Supplementary Information

3D Printed Field-Deployable Microfluidic Systems for the Separation and Assay of Pu in Nuclear Forensics

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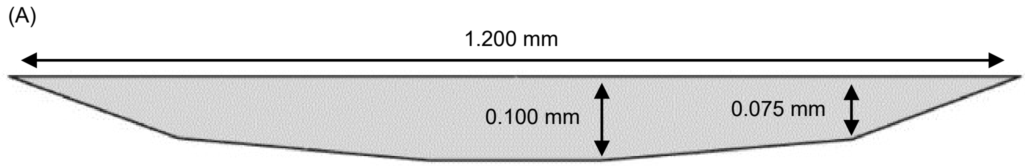


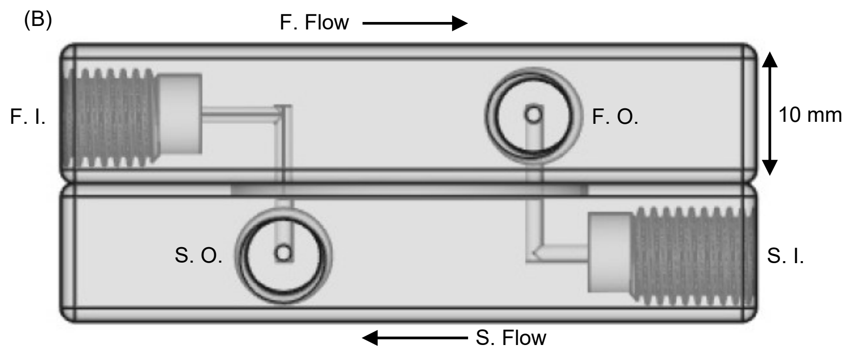
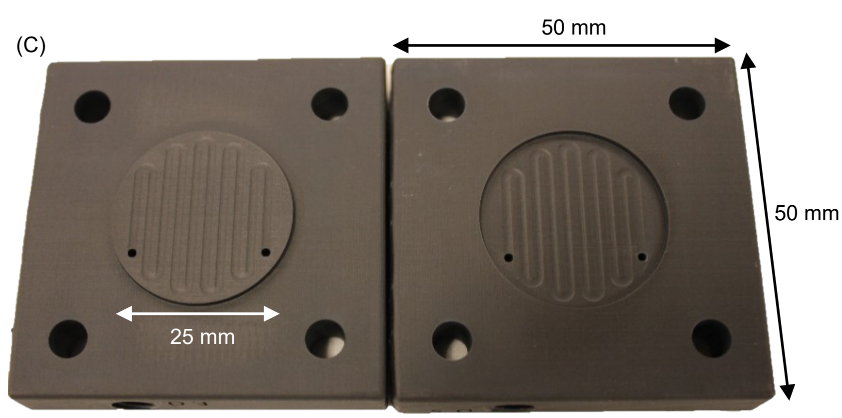


Fig. S1. FS-SLM design and production. (A) Dimensions of the 6-sided irregular polygon cross-section used for the 192 mm extraction channel. (B) Schematic view of an assembled



FS-SLM module with counter-current flow where F refers to the feed stream, S the stripping stream, I an inlet, and O an outlet. (C) Picture of a 3D printed feed (left) and stripping (right)

FS-SLM half-module. The extraction membrane placed between the FS-SLM modules in (B) has a diameter of 25 mm and a thickness of 80 μm.

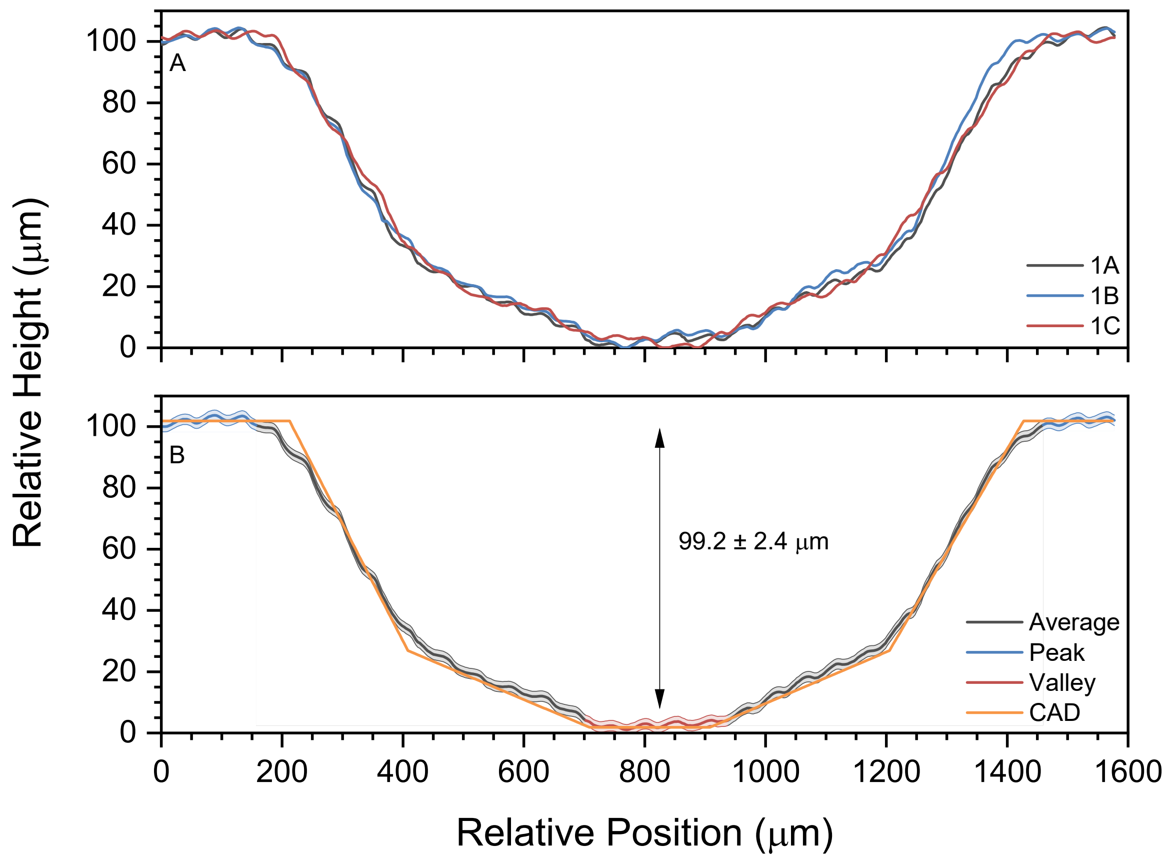


Fig. S2. Profilometry of series 1 stripping half-modules. These half-modules were printed together at the same time. (A) Profile of each half-module translated on top of each other. (B) Average profile with the peaks in blue and the valley in red. The geometry of the CAD drawing of the channel is in gold. The shaded area in (B) represents the average surface variation around the mean.

Each profile was translated onto each other along the x-axis prior to data analysis. Translation was performed in a way that minimized the average difference in the relative height (y-axis) across all three profiles. The uncertainties in Fig. S2B and S3B represent the average 1σ standard deviation in relative height across all three profiles after they have been translated onto each other. All points within two standard deviations of the maximum height were accepted as global peak values (blue). All points within two standard deviations of the minimum height were accepted as global valley values (red). The peak-to-valley distance was determined using the average of all global peak and global valley heights. The local peaks and valleys across all the profiles are a feature of the 3D printer. The local peaks in these figures are observed in approximately 50 μm intervals, which was the set resolution of the 3D printer along this axis (z-axis) while printing. The comparison of series 1 and 2 indicates that the 3D printer can produce consistent parts even when printed two weeks apart.

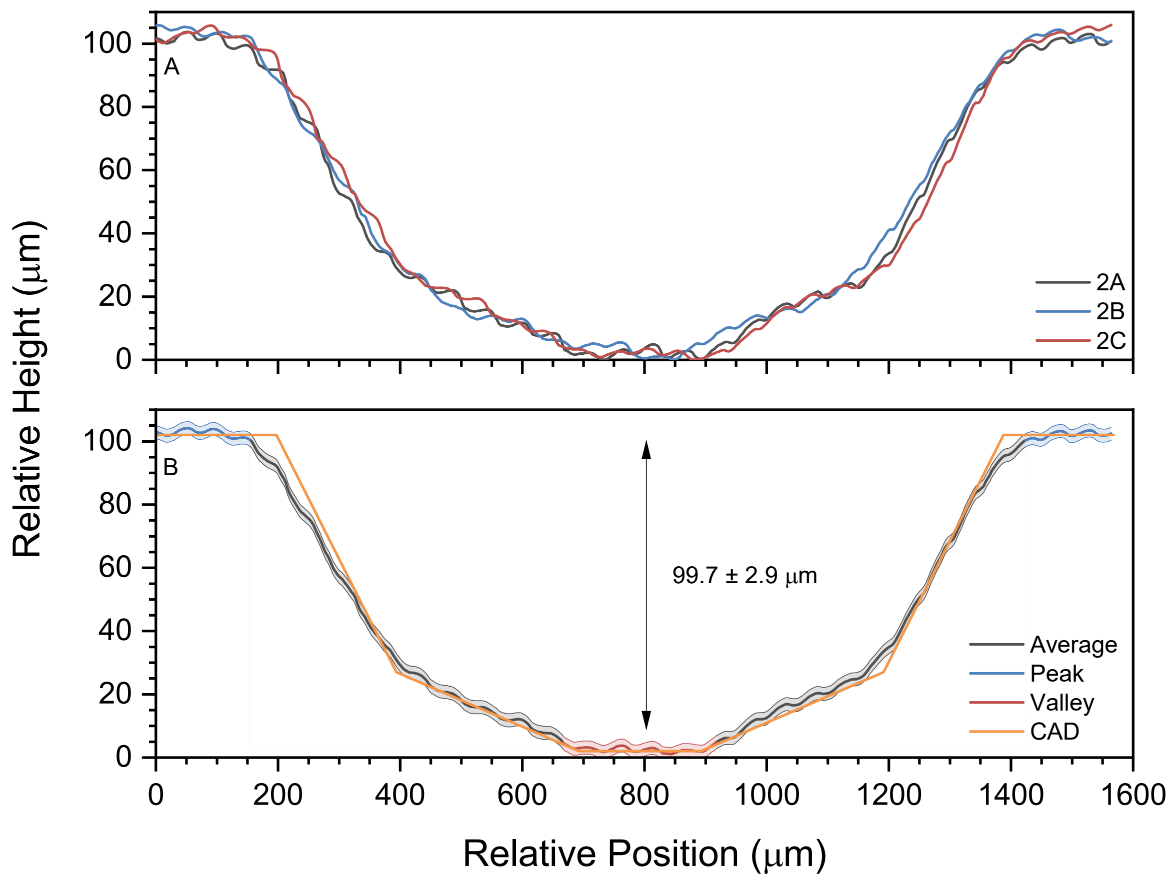


Fig. S3. Profilometry of series 2 stripping half-modules. These half-modules were printed two weeks after series 1. (A) Profile of each half-module translated on top of each other. (B) Average profile with the peaks in blue and the valley in red. The geometry of the CAD drawing of the channel is in gold. The shaded area in (B) represents the average surface variation around the mean.

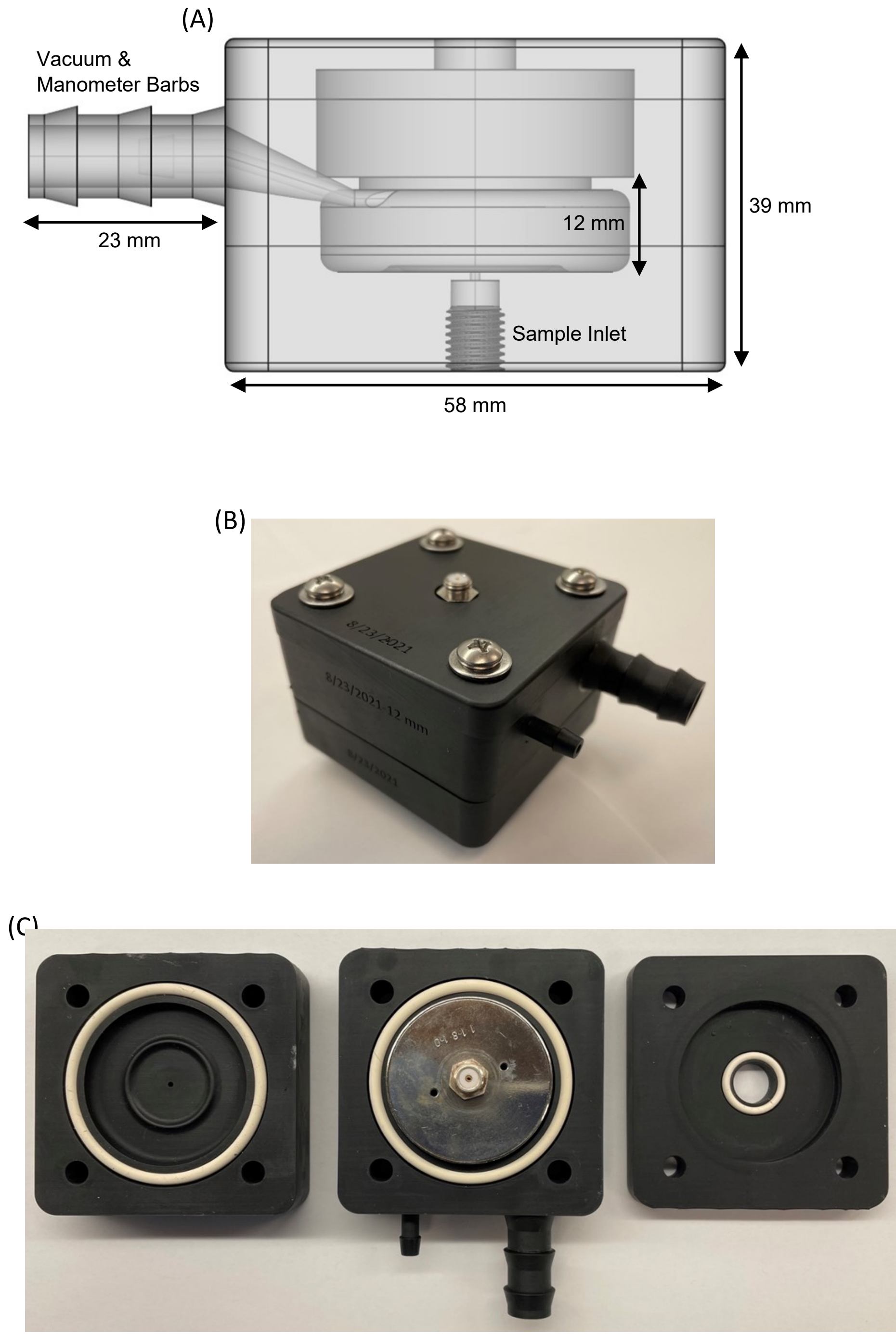


Fig. S4. Alpha chamber design. The CAD schematic (A) is shown with o-ring grooves and bolt clearance holes omitted for clarity. The distance between the sample and detector surface is

12 mm. The chamber is also shown fully constructed (B) and deconstructed (C). The top piece is displayed upside-down in (C) to show the o-ring that seals against the detector.

The approximately 100 μL solution-state sample is introduced through the sample inlet at the bottom of the alpha chamber. The sample is allowed to collect at the bottom (Fig. S4C, left) where it is dried after the vacuum is applied. The detector sits in the top of the chamber (Fig. S4C, middle) with a 12 mm gap between the sample and the detector surface. The detector connections feed through the hole in the top of the chamber (Fig. S4C, right) so the detector may be biased at +40 V.

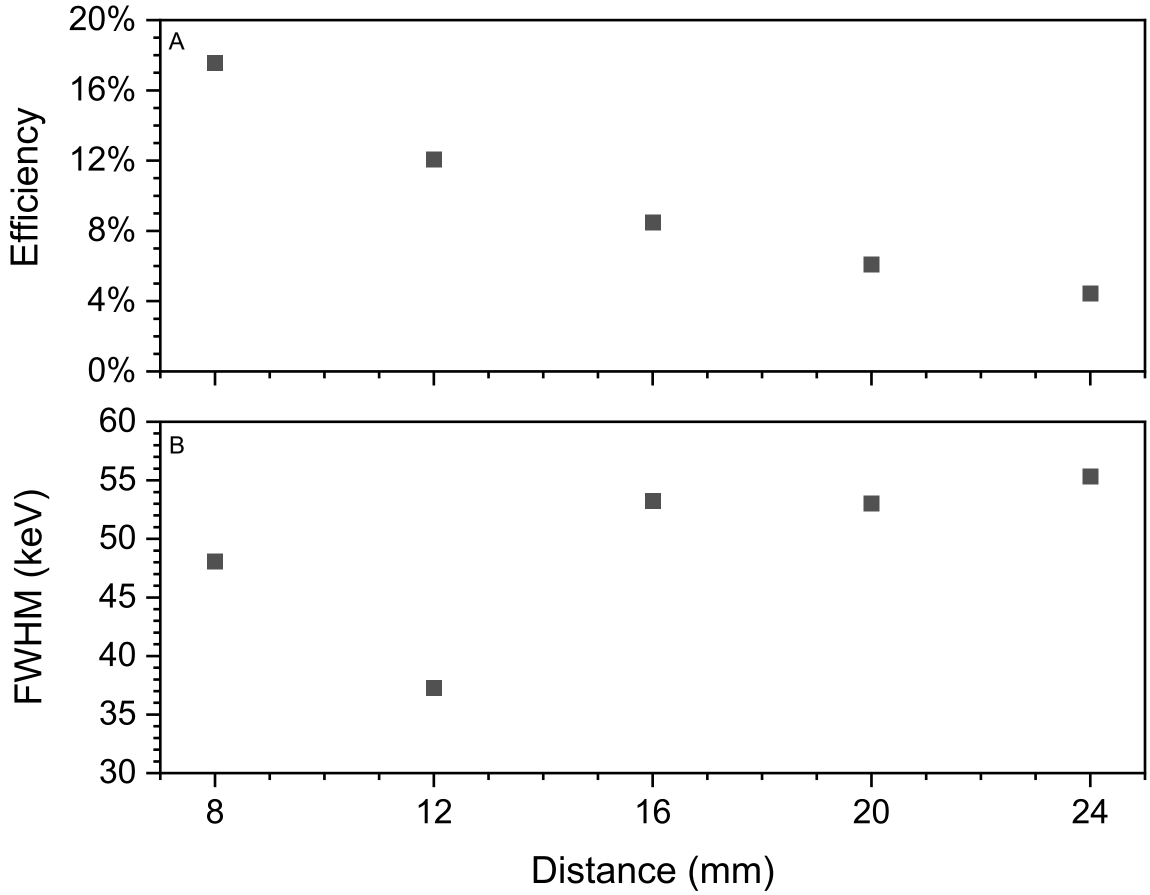


Fig. S5. Characteristics of the 3D alpha chamber. (A) Efficiency and (B) ^{238}Pu peak FWHM as a function of detector distance from sample stage.

Typically, a greater distance between sample and detector results in a lower full-width at half-maximum (FWHM); however, a minimum FWHM was observed at a 12 mm distance. This is likely because the system was operated with a coarse vacuum (approximately 20 – 30 torr), resulting in more straggling/degradation in the longer distance chambers. For this reason, the 12 mm distance was used for alpha spectrometry measurements to achieve the greatest resolution.