AN ORGANIC ANALYZER INSTRUMENT FOR HIGHLY SENSITIVE IN SITU ORGANIC DETECTION ON AN ICE SHELL IMPACT PENETRATOR DESCENT PROBE. A. M. Stockton[1*], Z. Duca[1], M. Cato[1], T. Cantrell[1], S. Foreman[2], J. Kim[2], P. Putman[3], and B. Schmidt[1], [1]Georgia Institute of Technology, GA, USA, [2]Texas Tech University, TX, USA, [3]Sierra Lobo, OH, USA.

Introduction: Kinetic penetrators have the potential to enable low cost in situ measurements of the ice shells of astrobiologically exciting worlds including Europa and Enceladus [1]. Their small size and mass, critical to limiting their kinetic energy to an acceptable range, makes them ideal small landers riding on primarily orbiter missions, while still enabling sampling at several m depth due simply to burial and excavation. In situ microfluidic-based organic analysis systems are a powerful, miniaturized approach for detecting markers of habitability and recent biological activity.

Quantitative, compositional, and chiral analysis of small organic molecules *in situ* provides important information for studying planetary formation and evolution, and, more excitingly, also can provide signatures of past or present life. The Extraterrestrial Organic Analyzer (EOA), with microchip capillary electrophoresis (μCE) and laser-induced fluorescence (LIF) detection, is the only technique currently ready for space flight that has the resolution, selectivity, and sensitivity to provide these analyses. Through both in-lab [2,3] and field [4] testing, μCE-LIF has demonstrated the capability to provide highly sensitive (sub parts-per-trillion, or pptr) automated quantitative compositional chiral analysis of multiple organic compound classes [5,6], including polycyclic aromatic hydrocarbons (PAHs) [7], amino acids [8], aldehydes and ketones [9], carboxylic acids [10], thiols [11], and amines [12]. Lander or fly-by missions have largely been the focus for the development of μCE-LIF, as proposed in the Mars Organic Analyzer (MOA) and the Enceladus Organic Analyzer.

Concept: Development of microfluidic technology, like that of the Mars Organic Analyzer (MOA) [2-12] and Enceladus Organic Analyzer (EOA), has led to an instrument capable of in situ organic chemical analysis compatible with a kinetic penetrator platform. This technology uses an integrated microfluidic processor to prepare samples for analysis via fluorescent derivatization prior to highly sensitive laser-induced fluorescence (LIF) detection. Selective derivatization in the presence of a chiral selector enables distinction between amino acid enantiomers.

Programmable microfluidic architechtures enable automated, complex microfluidic manipulation on-chip, including mixing, dilutions, fluorescent derivatization, and transfer [6]. Recently, we have shown that microdevices retain functionality of their pneumatically-actuated monolithic membrane microvalves after 10+ years in storage [13]. Here, we show the continued development of the microfluidic and LIF subsystems for a kinetic impactor mission. Preliminary results have shown promising suitability of microdevices during a 50000g impact, indicating that PMA and LIF are valid in situ techniques for this extreme planetary mission format.

Instrument Development: Finite element analysis of the core microfluidic processing and analytical device indicated that the device itself is more than capable of surviving the stresses associated with an impact acceleration of >50,000g. However, a number of developments were still required to enable a flight-ready system.

Preliminary experiments indicated that moving from a pneumatically-actuated to a hydraulically-actuated microvalve system may provide better impact resistance. A hydraulically-actuated microvalve system was developed and tested. A modification of an established microfabricated LIF detection system would use indium bump bonding to permanently weld optical components using standard microfabrication techniques with perfect alignment. Recent work has also focused on developing and characterizing impact-resistant electronics.

Summary: This work shows the low-TRL development of EOA's LIF and microfluidic subsystems for future planetary impact penetrator missions. With correct structural decisions and optimizations, EOA can survive a 50,000g impact, making it the only current optical instrument with this capability.

References: [1] Gowen et al., Adv. Space Res., 2011, 725. [2] Skelley et al, PNAS USA, 2005, 102, 1041. [3] Benhabib, M. et al. (2010) Anal. Chem., 82, 2372-2379. [4] Skelley, A. et al. (2007) JGR., 111, G04S11. [5] Kim J., et al, Anal. Chem., 2013, 85, 7682. [6] Kim, J. et al. (2016) Lab Chip. 16, 812-819. [7] Stockton, A. et al. (2009) Anal. Chem., 81, 790-7906. [8] Chiesl, T. et al. (2009) Anal. Chem., 81, 2537-2544. [9] Stockton, A. et al. (2010) Electrophoresis, 31, 3642-3649. [10] Stockton, A. et al. (2011) Astrobiology, 11, 519-528 [11] Mora, M. et al. (2013) Electrophoresis, 34, 309-216. [12] Cable, M. et al. (2013) Anal. Chem., 85, 1124-1131. [13] Duca, Z. et al. (2015) EPSC, Abstract #416.

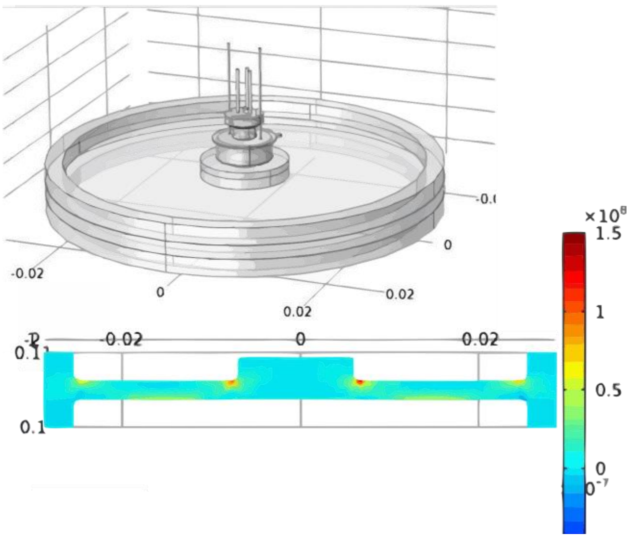

Figure 1: Structural (top) and stress (bottom) model of a centered optical stack without support structures