Electronic Supplementary Material (ESI) for Lab on a Chip
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Controlling bubbles using bubbles – Microfluidic synthesis of ultra-small gold nanocrystals with gas-evolving reducing agents

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Single phase microfluidic experiments

Single phase flow studies which involve premixing the aqueous solution of CTAB and $HAuCl_4$ and passing them through one of the reactor inlets at flow rate of 7.5 µL.min^{-1} and flowing $NaBH_4$ through the other inlet at a flow rate of 1 µL.min^{-1} were conducted. The experiments show that the uncontrolled out gassing in the aqueous $NaBH_4$ solution resulted in nucleation of bubbles that adhere to the channel walls as shown in Figure S1 (b) leading to flow disruption, heterogeneous particle nucleation and deposition on the channel walls as shown in Figure S1 (a) and eventually to clogging within an hour of experiments.

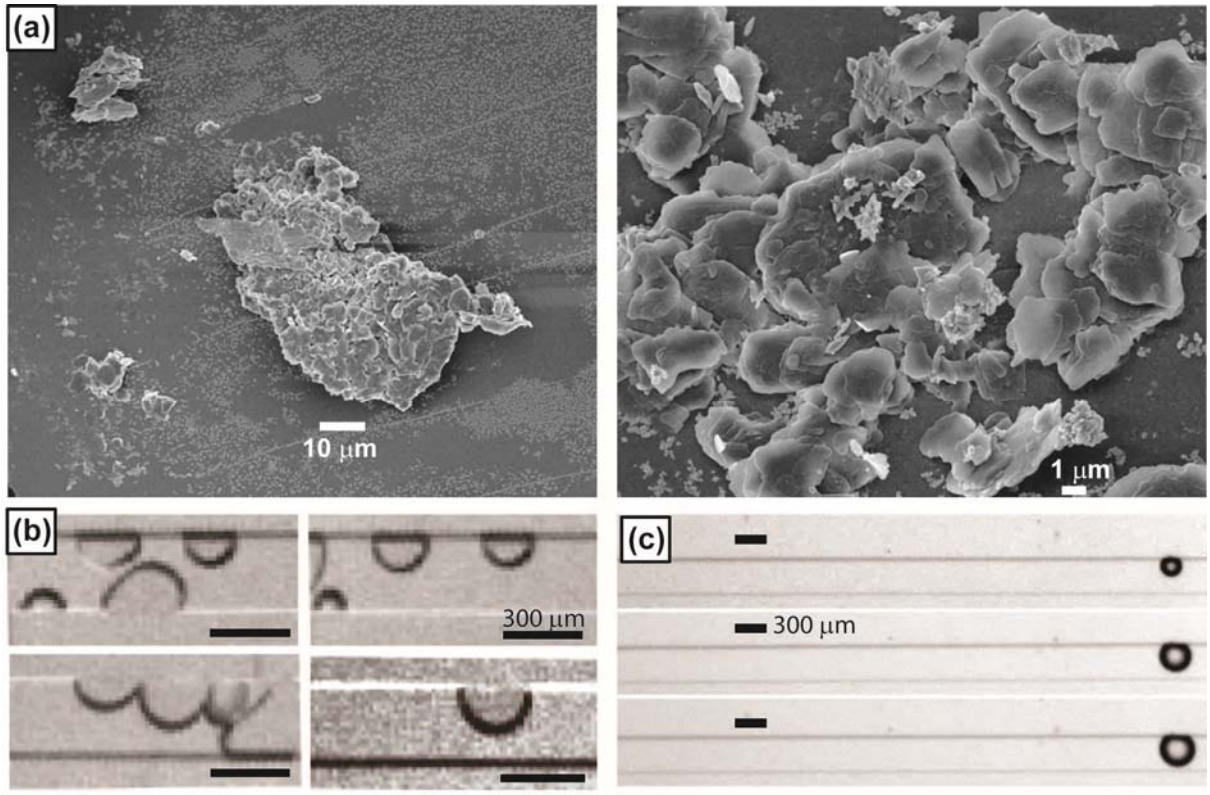

Figure S1. (a) Scanning electron microscope images of the reactor after 1 hour of experiment using the single phase flow method. (b) Stereomicroscope images of bubbles formed and adhered to the walls of the channel (c) Stereomicroscope images of the growth of a single bubble adhered onto the reactor wall over a period of 5 mins.

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SEM images of the channel

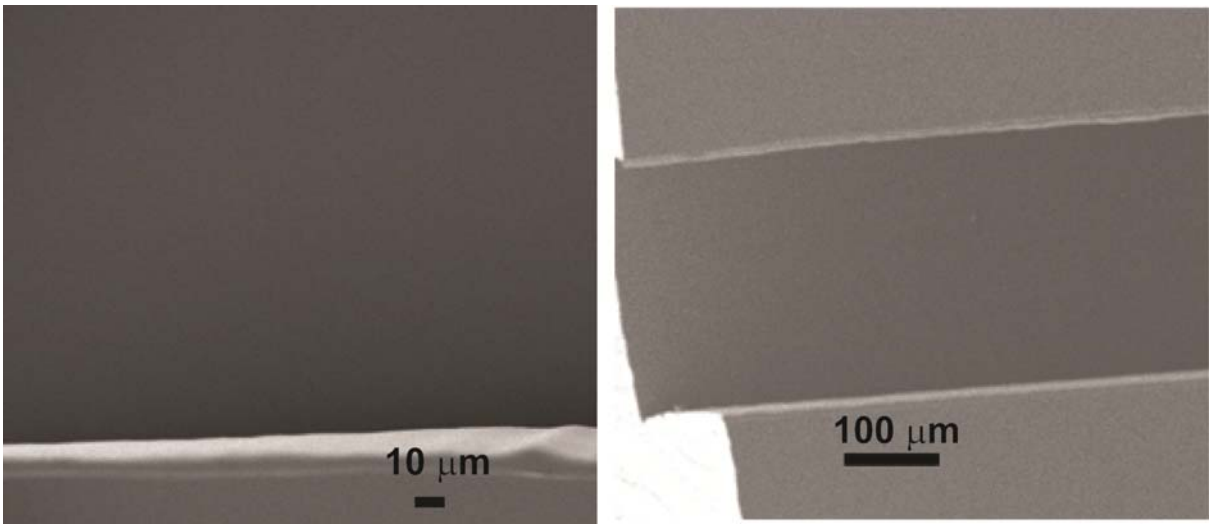

Fig. S2 SEM images of the device walls after 8 hrs of continuous synthesis using the segmented-flow method

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Seeded growth of gold nanorods using chemically modified $NaBH_4$

Experimental

Chemical modificatin of $NaBH_4$ solution

A stock solution was prepared by adding 0.038 g of $NaBH_4$ to 30 mL of 1 M NaOH and 70 mL of DI water. 3 mL of this stock solution was then mixed with a solution containing 0.1 g of $NaBH_4$ in 30 mL of iso-propanol.

Seed synthesis

Nearly spherical gold nanoparticle seeds (<4 nm in size) were synthesised by adding freshly prepared, ice cold sodium borohydride solution (0.6 mL of the above mentioned solution) to a mixture of aqueous $HAuCl_4.3H_2O$ (0.25 mL of 10 mM) and CTAB (7.5 mL of 100 mM) solution, while stirring vigorously (700 rpm, Heidolph) using a magnetic stirrer (teflon, 2 mm) in a borosilicate vial (20mL, scintillation, Kimble glass Inc., Singapore). The solution was brownish yellow and was maintained at 35°C to prevent CTAB from crystallizing.

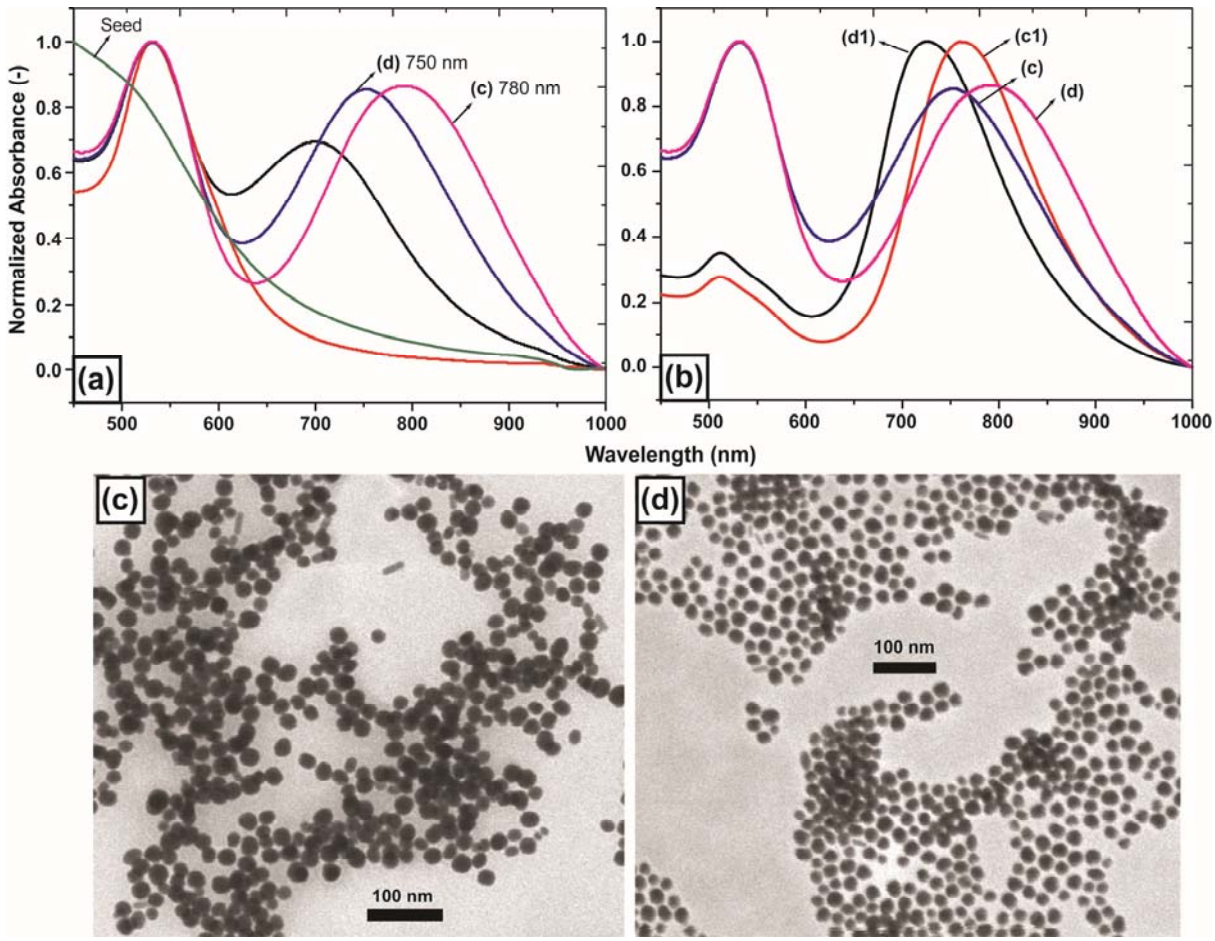

Figure S3. UV-vis absorbance spectra of (a) GNR synthesised using chemically modified $NaBH_4$ solution (b) Comparison of the spectra of GNR samples synthesised using seeds prepared from (c) and (d) chemically modified $NaBH_4$ solution and (c1) and (d1) unmodified $NaBH_4$ solution. TEM images of GNR samples synthesised using chemically modified $NaBH_4$ solution with silver ion content (c) 0.08 mM and (d) 0.1 mM.

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Table 1 : Other reactions that can be performed using our approach

1. Generation, separation, and reaction of diazomethane gas.[1]
2. Enzymatic reactions evolving CO_2, O_2, CH_3 and H_2.[2-4]
3. Bromine gas by oxidation of bromide by bromate.[5]
4. Nirogen and nitrous oxide by the oxidation of hydrazoic acid with bromate.[6]
5. Reactions involving strong acids evolving gases such as SO_2, CO_2 [7]

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