Modeling Lithium-ion Batteries and Packs for Crash Safety

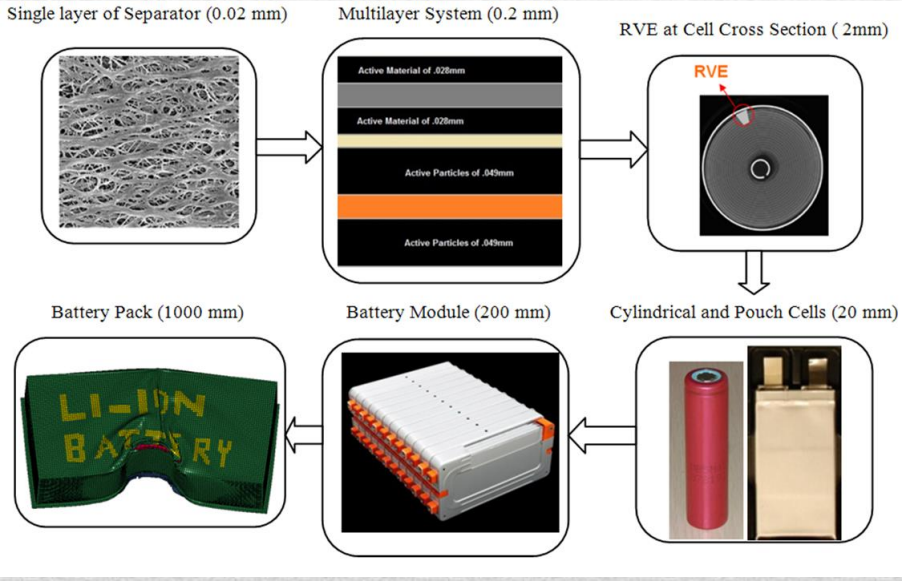
MIT Impact and Crashworthiness Lab

Content of this Presentation

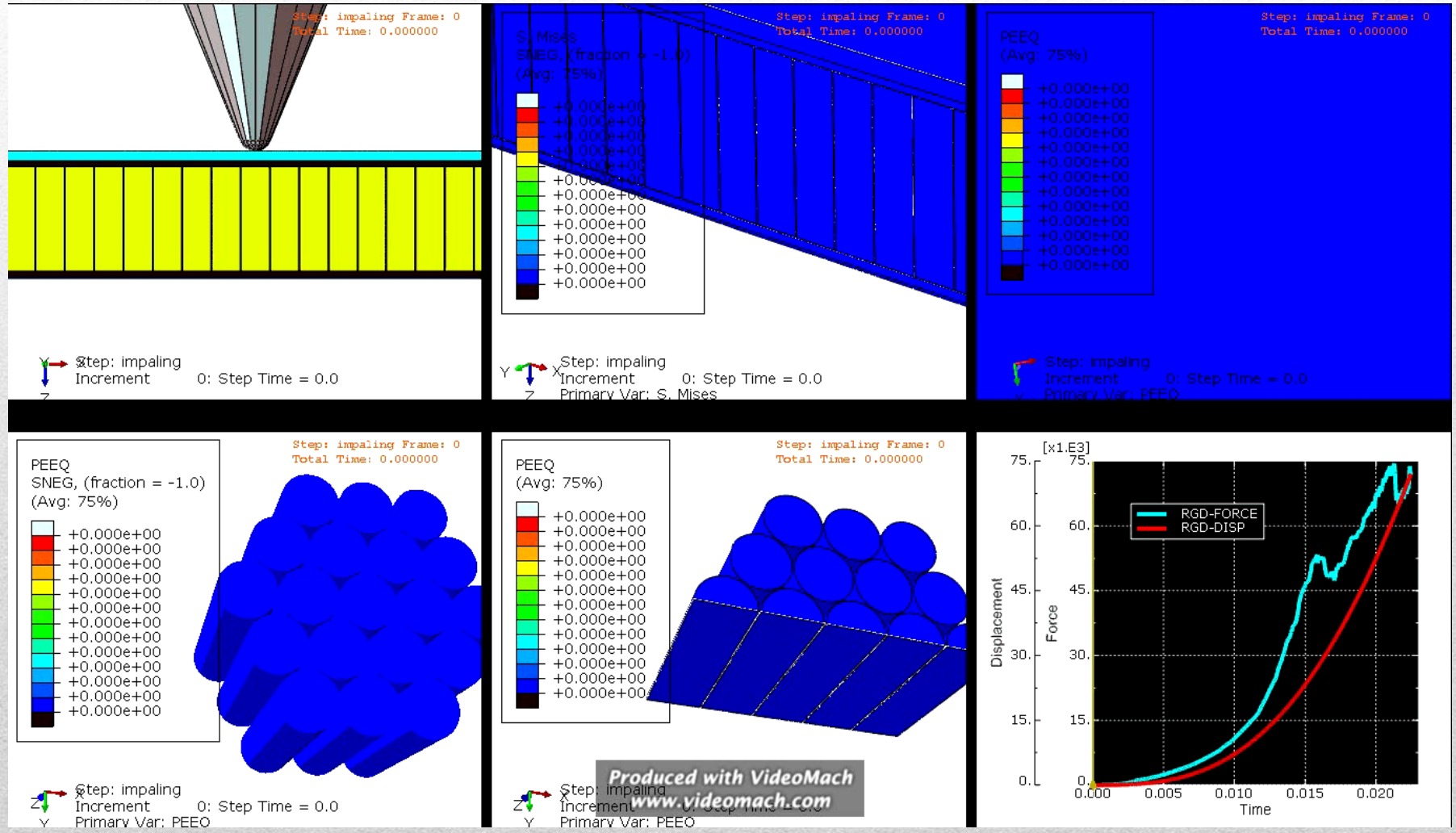
This set of slides presents selected important results of tests and simulations performed at Impact and Crashworthiness Lab at three different scales:

- Battery Pack level
- Cell level
- Component (Micro-Scale) level

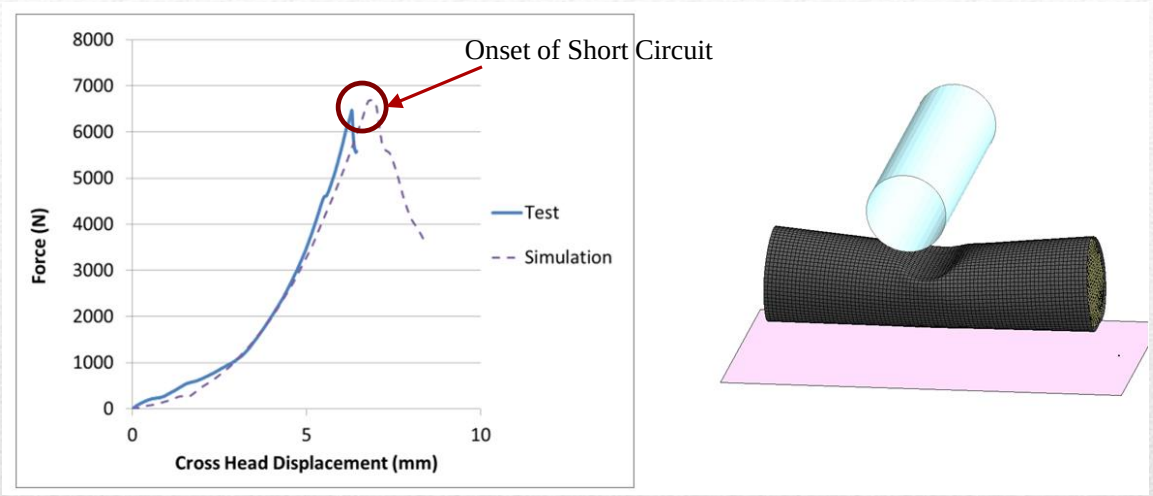
Six Length Scales in a Battery Pack

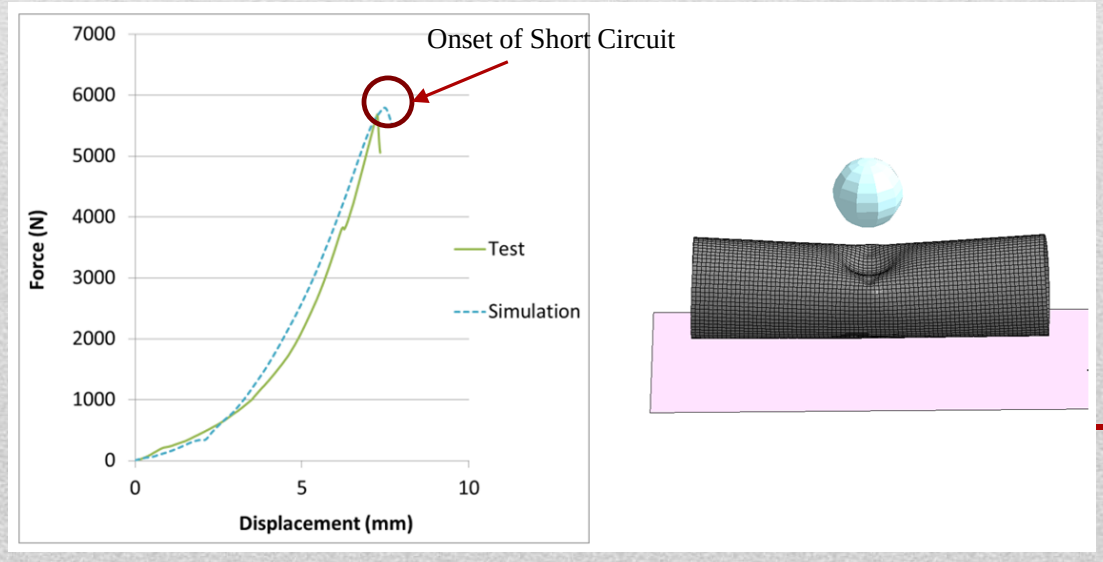


Battery Pack with Cylindrical Cells, Simulation of Ground Impact



Prediction of Onset of Electric Short Circuit

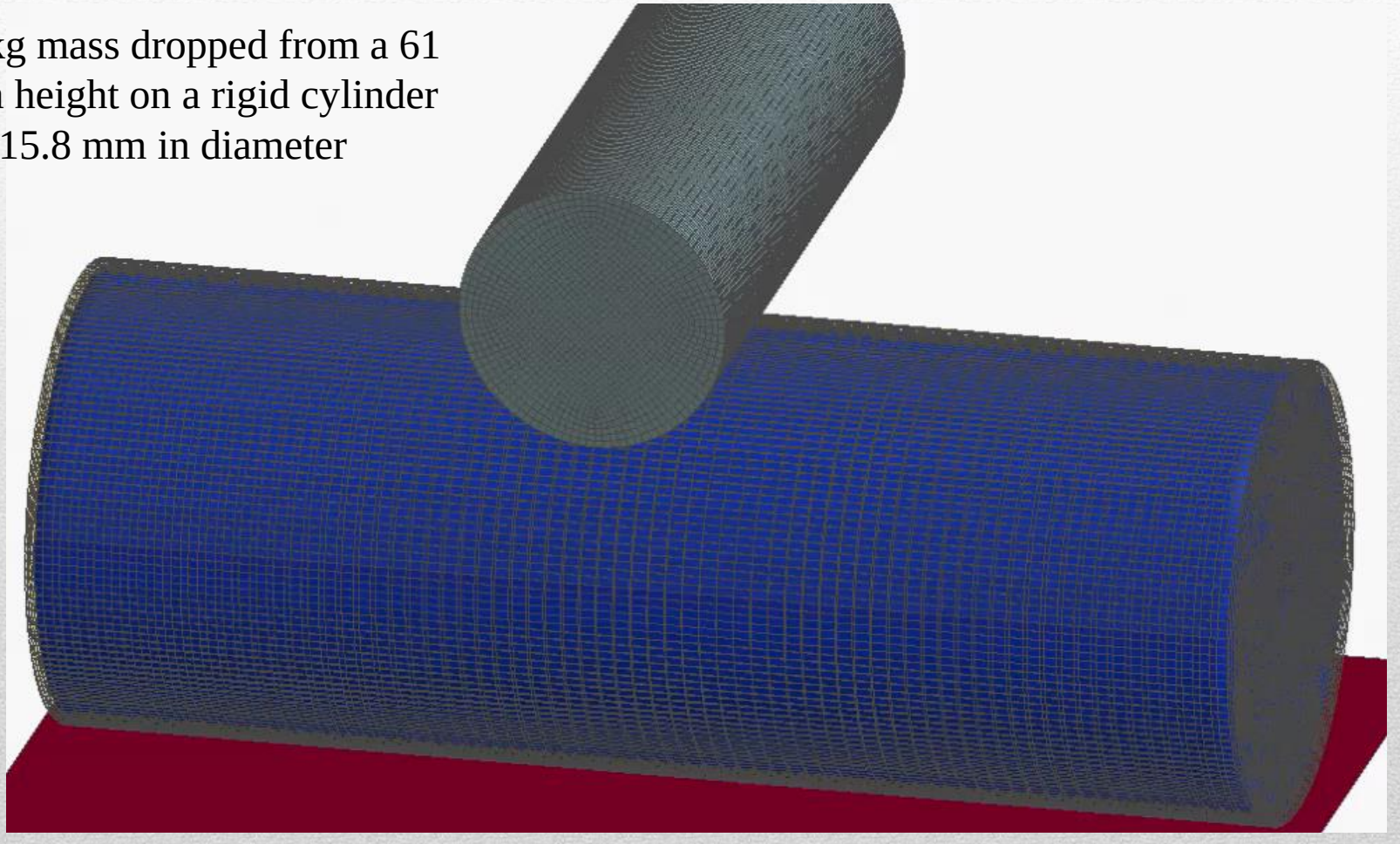




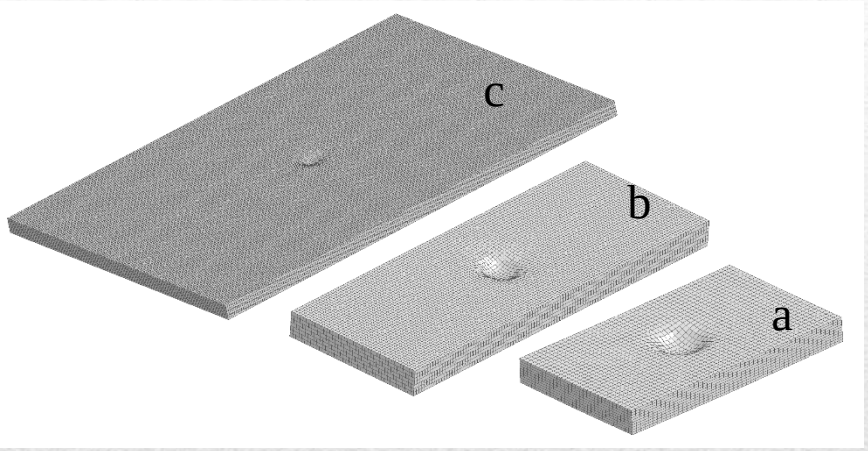
Finite Element Model of an 18650 Cylindrical Cell and Validation

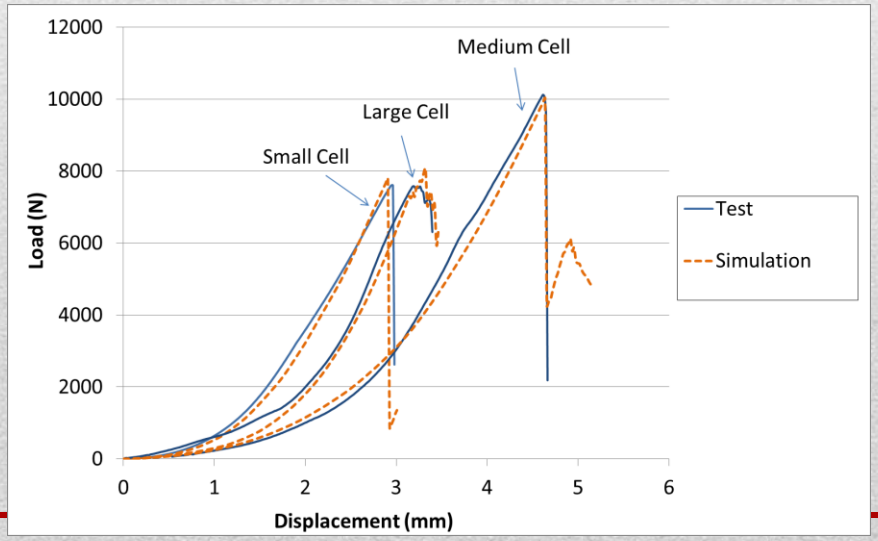
Simulation of UNDOT Test of a Cylindrical Cell

9 kg mass dropped from a 61 cm height on a rigid cylinder of 15.8 mm in diameter

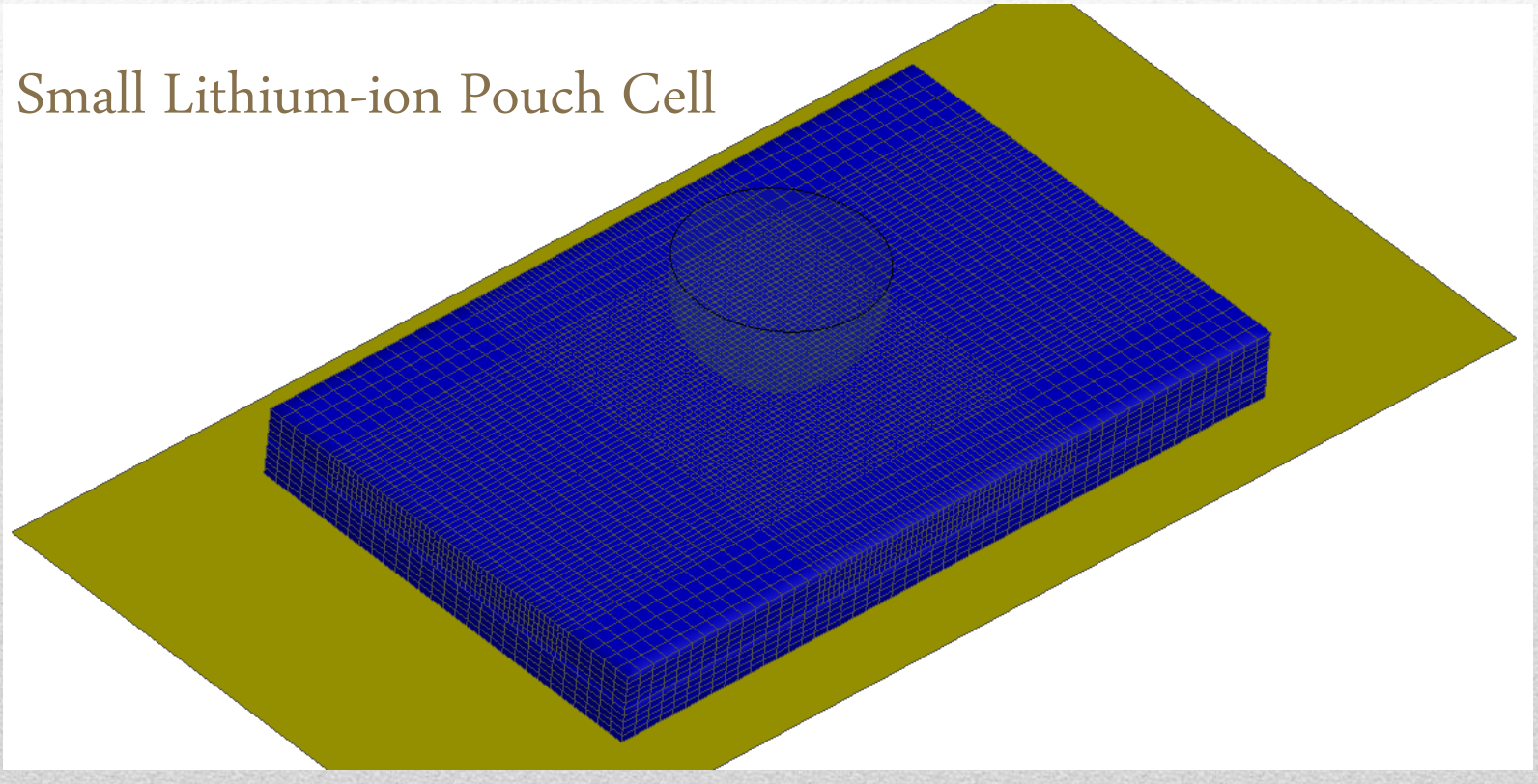


Finite Element Models of Three Types of Pouch Cells and Validation

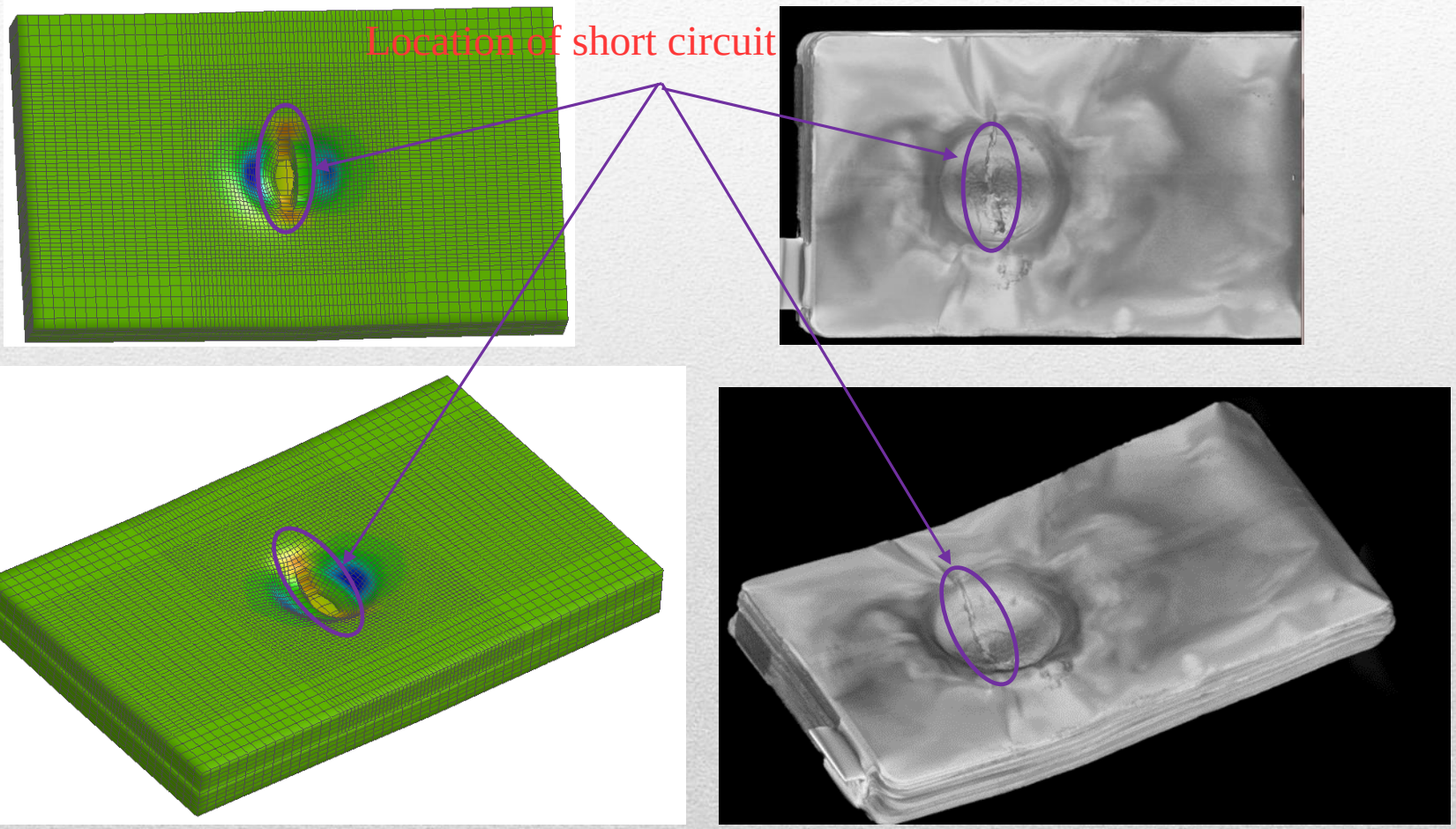




Prediction of Crack Location and Orientation, Indicating Short Circuit Area

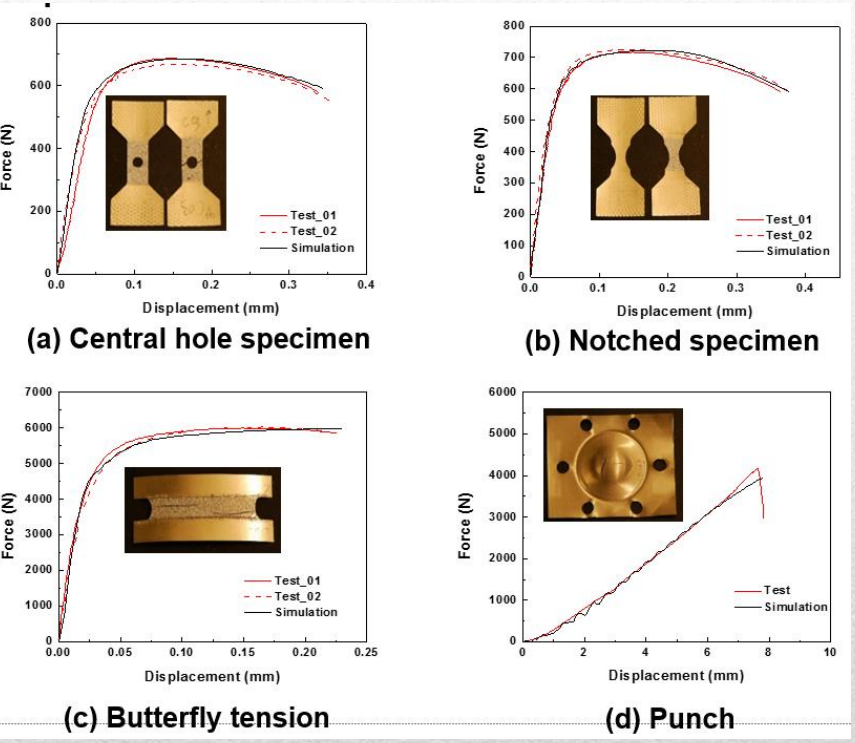


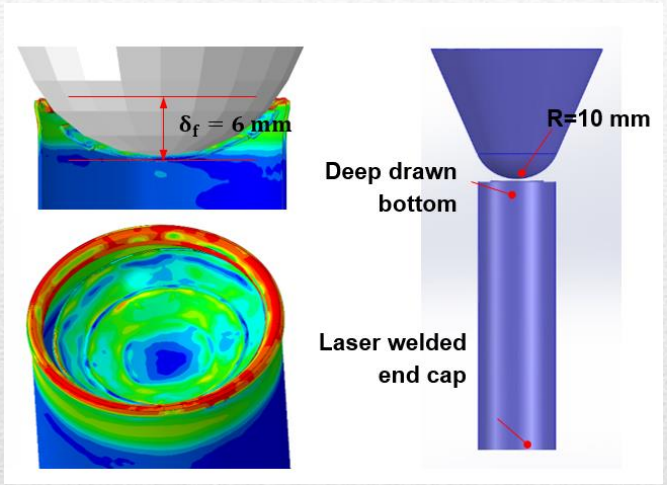
Detecting Location of Short Circuit in Simulation and Comparison with CT Scan of Cells Tested

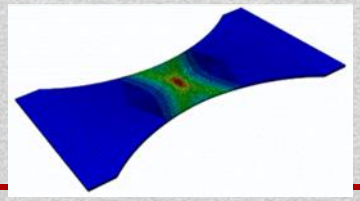


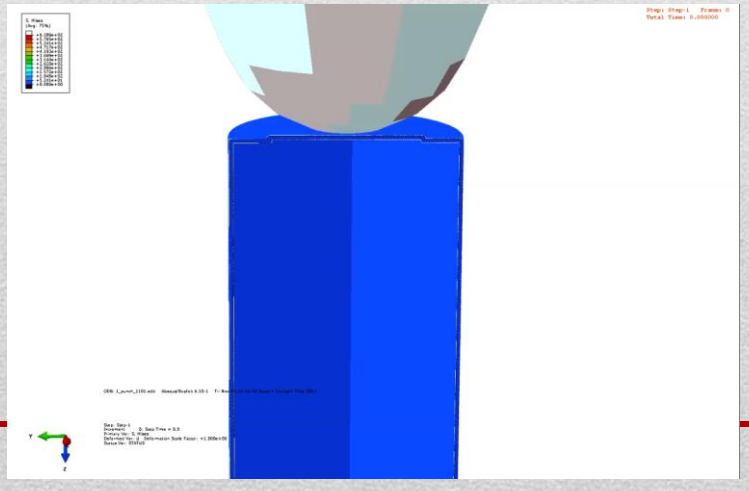
CT Scans courtesy of Exponent

Characterization Plasticity and Fracture of Shell Casing of Cylindrical Cell



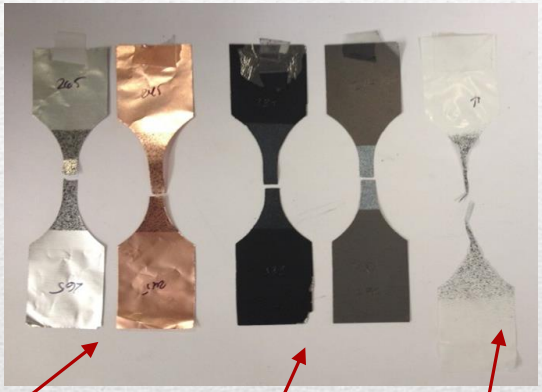






Jellyroll Components Tests and Scanning Electron Microscopies (SEM)

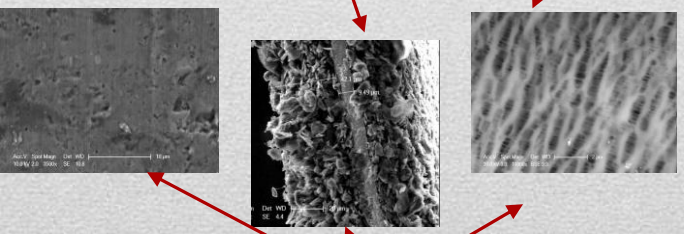
Tested Samples



Current Collectors

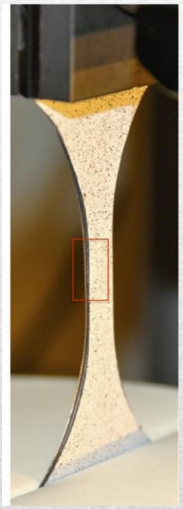
Electrodes

Separator

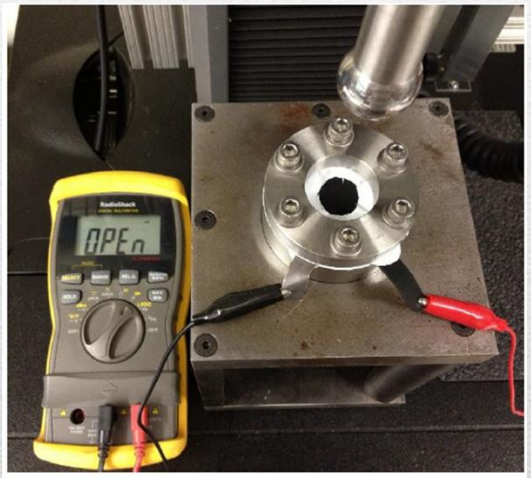


SEMs

Uniaxial Test



Biaxial Loading Fixture



List of ICL Publications on Battery Research

- Xia Y., Wierzbicki T., Sahraei E., Zhang X., "Damage of Cells and Battery Packs Due to Ground Impact", Journal of Power Sources (Impact Factor: 4.95), 2014
- Sahraei E., Meier J., Wierzbicki T., "Characterizing mechanical properties and onset of short circuit for three types of lithium-ion pouch cells," *vol.247, pp. 503-516, 2014.* , Journal of Power Sources (Impact Factor: 4.95), 2013.
- Wierzbicki T., Sahraei E., "Homogenized mechanical properties for the jellyroll of cylindrical Lithium-ion cells," Journal of Power Sources (Impact Factor: 4.95), Volume 241, pp 467-476 2013.
- Sahraei E., Campbell J., Wierzbicki, T., "Detection of Short Circuit in 18650 Li-ion Cells under Mechanical Abuse: Experiments, Finite Element Modeling, and Validation," Journal of Power Sources (Impact Factor: 4.95), Volume 220, pp 360–372, 2012.
- Sahraei E., Hill R., Wierzbicki, T., "Calibration and Finite Element Simulation of Pouch Li-ion Batteries for Mechanical Integrity," Journal of Power Sources (Impact Factor: 4.95), Vol. 201, pp 307– 321, 2012.
- Sahraei E., Wierzbicki T., "Testing and Constitutive Modeling of Four Types of Lithium-ion Batteries," Battery Safety 2013, *San Diego, CA, Nov. 14-15, 2013*.
- Sahraei E., Wierzbicki T., "Crashworthiness and Internal Short Modeling for Pouch and Cylindrical Lithium-ion Cells," Proceeding od Batteries 2013, *Nice, France, Oct. 14-16, 2013*.
- Meier J., Sahraei E., Salk M., Kisters T., Huberth F, "State of Charge vs. Thermal Runaway for Lithium Ion Large Pouch Cells", Proceedings of 3rd Battery Congress, East Lansing, MI, 2013.
- Campbell J., Sahraei E., and Wierzbicki T., "Detecting and modeling the onset of short circuit in a Li-ion cell under mechanical loading," Proceedings of 2nd Battery Congress, Ann Arbor, MI, 2012.
- Sahraei E., Hill R., and Wierzbicki T., "Modeling of Lithium-ion Cylindrical Batteries for Mechanical Integrity: Experiments, Calibrations, and Validation," Proceedings of 1st Battery Congress, Ann Arbor, MI, 2011.
- Sahraei E., Wierzbicki T., Hill R., Luo, M., "Crash Safety of Lithium-Ion Batteries, Towards Development of a Computational Model," SAE World Congress, Detroit, MI, SAE Technical Paper 2010-01-1078, 2010.
- Sahraei E., Hill R., and Wierzbicki T., "Modeling of Lithium-ion Batteries for Crash Safety," Proceedings of International Auto Body Congress (IABC), November 3-4, Troy, MI, 2010.