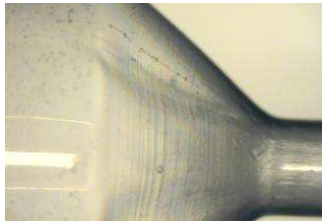
Computerized Double-End Stretcher

Blow Moulding

Computerized Hot-Mould Forming Machine

Tubing/Balloon Validation Tests

Hydraulic Pressure-Tester, Micro-Structure Inspections



Catheter Assembly

Tube Welding Machine, Multi-Flute Balloon Folder

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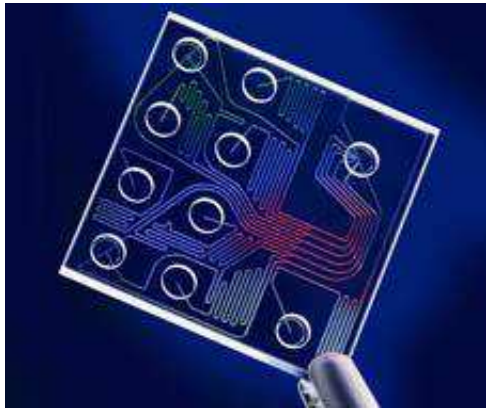
Micro-Thermoforming

Life Sciences Products

- Pioneered by Forschungszentrum Karlsruhe Research Center
  - Two step process to heat seal rigid backing onto formed part
- Lab on a chip/micro fluidics
  - Capillary electrophoresis
  - *In-vitro* cell culture
- Thin films 25 µm (0.001’’)
  - Polystyrene, Polypropylene, Polycarbonate
  - Transparent, thermally stable



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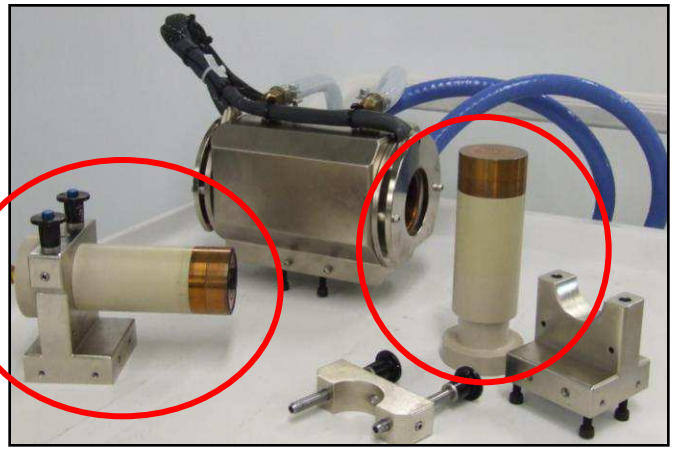
Micro-Thermoforming

Infrastructure Modifications

- Rapid heating and cooling
- Pressurizing system up to 1000 PSI with vacuum
- Quick mould opening and closing
- Mould can be machined at an affordable price

Computerized Hot-Mould Forming Machine



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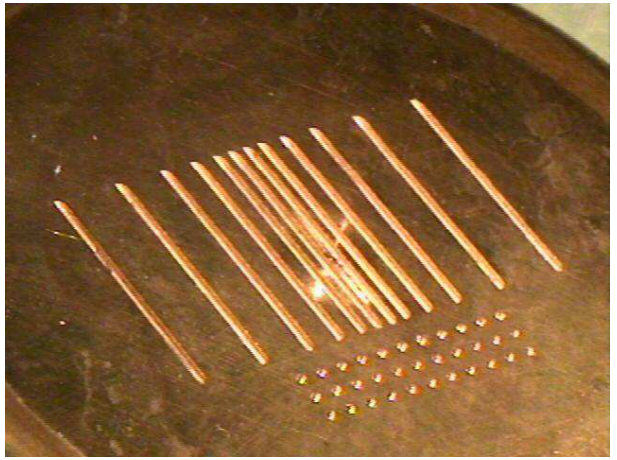
Micro-Thermoforming
Mould Modifications

Blow moulding machine mould modifications

- Beryllium copper mould
- Pits machined with sub miniature end-mills
  - 375 µm wide and 375 µm deep
- Series of lines burned by EDM machining
  - 375 µm wide
- Surface finish of Ra 0.2 µm is necessary



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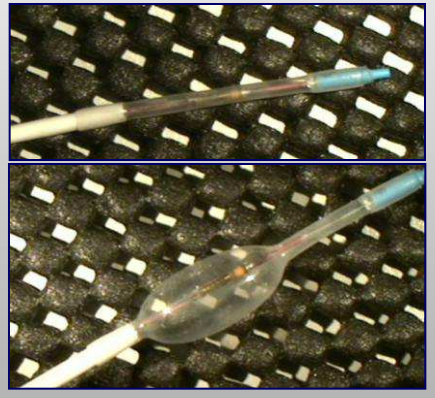
Micro-Scale Parts at IMI

Medical Balloons

- Minimally Invasive Interventions
- Drug Delivery

SCIREQ™
Building a better mouse data trap.™



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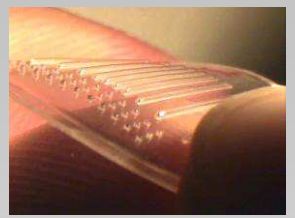
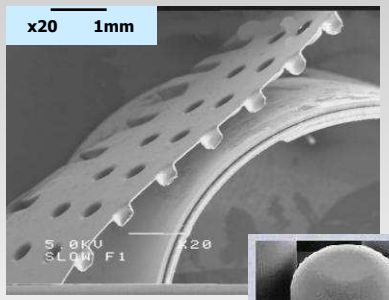
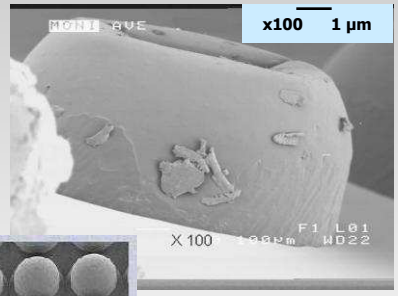
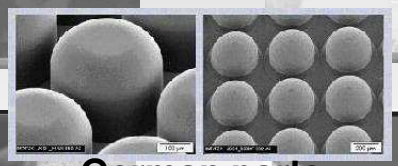
Life Science Products

- "Lab-on-a-Chip"
- Cell Culture

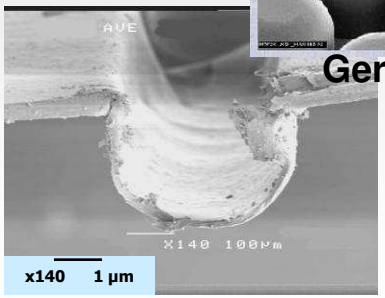


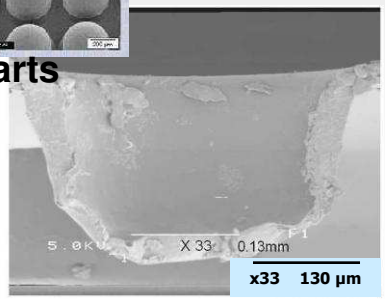






German parts





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Process Simulation

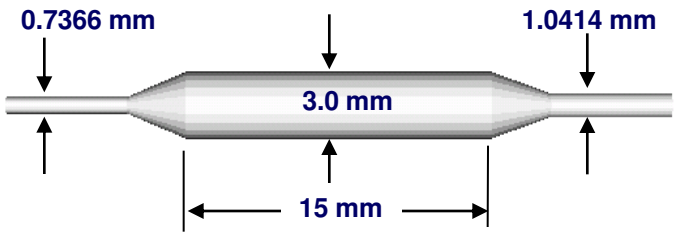
Blow moulding

Blowsim 8.4 with PEBAX model (Elasto-Plastic) -- with slip

Tubing:

Material : PEBAX
Diameter = 0.9144 mm
Thickness = 0.176 mm

Mould Dimensions:



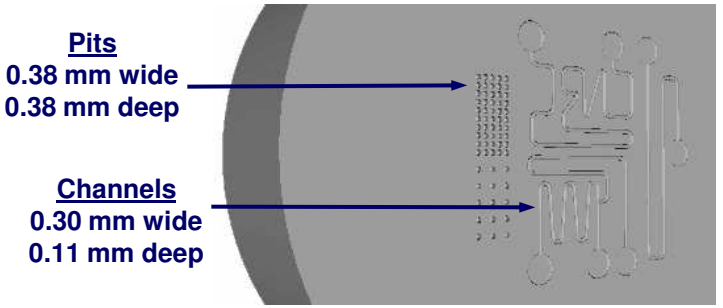
Thermoforming

Blowsim 8.4 with KBKZ model (Viscoelastic)

Sheet:

Material : PS
Thickness = 0.025 mm

Mould Dimensions:



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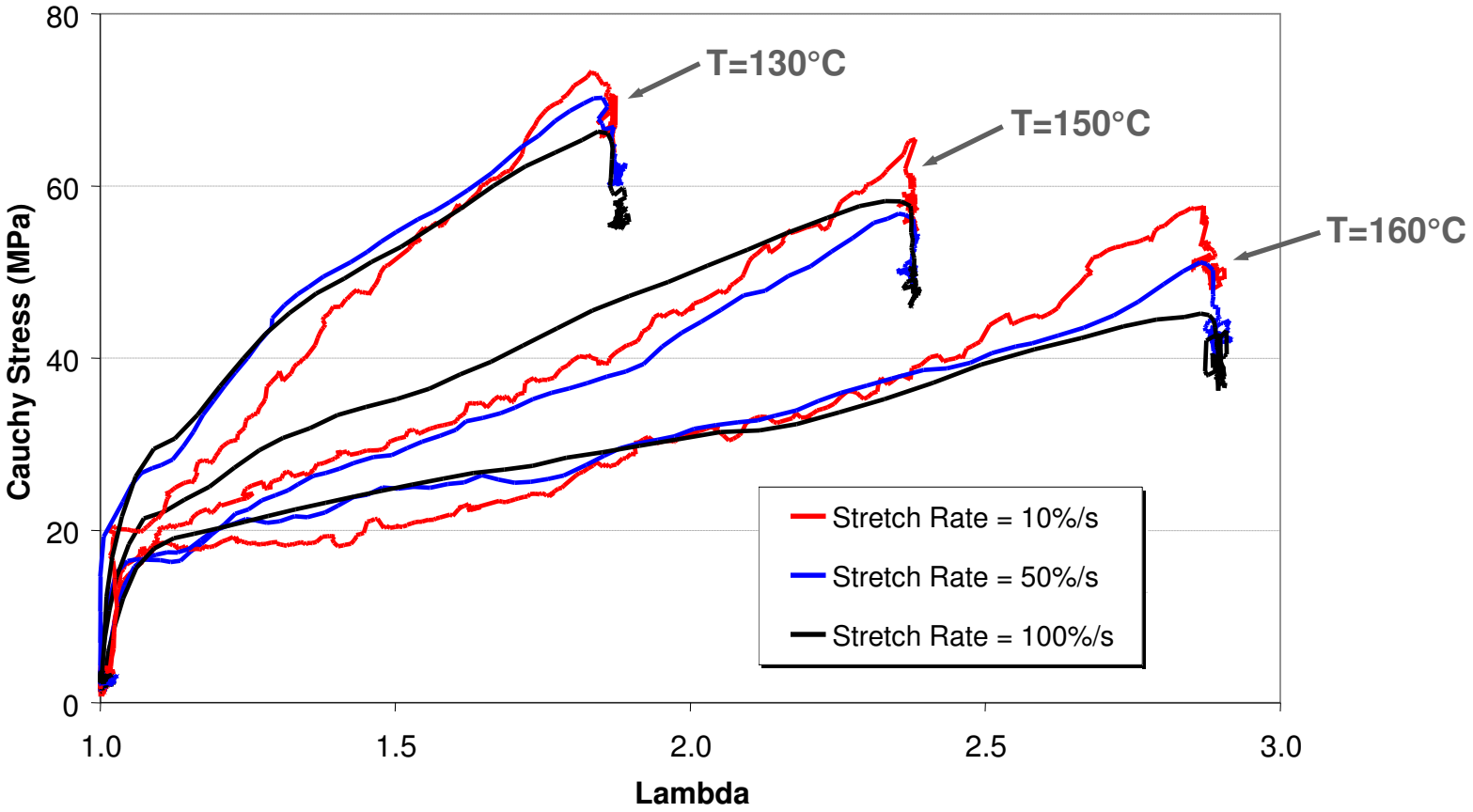
PEBAX Material Model



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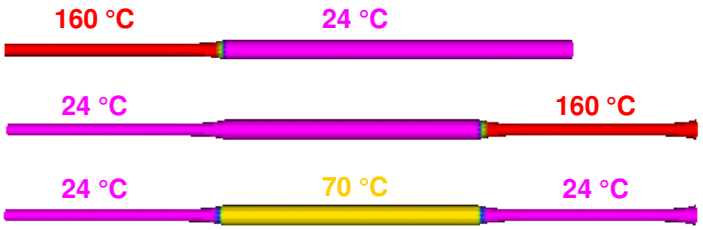
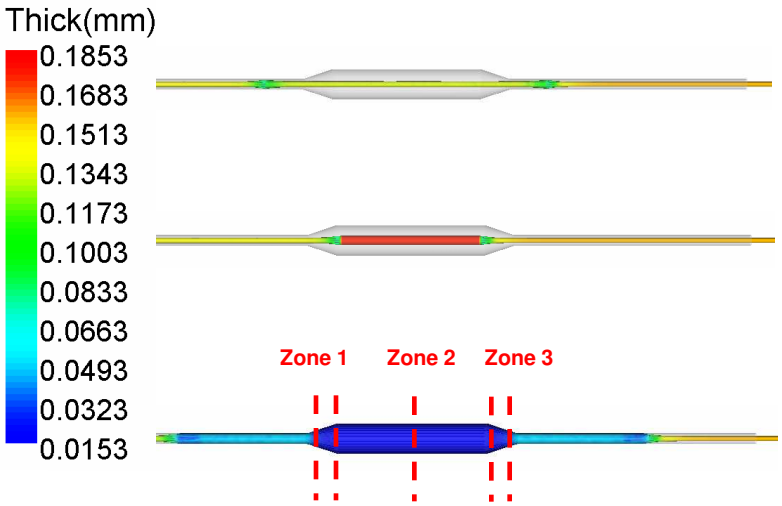
Micro-Blow Moulding

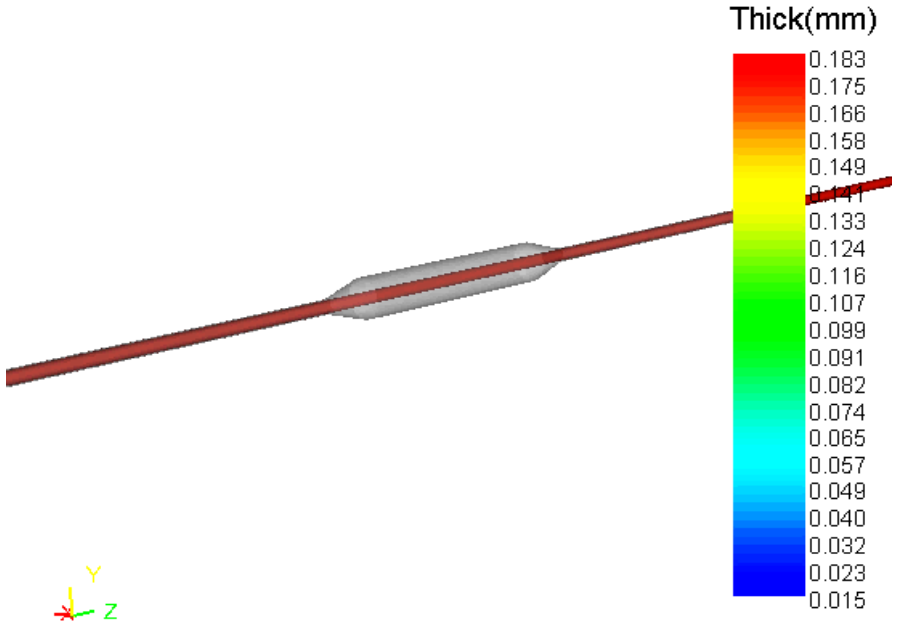
Simulation and Validation

Parison Preparation



Stretch Blow Moulding





Thickness Comparison

Thickness (mm)	Zone 1	Zone 2	Zone 3
Experimental	0.0175	0.0180	0.0175
Simulation	0.0197	0.0170	0.0197

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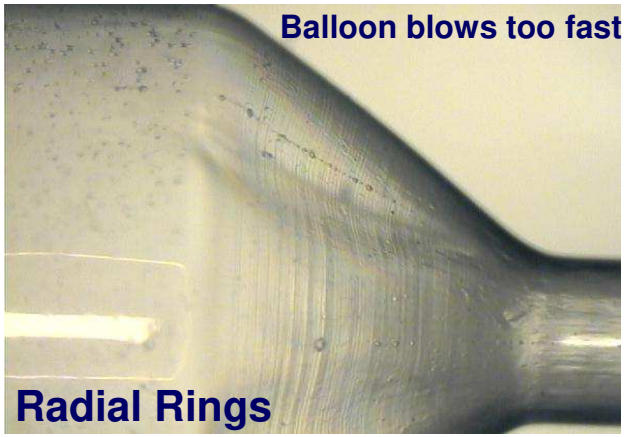
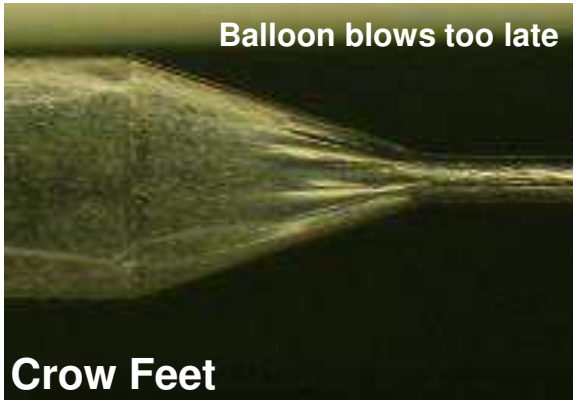
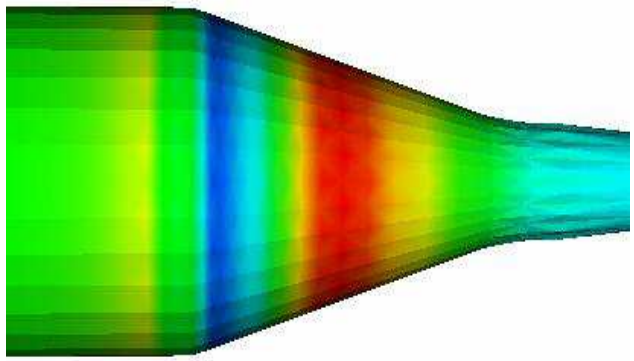
Micro-Blow Moulding

Processing Challenges

- Multi input-output process
- Complex material behaviour
- Miniature products, difficult to see







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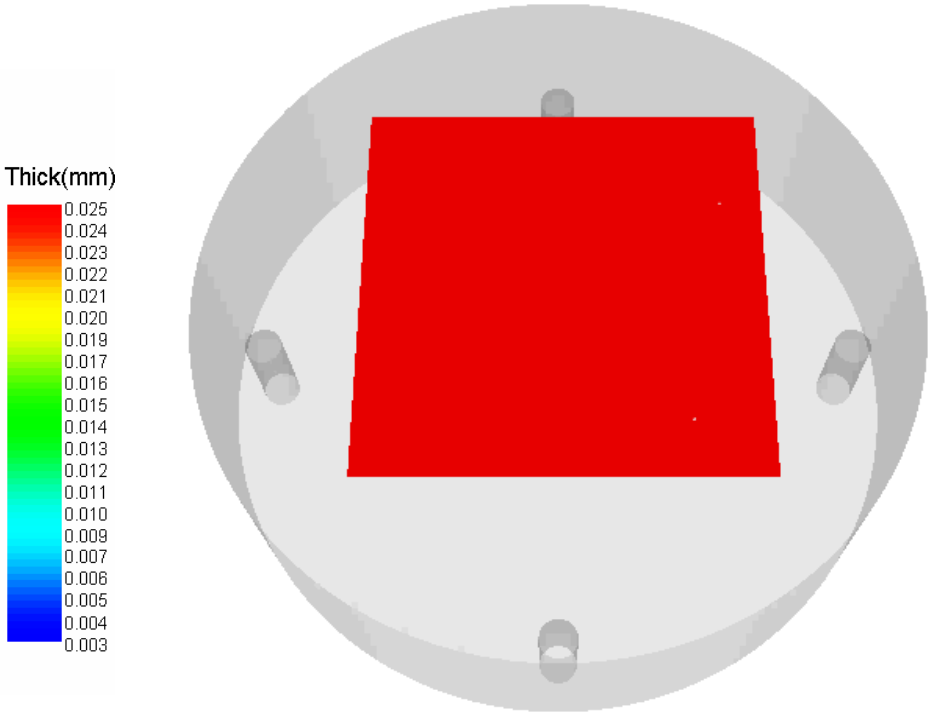
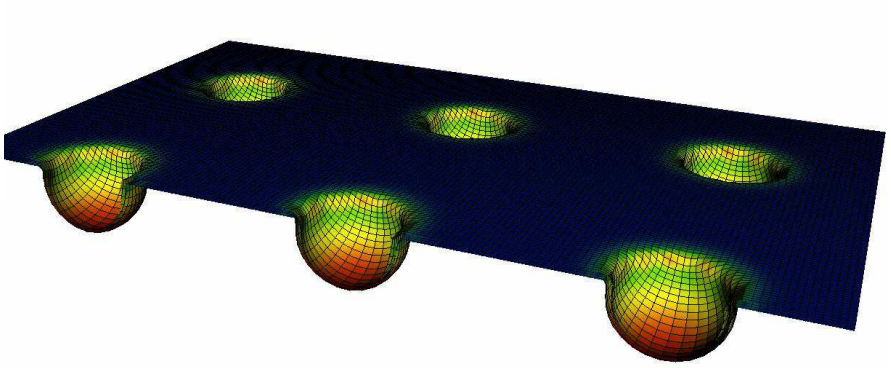
Simulation

Thermoforming



2.5D Simulation

3D Simulation



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Conclusions

- Micro-fabrication at IMI
  - Micro-blow moulding: optimized process for balloons
  - Micro-thermoforming: investigative work promising
- Numerical simulations useful tool
  - biaxial stretch behavior of PEBAX in micro-blow moulding
  - wall thickness distribution of formed parts
  - presence of defects (useful for industrial optimization)

Thank you

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Science at work for Canada

National Research Council Canada

Conseil national de recherches Canada

Canada