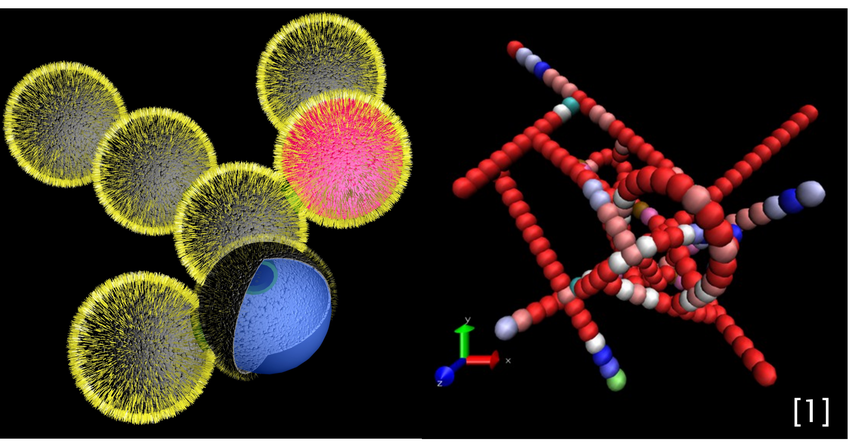
Microlitre droplet-in-oil arrays via rapid direct manufacture

UNIVERSITY OF Southampton
Hybrid Biodevices
Institute for Life Sciences

Philip H. King, Josephine C. Corsi, Hywel Morgan, Maurits R. R. de Planque and Klaus-Peter Zauner
Hybrid Biodevices, Institute for Life Sciences, Electronics and Computer Science, University of Southampton, UK

Molecular Computing in Droplet Arrays

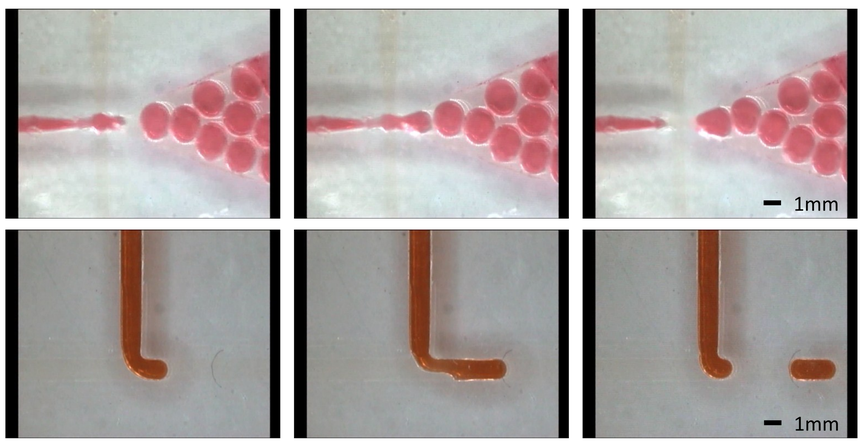
Our aim is to develop molecular computing substrates, based on the compartmentalisation of Belousov-Zhabotinsky (BZ) reaction mixture in lipid-coated droplets.



It is envisioned that the passage of the reaction excitation within networks of droplets will have computational potential [2]. The networks will be programmed by varying the droplet composition, or by moderating the excitation passage at droplet-droplet interfaces.

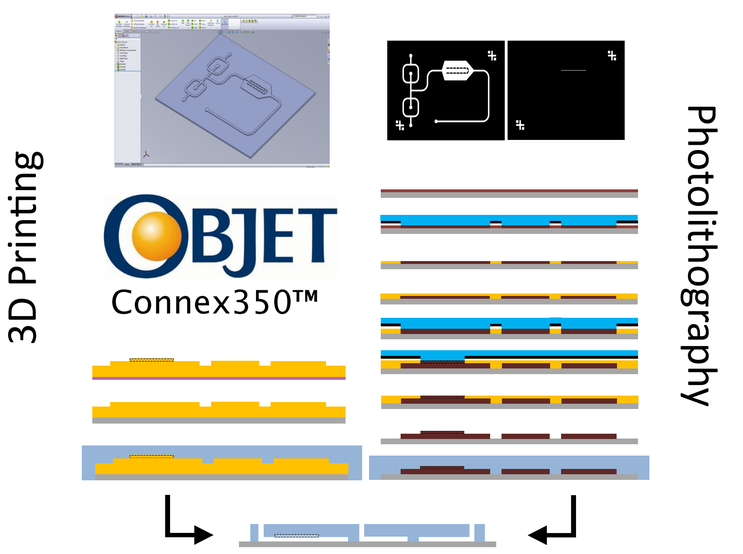
Droplet Microfluidics

Microfluidics chips allow the on-demand creation of droplets [3], which can be merged giving final concentration control. The droplets can then be arranged into 2D arrays.

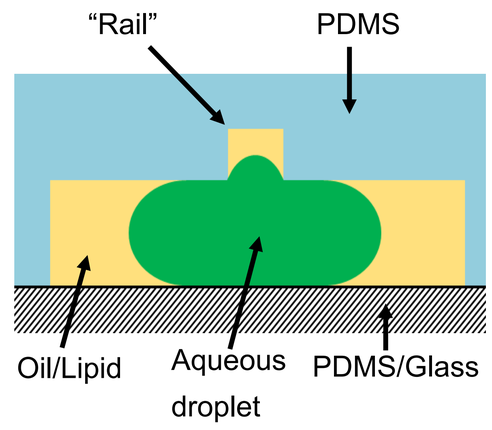


However, large droplets (>2 µl) are required to support multiple BZ oscillations, created in deep channels (500 µm). This requires high aspect-ratio moulds. If made using SU-8 photoresist, this would require multiple layers and several masks if complex designs are desired.

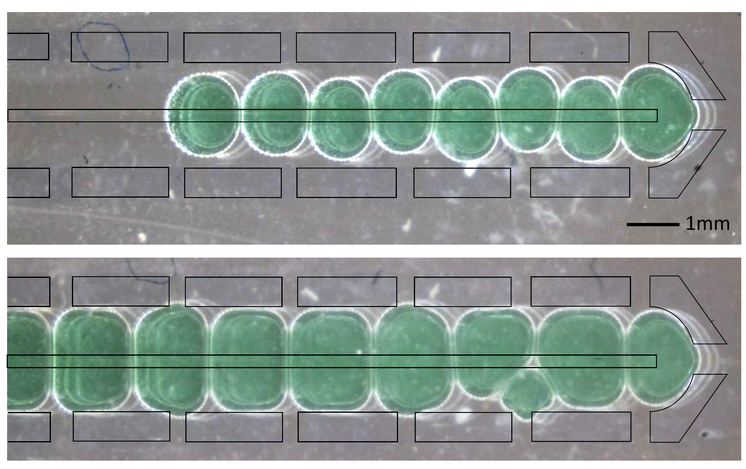
Microfluidics via 3D Printing



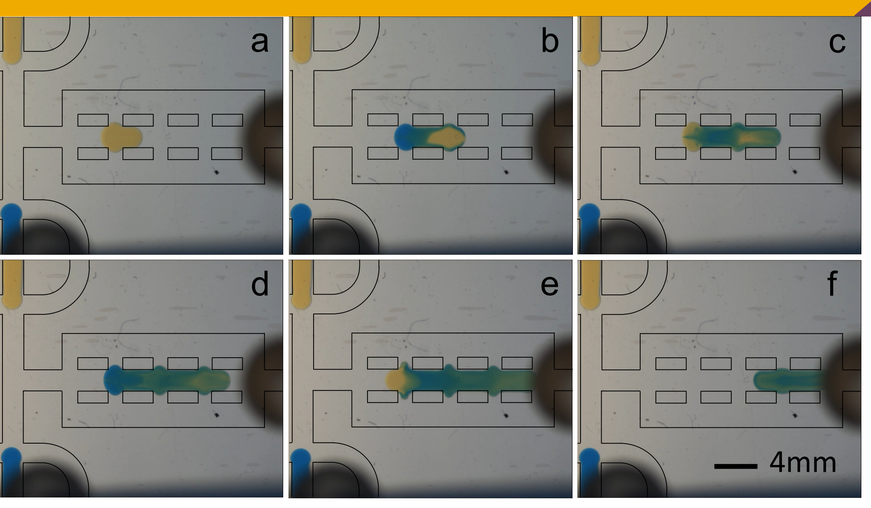
3D printing is a fast and automated alternative to photolithography for applications where resolution is not critical [4,5]. High aspect ratio, non-planar moulds can be made in a single step. Functional PDMS devices are made within 48 hours from initial design inception.



A hybrid of "droplet-on-rails" [6] and pillar-mediated droplet capture [7] is employed to form simple 2D droplet arrays. The rail prevents the lipid-stabilised droplets to adhere to the side walls of the capture chamber, and minimises undesirable non-linear packing of smaller droplets that do not touch the pillars. 3D printing allows the mould to be made in a single step, including the rail.



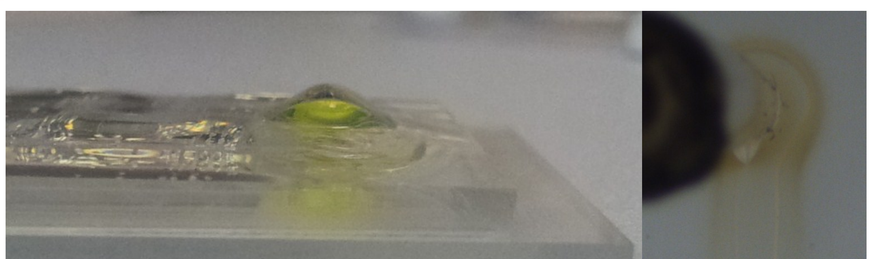
Microlitre-volume droplet merging



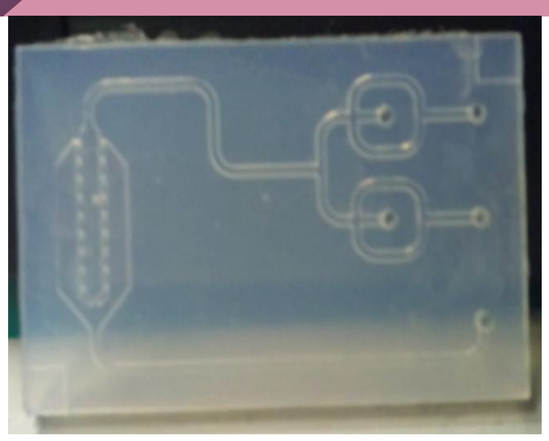
Pillar-mediated droplet merging [8] is used here with microlitre-volume, non lipid-stabilised droplets. A larger number of droplet generators enables more complex chemical reactions in the mixed droplet. The pillar array size determines the final droplet volume.

Limitations of PDMS

Although PDMS is not an ideal material for droplet-in-oil systems. As shown below, it swells heavily in decane, a non-polar solvent used as the continuous phase, which after a few hours destroys the chips. It is also damaged by sulfuric acid and absorbs bromide, both key components of the BZ reaction. Thus we are further developing our microlitre-droplet arrays in BZ-compatible materials.



Prototyping With Fluoropolymers



PTFE
PVDF
HFP

Dyneon THV 500 (3M) is a promising material for the prototyping of solvent- and acid-resistant microfluidic chips [9]. A terpolymer of PTFE, PVDF and HFP, THV is optically transparent, flexible and easily bonded. A low melting temperature (200˚C) allows melt casting into PDMS moulds in a vacuum oven.

[1] Grünert *et al* (2011) ERCIM News, 85, 30-32; [2] Gorecki *et al* (2011) J. Phys. Chem. A, 115, 8855-8859; [3] Churski *et al* (2010) Lab Chip, 10, 512-518; [4] Bonyár *et al* (2010) Procedia Engineering, 5, 291-294; [5] Huang *et al* (2009) Lab Chip, 9, 276-285; [6] *Abbyad et al* (2010) Lab Chip, 11, 813-821; [7] Bai *et al* (2010) Lab Chip, 10, 1281-1285; [8] Niu *et al* (2008) Lab Chip, 8, 1837-1841; [9] Begolo *et al* (2010) Lab Chip, 11, 508-512.

Neu Neu
Artificial Wet Neuronal Networks from Compartmentalised Excitable Chemical Media
http://neu-n.eu

FUNDING OPPORTUNITIES from the FUTURE & EMERGING TECHNOLOGIES scheme

SOUTHAMPTON NANOFABRICATION CENTRE