

CNC MILLING: PANTOGRAPH DEMONSTRATION

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THE ACTIVITY

Many different **microfabrication** techniques are used in the **manufacture of microfluidic devices**. The **CNC machine** is used for precise **3D milling and drilling** of glass, metals and plastics. To explain the input of a computer drawn design into a machine and the output of the same design milled into a piece of material, a **pantograph** activity has been developed.



AIM

To explain microfabrication techniques to school children and the general public by:

- producing a safe, interactive experiment to demonstrate CNC milling;
- highlighting examples of methods used in microfluidic device fabrication.

THE DEVICE

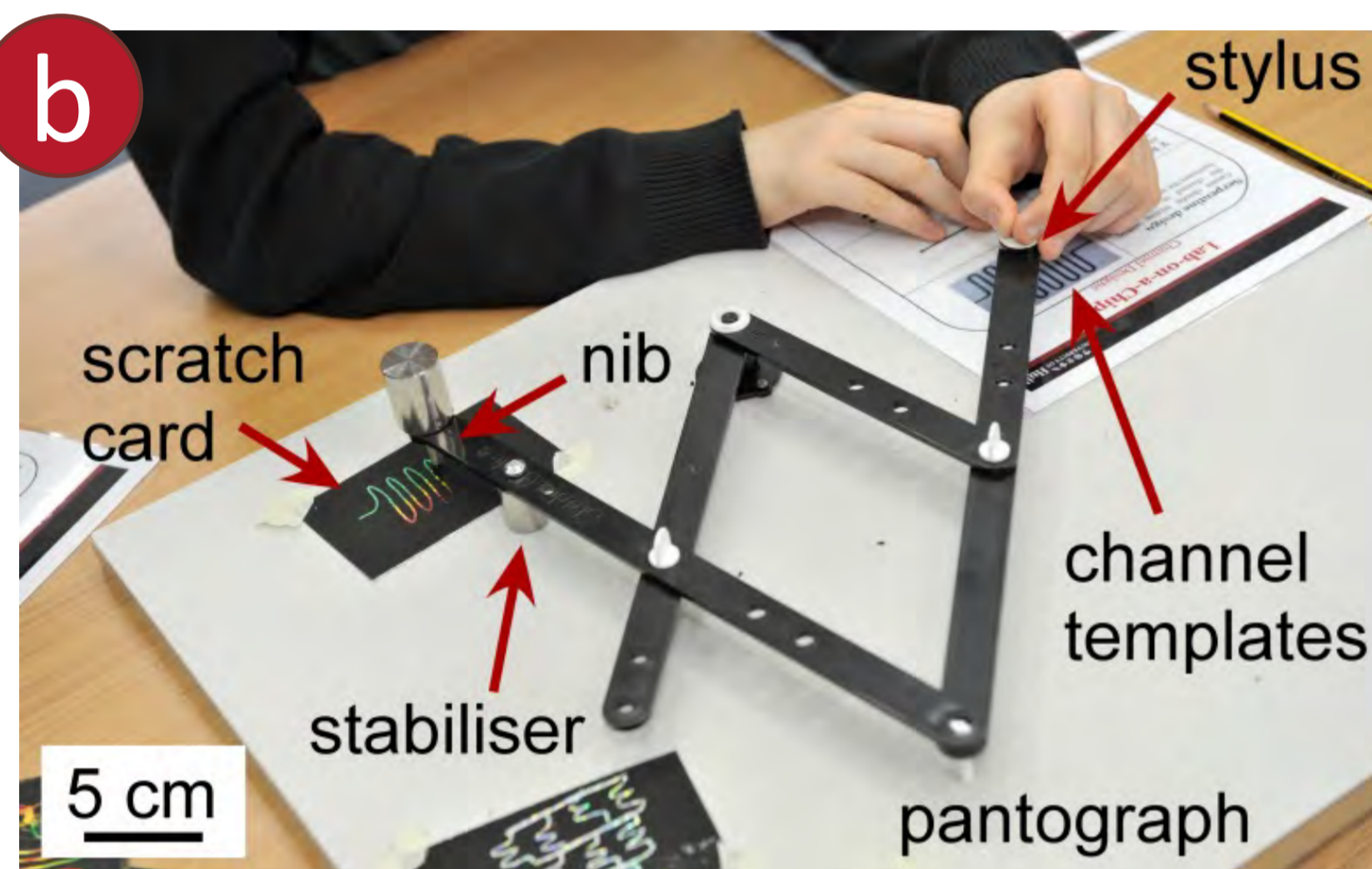


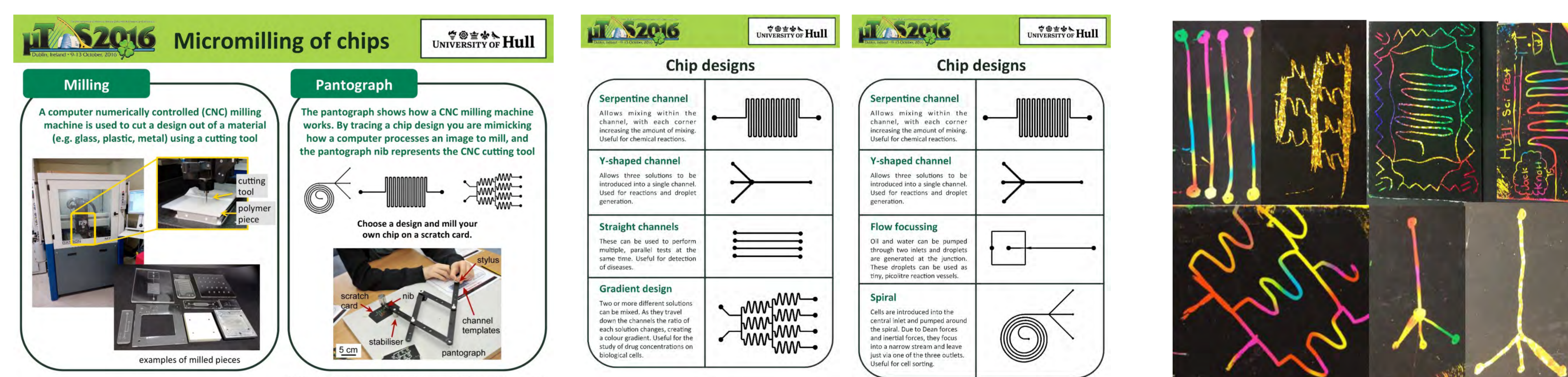
Fig. 1: (a) CNC machine cutting a piece of metal. (b) The pantograph fixed to a base plate is used to mimic the transfer of a chosen input design to an output on a scratch card.

HOW IT WORKS



Fig. 2: (a) A pantograph (Sketch-a-Graph, purchased from Amazon) was secured to a base plate with a weight and a pin for 'milling'. (b) A design is chosen and scratch art paper (Baker Ross Scratch Art Doodle Sheets) is secured in place with Blue Tac. (c) The chosen channel design is traced. (d) Results are observed.

Additional resources for activity to increase understanding and engagement:



USE OF CNC MILLING IN DEVICES

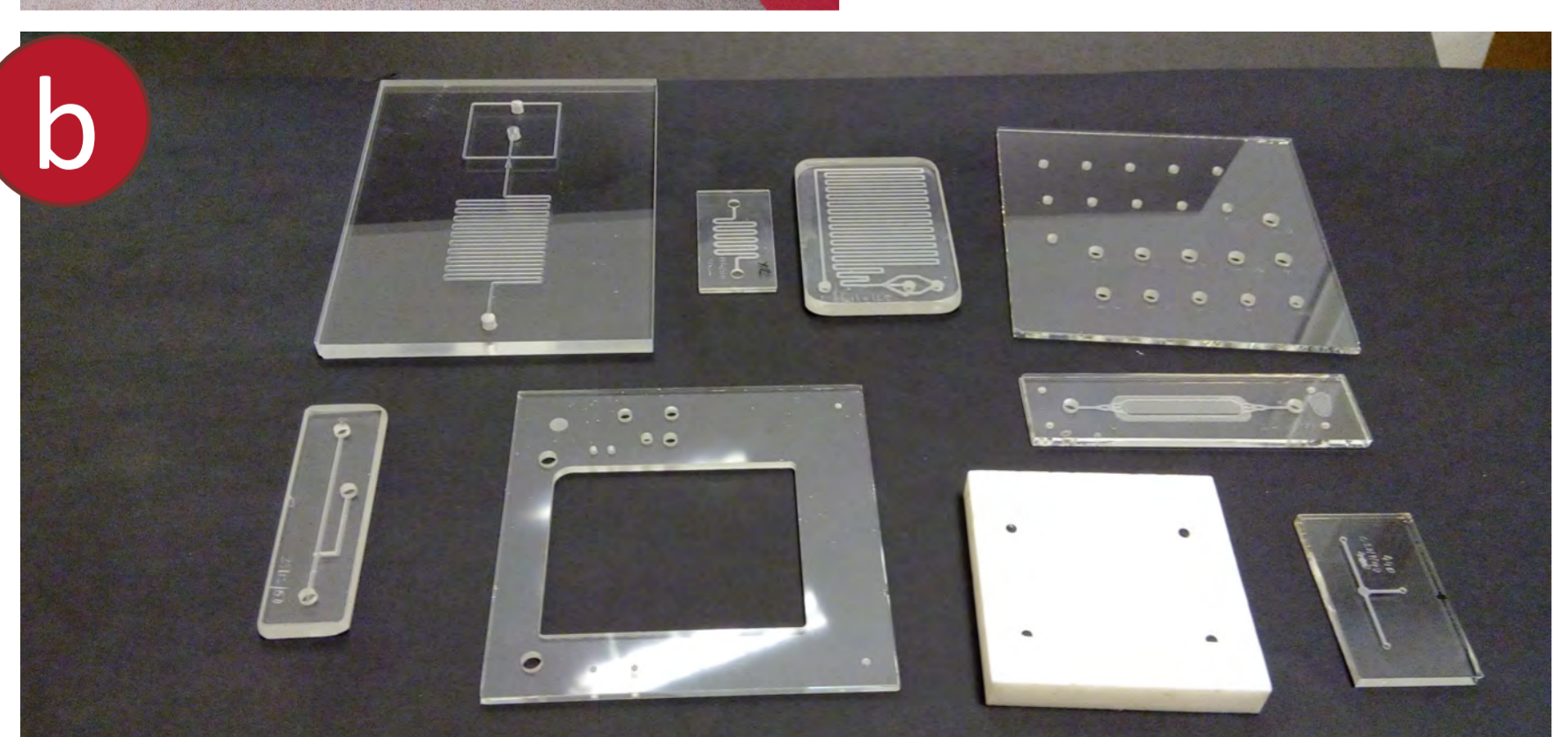
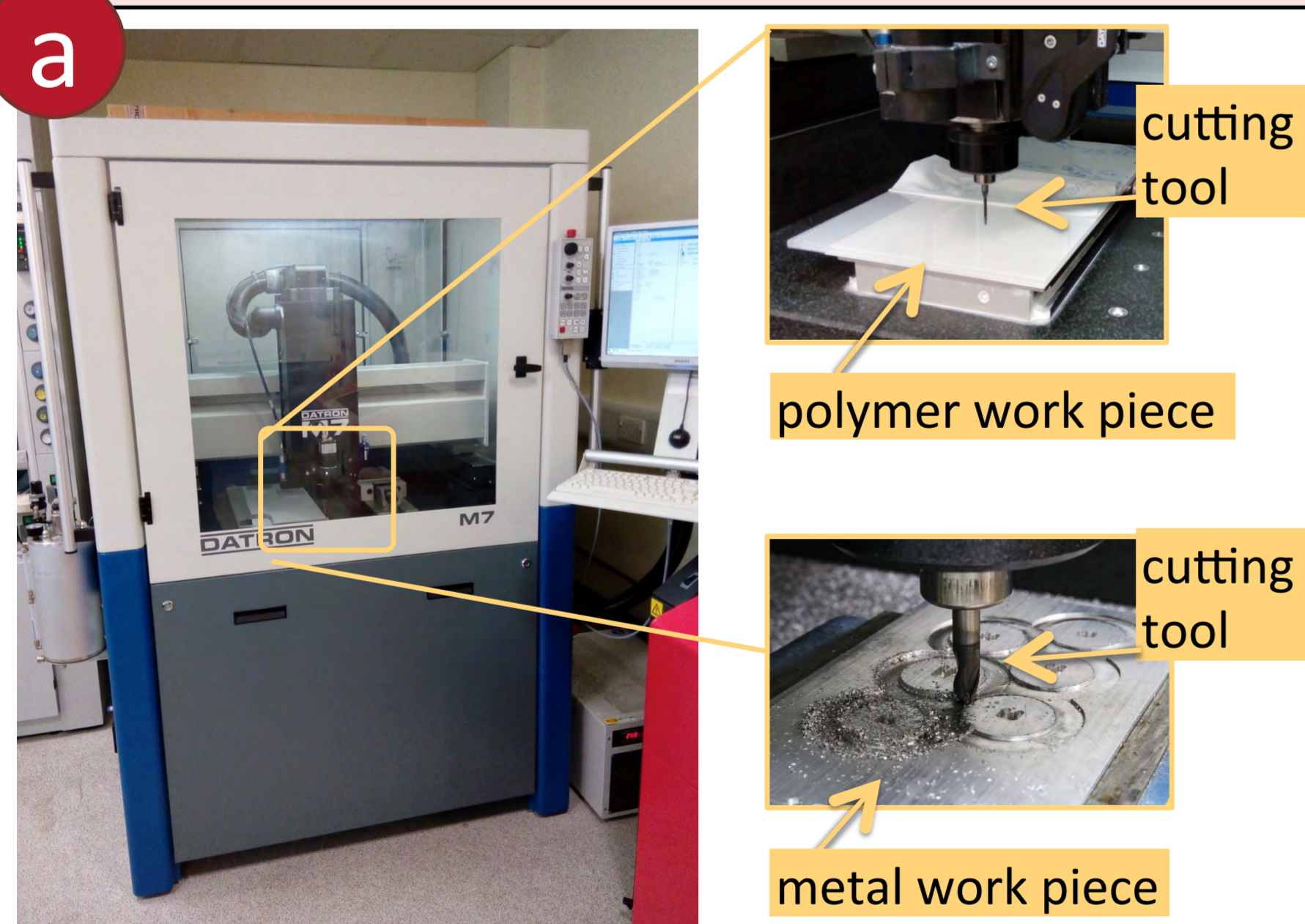


Figure 3: (a) Photograph of the CNC milling machine in our Lab-on-a-Chip fabrication facility, with enlarged pictures of cutting tools and work pieces. (b) Various items fabricated using our CNC machine.

At the University of Hull **computer numerically controlled (CNC) milling** is used for cutting channels, holes and features into a range of materials such as aluminium, plastics, PTFE and glass. CNC milled aluminium pieces serve as templates for injection moulding or hot embossing of polymers such as PMMA, PC or COC. CNC milled PTFE pieces serve as moulds for soft polymers such as PDMS. We also mill directly into glass or polymer pieces to cut out chambers and holes or to mill channels and cavities. With our machine, cutting tools vary in size from 0.1 mm to 6 mm in diameter.

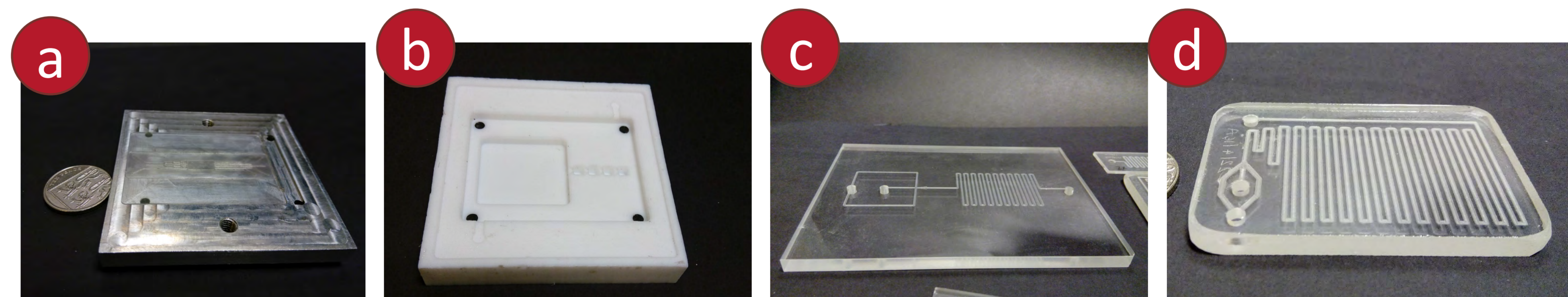


Figure 4: The CNC machine allows milling in a range of materials including (a) aluminium, (b) PTFE (teflon), (c) rigid polymers such as sheets of PMMA, and (d) glass.

KEY REFERENCES

- Esfahani MM N, Tarn MD, Choudhury TA, Hewitt LC, Mayo AJ, Rubin TA, Waller MR, Christensen MG, Dawson A, Pamme N, Lab-on-a-chip workshop activities for secondary school students. *Biomicrofluidics*. 2016;10(1):011301.