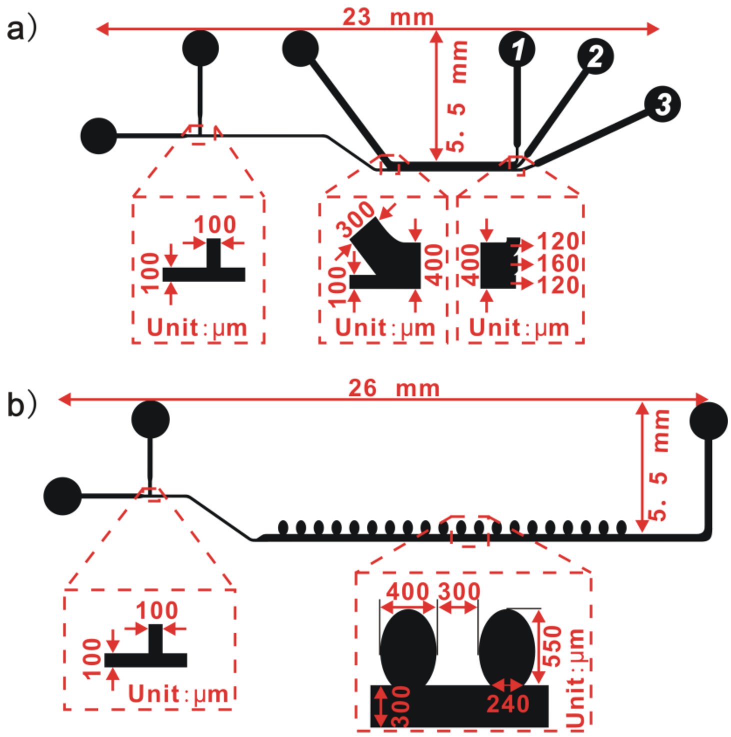
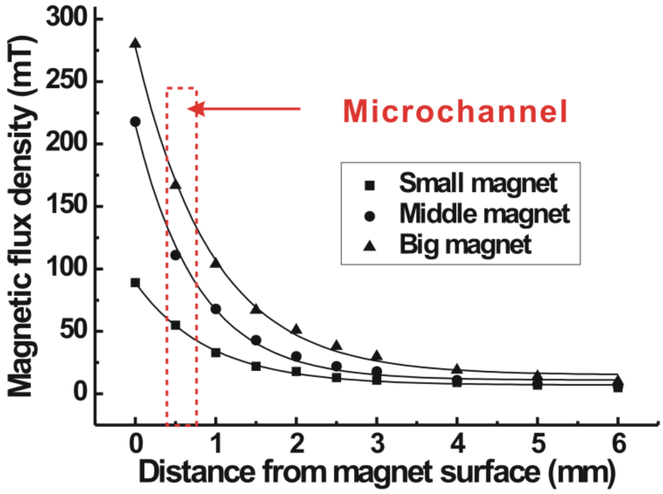
Electronic Supplementary Information

Fabrication of microfluidic chips and preparation of mineral oil-based ferrofluid:

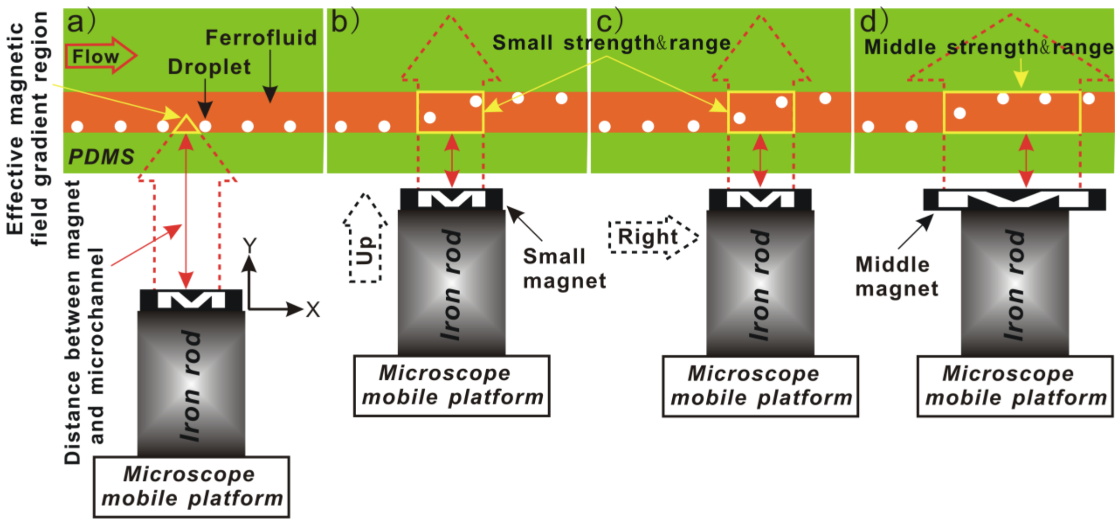
Standard poly(dimethylsiloxane) (PDMS) fabrication techniques[1] were used to fabricate microfluidic chips. Before use, the chips were left at 70 ℃ for 12 hours to ensure full recovery of the PDMS hydrophobicity. Engine oil-based ferrofluid (1.23 g/mL density, MF01, Sunrise Ferrofluid Technological Ltd.) was washed some times with ethanol until all the Fe_3O_4 magnetic nanoparticles naturally deposited and the solution was removed. After drying, the obtained magnetic nanoparticles were dispersed into the mineral oil (0.84 g/mL density, for molecular biology, Sigma) to form a mineral oil-based ferrofluid (100 g/L concentration).



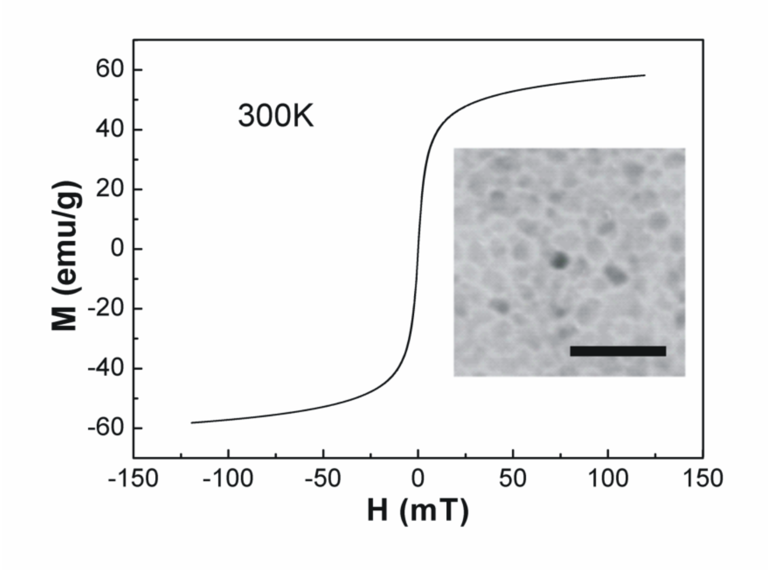
Supplementary Fig.1 Detail information of microfluidic chips including length, width and height of microchannels. (a) The microfluidic chip 1and (b) the microfluidic chip 2. All the microchannels are 100 μm in depth.



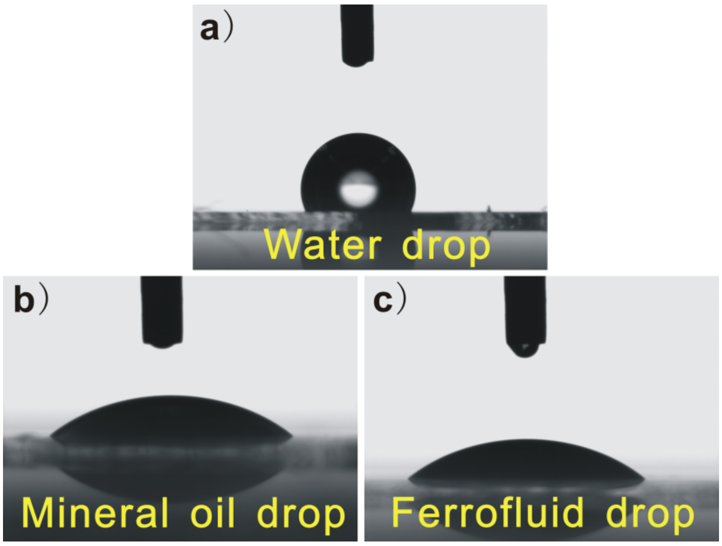
Supplementary Fig.2 Map of the measured magnetic flux density *versus* distance away from magnet surface (Gauss Meter, Shanghai). Pointes are well fitted to an exponential decay. Red dashed rectangle (400 µm in width) indicates the location of the microchannel and different magnetic field gradients across this distance are generated by three types of NdFeB magnets. They are small, middle and big magnet respectively, and had diameters of 1, 2 and 3 mm respectively.



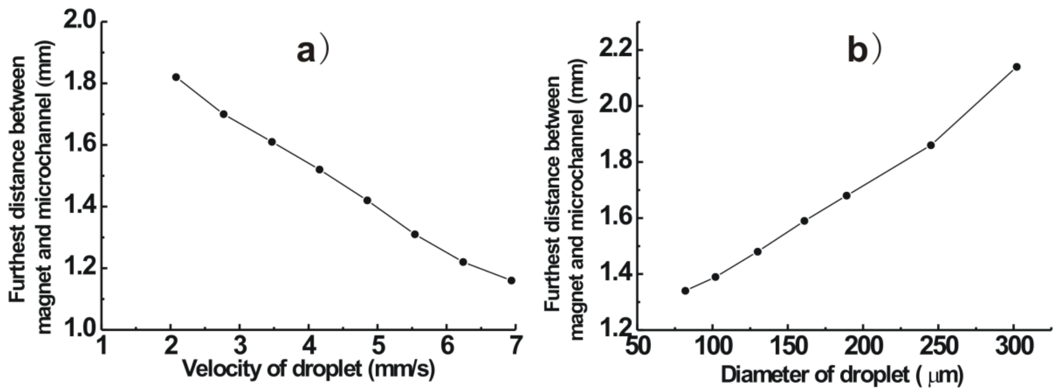
Supplementary Fig.3 Control of strength and range of magnetic repulsion. The magnet fixed at end of iron rod can be precisely moved at X-direction and Y-direction according to the experimental requirement by microscope mobile platform. We define effective magnet field gradient region (indicated by closed yellow lines) that exists in the overlap area between magnetic field region and microchannel region. The strength of magnetic repulsion is inversely proportional to distance between magnet and microchannel and proportional to magnet size, and the range of magnetic repulsion is also proportional to magnet size. (a) Droplets do not deflect in the microchannel when the distance between magnet and microchannel is too far. (b) The droplets will deflect in the effective magnetic field gradient region when the distance between magnet and microchannel is reduced. (c) By shifting the magnet to the right, droplet deflection region correspondingly moves to the right. (d) Greater numbers of droplets can be simultaneously deflected when using a middle magnet to provide a wider effective magnetic field gradient region.



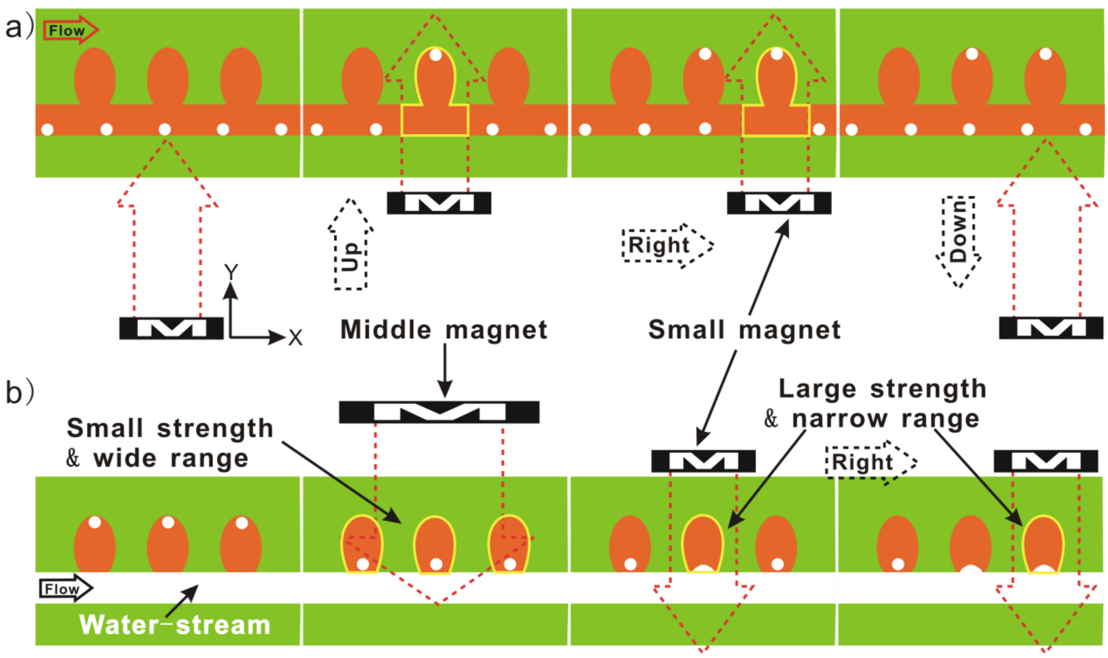
Supplementary Fig.4 Characteristics of magnetic nanoparticles. TEM image (the insert and scale bar, 50 nm, measured by H800, Hitachi) and 300 K magnetization curve (measured by PPMS-9T, Quantum Design) demonstrates average size (10 ± 2 nm) and saturation magnetic flux density (～50 mT) of magnetic nanoparticles, respectively.



Supplementary Fig.5 Experiments of intrinsic contact angle measurement (OCA, Dataphysics). Profiles of (a) a deionized water drop, (b) a mineral oil drop and (c) a ferrofluid drop on a bed of PDMS. Each drop has a volume of 2 μL. The results show that intrinsic contact angles are a) 116.5º, b) 41.9º and c) 42.1º, respectively.



Supplementary Fig.6 Controlled droplet deflection. Droplets can achieve a complete deflection at Y-direction in the microchannel only when the distance between magnet and microchannel is less than or equal to the furthest distance (also called critical distance) between magnet and microchannel. The furthest distance (a) decreases with increasing velocity of droplet and (b) increases with diameter of droplet. Diameter of droplet is 150 μm in (a) and velocity of droplet is 3.6 mm/s in (b). Width of microchannel is 400 μm and each point is the average of at least five measurements. All the magnetic repulsions are provided by middle magnet.



Supplementary Fig.7 Trapping and demulsification of single-droplet. (a) On-demand trapping of single-droplet into the designated microwells by controlling the position of small magnet. And desired numbers of droplets can be captured into the designated single-microwell by repeating above operations. (b) Selective coalescence of single-droplet with continuous water-stream using a relatively large strength and narrow range of magnetic repulsion provided by small magnet. The effective magnet field gradient regions are indicated by closed yellow lines.

1. D. C. Duffy, J. C. McDonald, O. J. A. Schueller, G. M. Whitesides, *Anal. Chem.* 1998, 49, 74.