NanoBiotech Laboratory 2017

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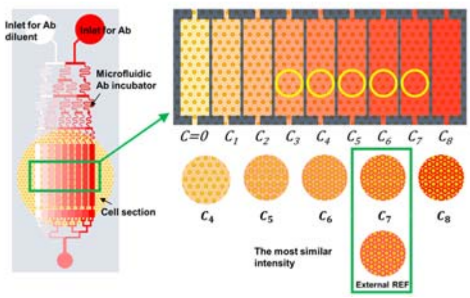
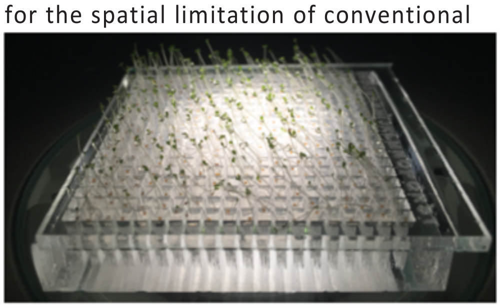
NanoBiotech Laboratory (NBL) has been interested in developing novel microfluidic and lab-on-a-chip devices as a new platform for biological sample processing, separation, and detection. Microfluidics is a key technology for the realization of micro total analysis systems (μTAS) and lab-on-a-chip in the areas of drug discovery, medical diagnostics, and tissue engineering due to several advantages such as precise fluid handling, low reagent consumption and potentially massive parallelization of experiments. In particular, microfluidic cell culture allows control of fluid flow on the micrometer-scale on the basis of diffusion transport and provides more in vivo-like environments for organ function-on-a-chip. Our recent development of microfluidic analytical technologies includes optoelectrofluidics, hydrophoretic separations, magnetophoretic assays, and microfluidic immunohistochemistry. Currently, we are focusing on the practical aspects of microfluidic diagnostic devices and multicellular 3D assay platforms. Since June 2008, his laboratory has been selected to receive a National Leading Research Laboratory Program grant through the National Research Foundation of Korea, funded by the Ministry of Science and ICT.

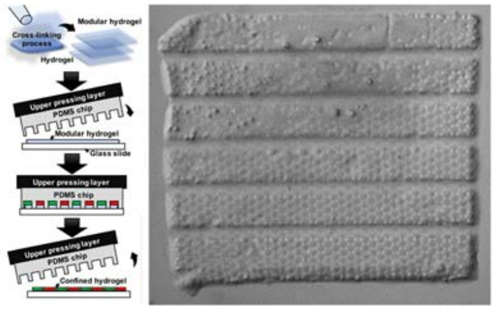
Microfluidic immunostaining system for standardization: Conventional immunohistochemistry (IHC) process is difficult to standardize for quality assurance of the test, which was subjective and qualitative. In particular, immunostaining quality is highly variable among laboratories, technicians, and protocols. Moreover, there is no effective system for verifying and standardizing IHC testing. To address this problem, we first developed a microfluidic immunostaining system which enables standardization and quality assurance of cancer diagnostic test [7]. We also report a simple and easy-to-use microfluidic IHC platform based on the operation of a manual pipette [5]. This simple pipetting-based approach allows end users to better use microfluidic IHC in real-world environments.



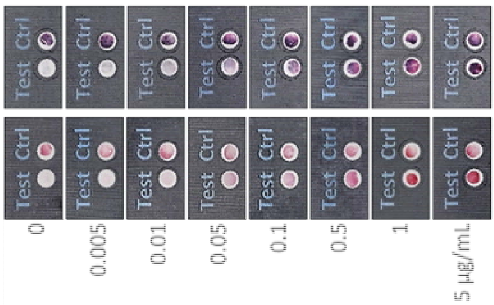
Plant array chip for *Arabidopsis thaliana*: We report a novel plant array chip suitable for testing various environmental factors that affect seed germination and seedling growth in a small space [11]. There is an unmet need for a multi-purpose, standardized platform that is capable of observing various phenotypes besides root. The proposed array chip allows the tracking of an individual seed in spatially partitioned arrays of solid medium blocks and provides a solution for the spatial limitation of conventional experimental setups that require a large space to test many conditions. We expect this platform to be widely used for various purposes, including germination test, stimuli screening, and pesticide screening in both industry and academia.



Multicellular analysis in a microfluidic assembly platform: We describe a new approach for multicellular analysis using a microfluidic assembly platform based on the ce ll-containing hydrogel sheet, which can be integrated as an interposed module in a microfluidic device [8]. After simultaneously obtaining multi-labeled cells in the hydrogel sheet, each modular hydrogel sheet is recoverable and recultured without any distortion. The modular hydrogel sheet can be simply manipulated and conserved as a multicellular module in a 3D in vitro culture platform. Using the modular concept of hydrogel sheet capable of cell culture and assay, an integrated multicellular analysis in the microfluidic device expects to improve accessibility, scalability and practicality for end users.



Paper-based vertical flow assays: We present vertical flow assays (VFAs) with multistep reactions based on the programmed reagent loading using a pressed paper [9]. In this work, a pressed paper was integrated into a 3D paper-based microfluidic device to simplify complicated operation principle of VFAs and to handle multistep reactions by delaying the flow. The reagent loading order was easily changed by controlling the amount of applied pressure as well as the geometry of the paper channel. By loading all reagents simultaneously, each reagent was loaded into the test regions in the programmed order. As a target analyte, high sensitive detection of C-reactive protein was demonstrated for the prediction of cardiovascular diseases in a clinically relevant rage (0.005–5 μg/mL) without Hook effect.



Key Achievements

1. K. S. Kim and J.-K. Park*, "Magnetic force-based multiplexed immunoassay using superparamagnetic nanoparticles in microfluidic channel," Lab on a Chip, Vol. 5, No. 6, pp. 657-664, June, 2005. (Cited by 215)
2. H. Hwang, Y.-J. Choi, W. Choi, S.-H. Kim, J. Jang, and J.-K. Park*, "Interactive manipulation of blood cells using a lens-integrated liquid crystal display based optoelectronic tweezers system," Electrophoresis, Vol. 29, No. 6, pp. 1203-1212, March, 2008. (Cited by 85)
3. W. Lee, J. C. Debasitis, V. K. Lee, J.-H. Lee, K. Fischer, K. Edminster, J.-K. Park, and S.-S. Yoo*, "Multi-layered culture of human skin fibroblasts and keratinocytes through three-dimensional freeform fabrication," Biomaterials, Vol. 30, No. 8, pp. 1587-1595, March, 2009. (Cited by 246)
4. M. S. Kim, T. Kim, S.-Y. Kong, S. Kwon, C. Y. Bae, J. Choi, C. H. Kim, E. S. Lee*, and J.-K. Park*, “Breast cancer diagnosis using a microfluidic multiplexed immunohistochemistry platform,” PLoS One, Vol. 5, No. 5, e10441, May, 2010. (Cited by 61)

5. M. G. Lee, J. H. Shin, C. Y. Bae, S. Choi, and J.-K. Park*, "Label-free cancer cell separation from human whole blood using inertial microfluidics at low shear stress," Analytical Chemistry, Vol. 85, No. 13., pp. 6213–6218, July, 2013. (Cited by 81)

Achievement in This Year

1. C. H. Cho, S. Kwon, and **J.-K. Park***, "Assembly of hydrogel units for 3D microenvironment in a poly(dimethylsiloxane) channel," *Micro and Nano Systems Letters*, Vol. 5, 2, January, 2017.
2. J. H. Shin, J. Park, and **J.-K. Park***, "Organic solvent and surfactant resistant paper-fluidic devices fabricated by one-step embossing of nonwoven polypropylene sheet," *Micromachines*, Vol. 8, No. 1, 30, January, 2017.
3. S.-G. Park, Y. Lee, S. Kwon, S. Yoo, Q-H. Park, **J.-K. Park**, and K.-H. Jeong*, "Extraordinary figure-of-merit of magnetic resonance from ultrathin silicon nanohole membrane as all-dielectric metamaterial," *Advanced Optical Materials*, Vol. 5, No. 3, 1600628, February, 2017.
4. H. J. Gi, D. Han, and **J.-K. Park***, "Optoelectrofluidic printing system for fabricating hydrogel sheets with on-demand patterned cells and microparticles," *Biofabrication*, Vol. 9, No. 1, 015011, March, 2017.
5. S. Kim, S. Kwon, C. H. Cho, and **J.-K. Park***, "Pipetting-driven microfluidic immunohistochemistry platform to facilitate enhanced immunoreaction and effective use of antibodies," *Lab on a Chip*, Vol. 17, No. 4, pp. 702-709, February, 2017.
6. Y. Jo, Y. K. Hahn, and **J.-K. Park***, "A magnetophoresis-based microfluidic platform under a static-fluid environment," *Microfluidics and Nanofluidics*, Vol. 21, No. 4, 74, April, 2017.
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8. C. Y. Bae, J. Son, H. Kim, and **J.-K. Park***, "Demonstration of interposed modular hydrogel sheet for multicellular analysis in a microfluidic assembly platform," *Scientific Reports*, Vol. 7, 1289, May, 2017.
9. J. Park and **J.-K. Park***, "Pressed region integrated 3D paper-based microfluidic device that enables vertical flow multistep assays for the detection of C-reactive protein based on programmed reagent loading," *Sensors and Actuators B: Chemical*, Vol. 246, pp. 1049-1055, July, 2017.
10. G. Park, D. Han, G. Kim, S. Shin, K. Kim, **J.-K. Park**, and Y. Park*, "Visualization and label-free quantification of microfluidic mixing using quantitative phase imaging," *Applied Optics*, Vol. 56, No. 22, pp. 6341-6347, August, 2017.
11. Y.-H. Park, N. Lee, G. Choi*, and **J.-K. Park***, "Plant array chip for the germination and growth screening of Arabidopsis thaliana," *Lab on a Chip*, Vol. 17, No. 18, pp. 3071-3077, September, 2017.
12. M. Kong, J. H. Shin, S. Heu, **J.-K. Park***, and S. Ryu*, "Lateral flow assay-based bacterial detection using engineered cell wall binding domains of a phage endolysin," *Biosensors and Bioelectronics*, Vol. 96, pp. 173-177, October, 2017.
13. Y Lee and **J.-K. Park***, "Microfabricated cell culture system for the live cell observation of the multilayered proliferation of undifferentiated HT-29 cells," BioChip Journal, Vol 11, No. 4, pp. 3080315, December, 2017.