Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Chemical kinetics and spectroscopy enabled by 3D hydrodynamic focusing and mixing in a 3D-printed microfluidic device DIEGO A. HUYKE, ASHWIN RAMACHANDRAN, Stanford University, THOMAS KROLL, DANIEL P. DEPONTE, SLAC National Accelerator Laboratory, JUAN G. SANTIAGO, Stanford University, STANFORD UNIVERSITY TEAM, SLAC NATIONAL ACCELERATOR LAB TEAM — We have developed a three-dimensional (3D) hydrodynamic focusing and 3D-printed microfluidic mixer for chemical kinetics studied by X-ray absorption and emission spectroscopy (XAS/XES). To trigger reactions, our device co-flows a 30 L min-1 sample stream into a 1 mL min-1 sheath stream. This sheath focuses the sample from a 75 to 10 m hydraulic diameter within 500 s. After mixing sheath species into the sample stream, the sample stream is expanded to 50 m where XAS/XES measurements are performed. The residence times between mixing initiation and measurement are within 2.5 to 350 ms. The fused silica component of our device is a clear monolithic chip fabricated using a femtosecond laser exposure and chemical etching technique. This chip interfaces with a polyimide capillary which provides a low X-ray adsorption region. The system enables X-ray studies of order millisecond reactions, toxic chemicals, and/or anaerobic conditions. We will present the device design and fabrication and the development and experimental validation of convection-diffusion-reaction models. The models are quantitatively validated by (widefield and confocal) microscopy and by XAS/XES experiments of reacting ferricyanide and ascorbic acid. Our combined system and models are applicable to studies of the electronic structure of reaction intermediates.

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Date submitted: 31 Jul 2020 Electronic form version 1.4