## Fluid mechanism of three-nozzle chemical pen for nanofabrication Peng Chenhan<sup>1</sup>, 河西 奈保子<sup>1</sup>, 中嶋 秀<sup>1</sup>, 加藤 俊吾<sup>1</sup>, Mao Sifeng<sup>1</sup> Tokyo Metropolitan Univ.<sup>1</sup>. E-mail: maosifeng@tmu.ac.jp

## [Introduction]

Micro-chemical pen (MCP) developed by our group has achieved Ag nanowire fabrication with a finest width of 85 nm<sup>1</sup>. However, the mechanism of why MCP can perform fabrication at nanometer levels has not been revealed, we assume that the existence of an intermediate layer between two reaction flows in MCP influences the product sizes. Here, numeric simulation in combination with fluorescent experiments were applied to verify the existence of the intermediate layer. This result will enable us to further understand this mechanism.

## [Experiment]

Comsol® Multiphysics 5.5 software was used to carry out 3-dimentional simulations. Uranine was used as the injected reagent both in simulation and experiments.

In the traditional two-phase diffusion (*Fig. 1a*), solutions A and B diffused into each other simultaneously to generate a mixing region (*Fig. 1b green line*) at an efficient diffusion concentration (*black dash line*). In the case of MCP, there was a surrounding medium layer W between the solution A and B, and both A and B diffused first through intermediate layer W then into each other (*Fig. 1c*). Because of the existence of W,

![](_page_0_Figure_8.jpeg)

Figure 1 illustration of how intermediate layer influence the size of mixing region.

after diffusion, the mixing region (Fig. 1d green line) was much small than the traditional case.

[Results and Discussion]

From both the simulation (*Fig. 2a*) and experimental results (*Fig. 2b*) we confirmed the existence of the intermediate layer between the two solutions. As the width of inter mediate layer increased, the width of the mixing region became smaller (*Fig. 2c*). All the

![](_page_0_Figure_13.jpeg)

region became smaller (*Fig. 2c*). All the Figure 2 Results from (a)(c) Numeric simulation (b) Experiments. results revealed that the existence of an Scale bar:  $50\mu m$ 

intermediate layer would be an important feature for the high-resolution fabrication of MCP.

## [Reference]

1. Zhang Y et al. Chem Commun (Camb) 54, 719-722(2018).