

## SUPPLEMENTARY MATERIAL

# Deterministic bead-in-droplet ejection utilizing an integrated plug-in bead dispenser for single bead-based applications

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## 1. The design and dimensions of the plug-in bead dispenser

## (a) The top view of the dispenser

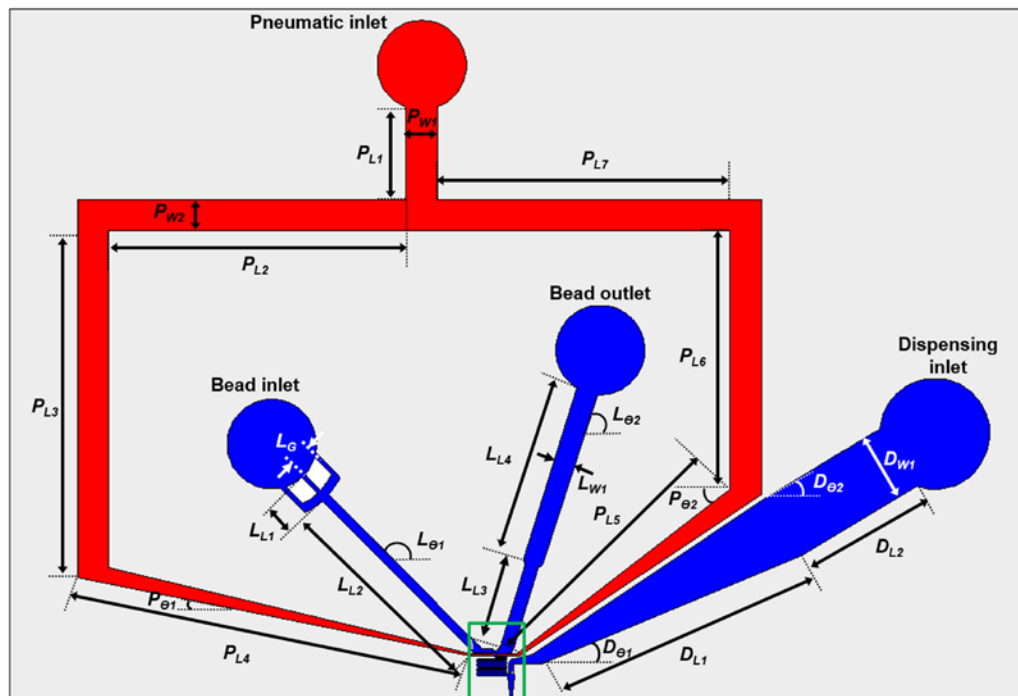
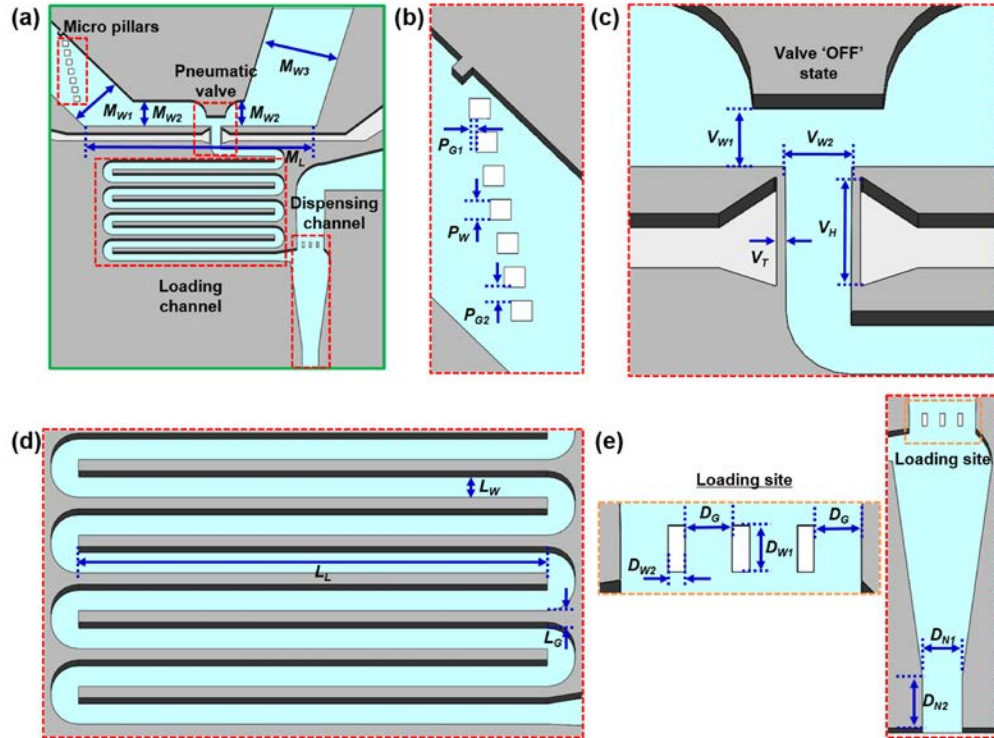


Figure S1. The top view of the dispenser

Table S1. Summary of dispenser dimensions in figure S1

| Pneumatic channel | Dimensions | Bead channel  | Dimensions | Dispensing channel | Dimensions |
|-------------------|------------|---------------|------------|--------------------|------------|
| $P_{L1}$          | 2.067 mm   | $L_{L1}$      | 0.698 mm   | $D_{L1}$           | 6.306 mm   |
| $P_{L2}$          | 6.658 mm   | $L_{L2}$      | 4.802 mm   | $D_{L2}$           | 3.000 mm   |
| $P_{L3}$          | 7.530 mm   | $L_{L3}$      | 2.000 mm   | $D_{\theta1}$      | 23 °       |
| $P_{L4}$          | 8.951 mm   | $L_{L4}$      | 4.062 mm   | $D_{\theta2}$      | 31 °       |
| $P_{L5}$          | 6.029 mm   | $L_G$         | 0.408 mm   | $D_{W1}$           | 1.516 mm   |
| $P_{L6}$          | 5.792 mm   | $L_{\theta1}$ | 135 °      | -                  | -          |
| $P_{L7}$          | 6.545 mm   | $L_{\theta2}$ | 72 °       | -                  | -          |
| $P_{W1}$          | 0.725 mm   | $L_{W1}$      | 0.443 mm   | -                  | -          |
| $P_{W2}$          | 0.700 mm   | -             | -          | -                  | -          |
| $P_{\theta1}$     | 11 °       | -             | -          | -                  | -          |
| $P_{\theta2}$     | 38 °       | -             | -          | -                  | -          |

(b) An expanded view of the green box in figure S1

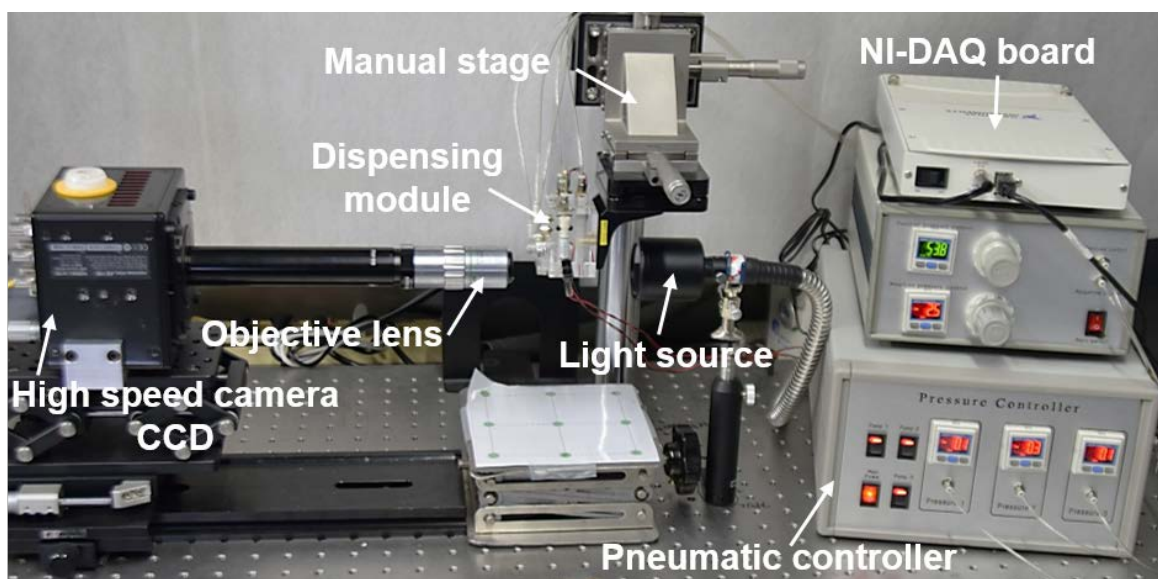


**Figure S2.** Details of the dispenser in an expanded view. (a) overall view, (b) micro pillars, (c) pneumatic valve, (d) loading channel, and (e) dispensing channel with the loading site.

**Table S2.** Summary of the dispenser dimensions in figure S2

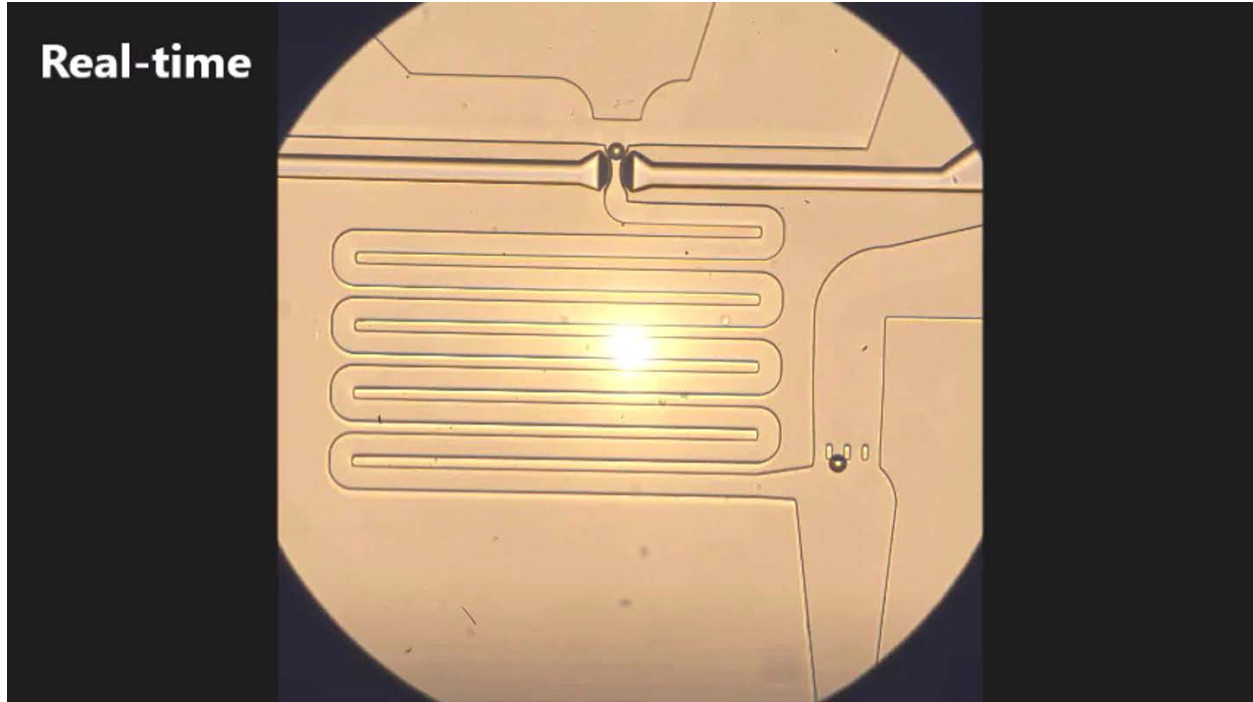
|                               |          |                   |
|-------------------------------|----------|-------------------|
| <b>Main channel (a)</b>       | $M_{W1}$ | 200 $\mu\text{m}$ |
|                               | $M_{W2}$ | 100 $\mu\text{m}$ |
|                               | $M_{W3}$ | 300 $\mu\text{m}$ |
|                               | $M_L$    | 860 $\mu\text{m}$ |
| <b>Micro pillars (b)</b>      | $P_{G1}$ | 7 $\mu\text{m}$   |
|                               | $P_{G2}$ | 14 $\mu\text{m}$  |
|                               | $P_W$    | 21 $\mu\text{m}$  |
| <b>Pneumatic valve (c)</b>    | $V_{W1}$ | 40 $\mu\text{m}$  |
|                               | $V_{W2}$ | 35 $\mu\text{m}$  |
|                               | $V_T$    | 5 $\mu\text{m}$   |
|                               | $V_H$    | 60 $\mu\text{m}$  |
| <b>Loading channel (d)</b>    | $L_W$    | 35 $\mu\text{m}$  |
|                               | $L_L$    | 600 $\mu\text{m}$ |
|                               | $L_G$    | 15 $\mu\text{m}$  |
| <b>Dispensing channel (e)</b> | $D_{W1}$ | 20 $\mu\text{m}$  |
|                               | $D_{W2}$ | 7 $\mu\text{m}$   |
|                               | $D_G$    | 20 $\mu\text{m}$  |
|                               | $D_{N1}$ | 60 $\mu\text{m}$  |
|                               | $D_{N2}$ | 100 $\mu\text{m}$ |

## 2. Details of experimental setup



**Figure S3.** Experimental setup.

3. Video clip 1 showing the defect-free operation of the deterministic BIDE at the optimized operating conditions (captured by a high-speed camera at 500 fps)



4. Video clip 2 showing the aggregation of four fluorescent beads in an evaporating droplet

