College of Engineering

Department of Mechanical & Industrial Engineering

The Robert W. Courter Seminar Series

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PFT 1206

Engineering A Monolithic 3D Paper-Based Analytical Device (µPAD) by Stereolithography 3D Printing for Chemical Analysis

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In recent years, there has been a significant need in the exploration of precise and rapid diagnostic devices, particularly since the beginning of the pandemic. Conventional diagnostic tools faced limitations due to being labor-intensive, costly, and time-consuming. As an alternative, paper-based microfluidic analytical devices (µPADs) have gained importance as widely used Point-of-Care (POC) diagnostic devices. In contrast to traditional microfluidic devices, µPADs are characterized by their simplicity, cost-effectiveness, and ease of operation, with using capillary phenomenon through a porous structure. This property serves as a passive pump, facilitating fluid transport without the need for external devices. Consequently, µPADs align with the criteria of ASSURED (affordable, sensitive, specific, user-friendly, rapid, robust, equipment-free, and deliverable to users) set by the World Health Organization for point-of-care diagnostic devices. Various methods have been employed to fabricate 2D µPADs, including photolithography, wax printing, inkjet printing, screen printing, laser treatment, and cutting processes. While 2D µPAD fabrication has seen diverse approaches, methods for 3D µPADs have been relatively limited, often requiring stacking and folding steps. This limitation has been addressed through Stereolithography 3D printing and digital masks in sequence in our research, enabling the manufacture of 3D µPADs within a monolithic layer of paper substrate in just one second. Systematic experiments were conducted to comprehensively understand the fundamentals and limitations of this efficient manufacturing process. This efficient manufacturing process allows for the creation of essential functional µPADs, including: (1) a novel 3D mixer and a fluorescent chemosensor assay used for determining dopamine concentration under high-alkaline pH conditions, (2) Loop-mediated isothermal amplification (LAMP) on µPAD for identifying harmful bacteria, and (3) a 3D µPAD coupled with liquid chromatography-MS (µPC-LC-MS) for detecting New Psychoactive Substances (NPS).

* **Pin-Chuan Chen** received his Ph.D. in the Mechanical Engineering Department of Louisiana State University, Baton Rouge, LA, USA, in 2009. Following graduation, he worked in the Microfluidics Manufacturing Programme (MMP) of Singapore Institute of Manufacturing Technology (SIMTech) from June 2009 to Aug 2011. He has been recognized as a Fellow of Royal Society of Chemistry since Feb. of 2020 and now is holding a Distinguished Professorship in the Mechanical Engineering Department of National Taiwan University of Science and Technology (Taiwan Tech) since Feb. of 2022. His current research interests include Using Additive Manufacturing (3D Printing) to Create 2D/3D Micro/Mill Fluidic Devices for Chemical/ Biochemical Applications (New Psychoactive substances (NPS), Organ-on-a-Chip), Manufacturing of Polymeric/Paper microfluidics for Chemical/Biochemical Applications, and Sensors on Polymeric/Paper substrates.