SOFC Quality Control and the Role of Manufacturing Defects in Stack Longevity

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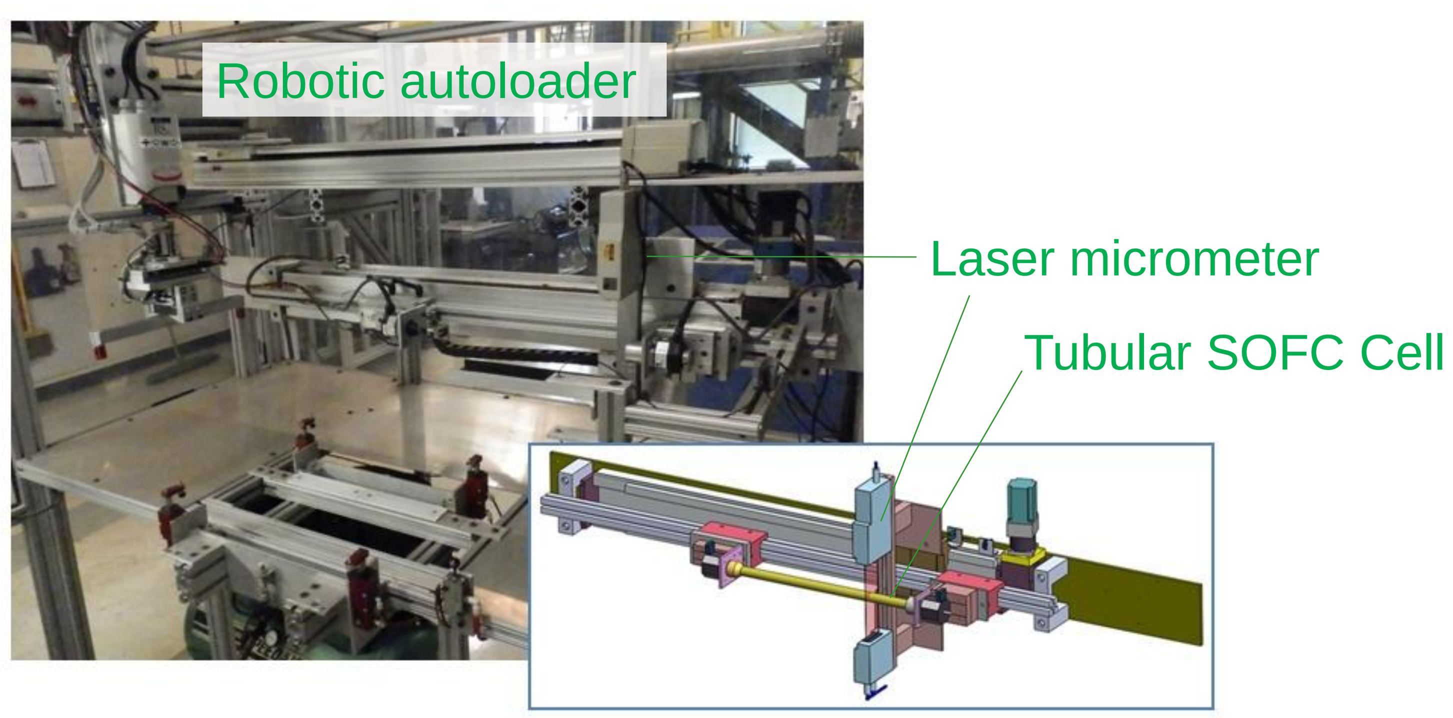
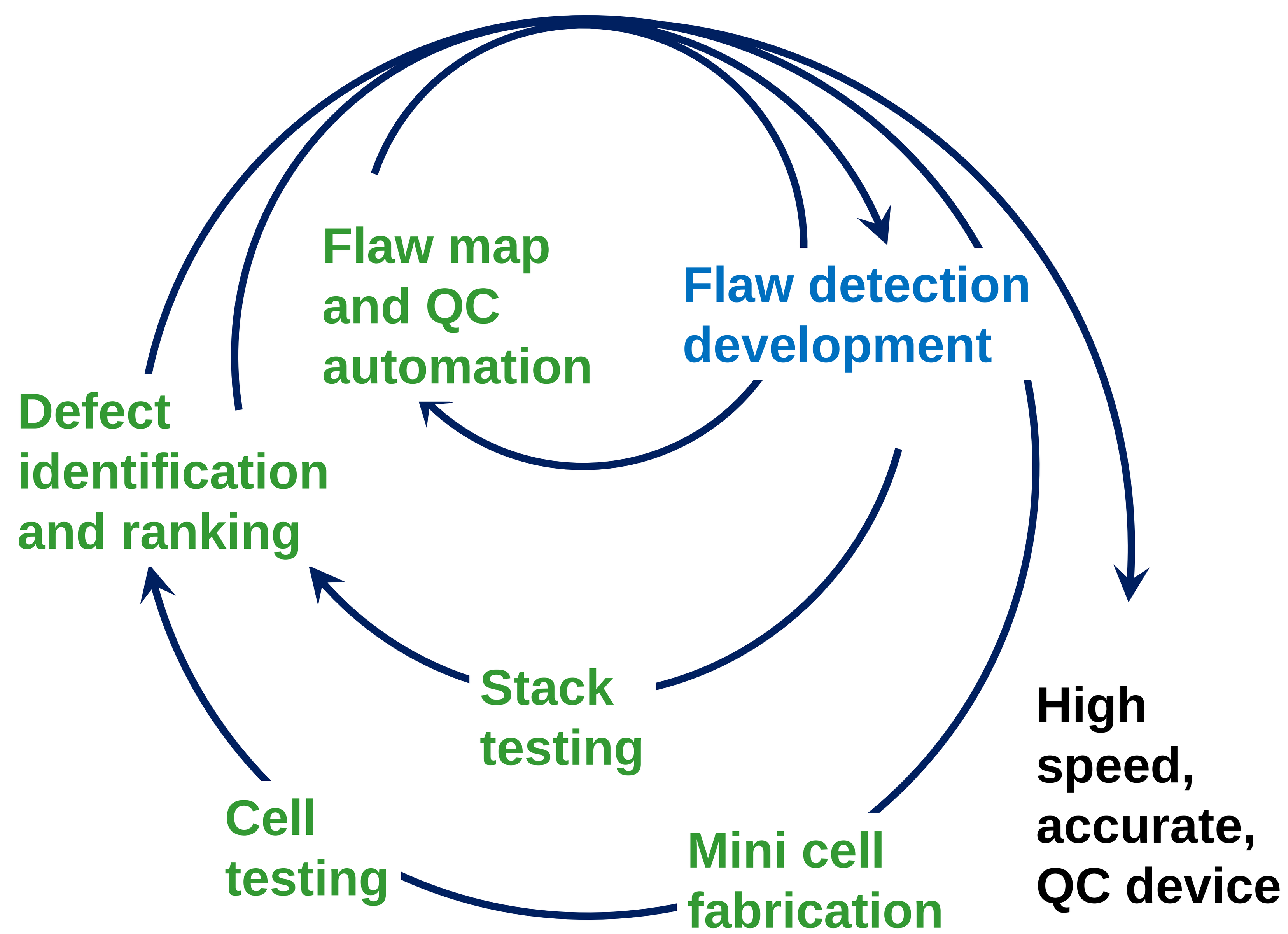
SOFCs are now commercial products but widespread market penetration requires "cheap" fuel cells that "last forever". Ultimately the life cycle cost must be low requiring mass production, material and labor cost reduction, and high cell yields. Such low cost compromises will generally be at odds with stack longevity goals with the increased threat that one bad cell may lead to a premature stack failure. Yet rejecting every cell that is merely visually in doubt would be costly and likely unnecessary. This speaks to the need for a high speed QC device that can first automatically detect cell flaws at room temperature, but then reject only those cells whose flaws are associated with cell and stack degradation at operating temperature. The development of such a device for SOFCs relies on attaining and marrying two goals – fast automatic flaw identification, and the development of an empirical knowledge base for quantitatively associating flaws with degradation, *i.e.* identifying a flaw as a defect.

QC automation:

Below is an example of a tubular SOFC QC device with a robotic autoloader. In collaboration with NREL such a device would be upgraded with appropriate imaging sensors to be used for mapping cell flaws for degradation study at the cell and stack levels, before being converted into a high throughput QC device.



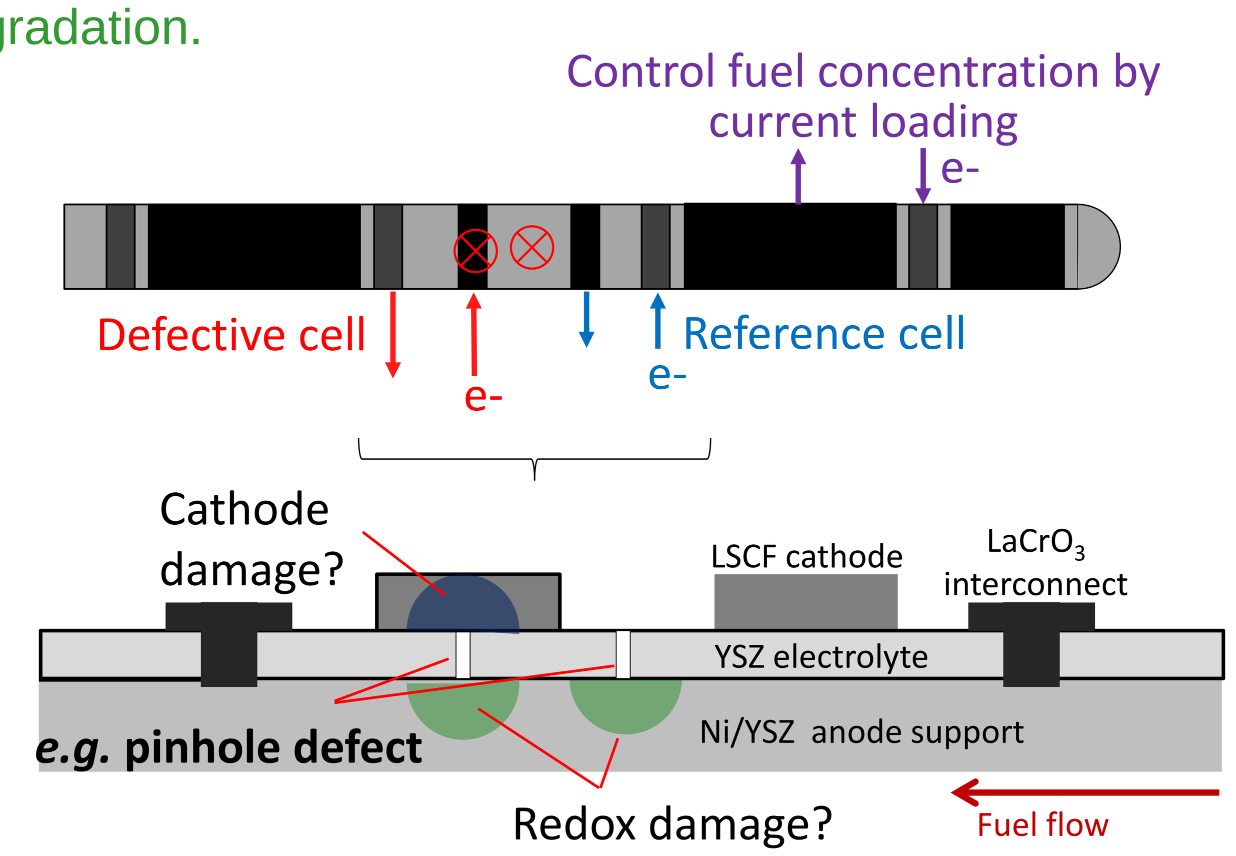


Stack testing:

By instrumenting an SOFC stack comprising both ideal and flawed cells with thermocouples, voltage taps and individual cell gas sample ports, high resolution data for degrading stacks can be obtained. Acumentrics tubular stack design is an ideal vehicle for such a study as it allows for the relatively straight forward replacement of individual cells as they fail. Thus defect types tested at the cell level can also be tested at the stack level, for long periods and at true stack operating conditions.

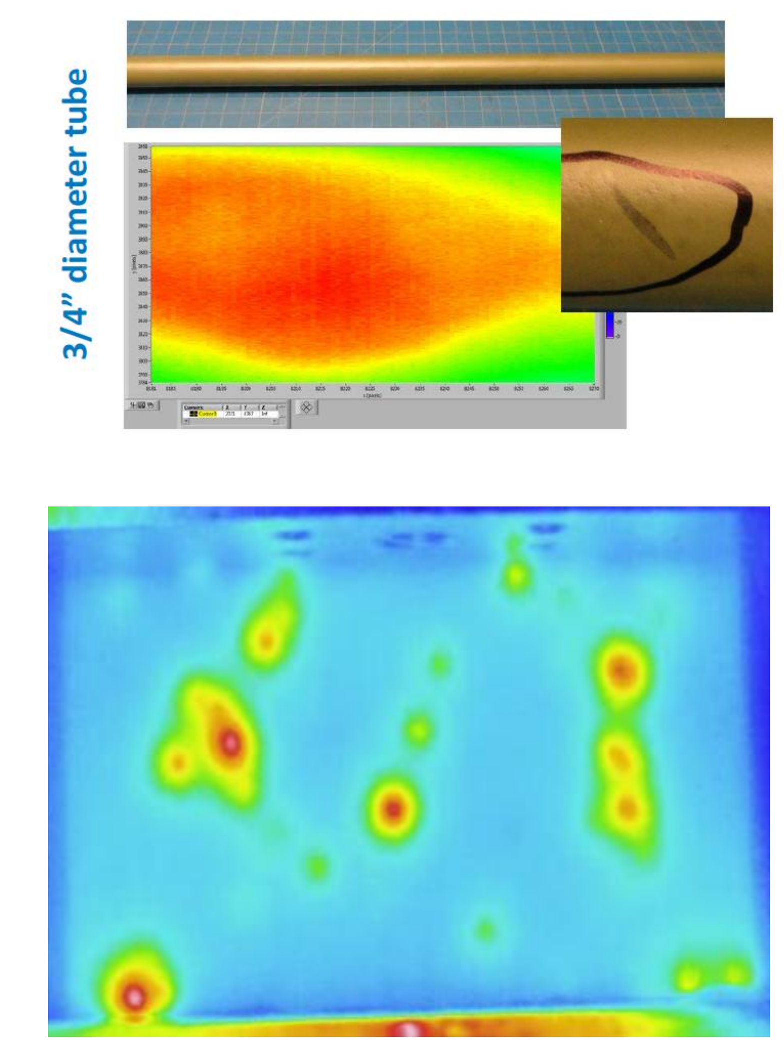
Cell testing:

The Acumentrics tubular cell is conducive to experimental designs magnifying defect degradation. Miniature cells incorporating the defect can be fired so that areal degradation effects are exaggerated relative to a full size cell. The cell tests can be conducted with reference cells to distinguish degradation caused by the flaw from materials degradation.

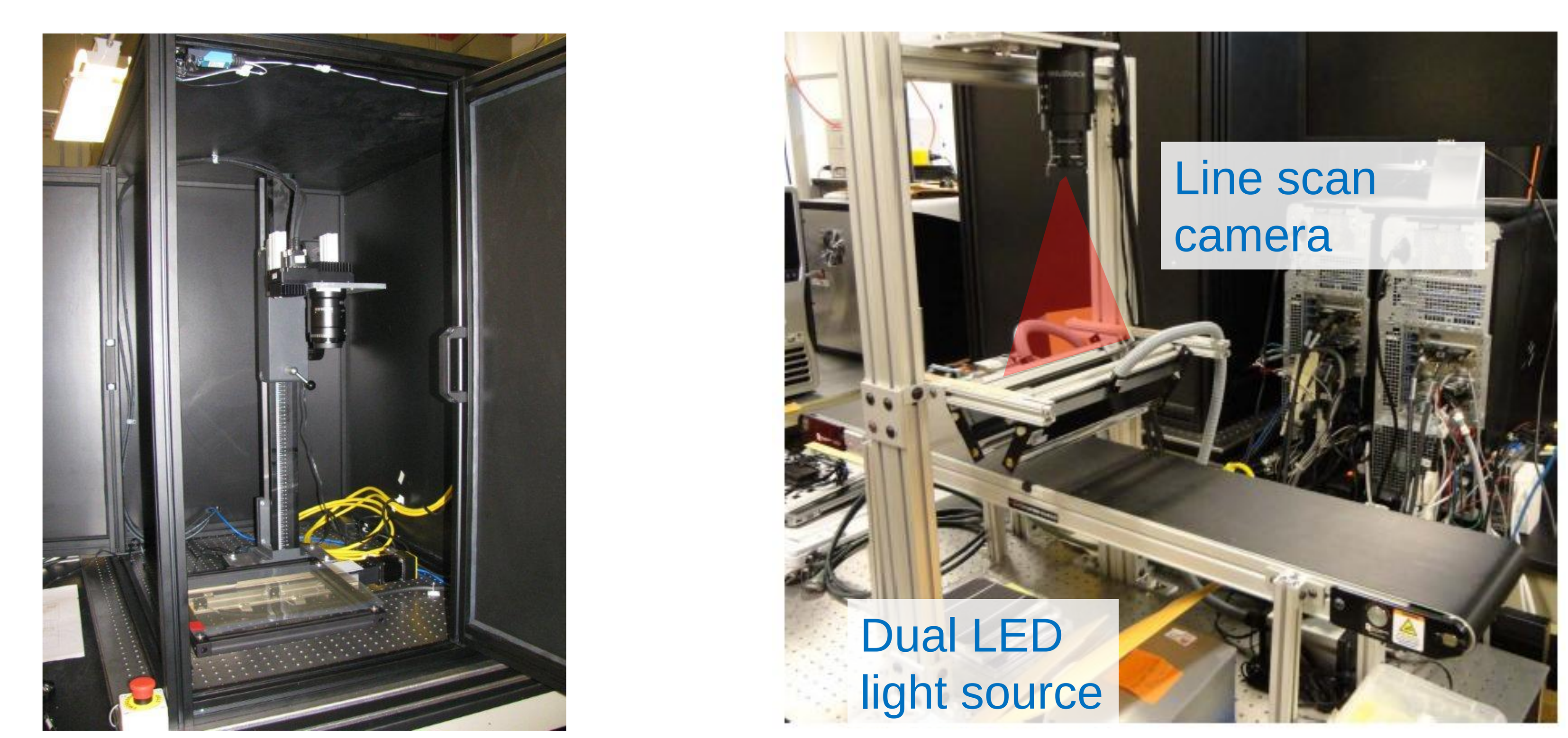


Flaw detection development:

NREL evaluates, develops, and validates rapid, noncontact quality inspection techniques for clean energy technology materials, including fuel cells, solar cells, and batteries. A major focus is developing techniques that provide wide area rather than point measurements. NREL has previously applied its optical reflectance technique for the detection of tubular and planar SOFC cell surface defects. Infrared methods with active excitation, *e.g.* optical, electrical, thermal, and ultrasonic, will also be explored with an emphasis on application to those defect types discovered to cause degradation



Examples: (TOP) Electrolyte defect on a tubular cell imaged with reciprocal optical reflectance, (BOTTOM) through-plane detection of electrical shorts in a PEM cell caused by GDL fibers penetrating the membrane during hot-pressing.



NREL has several prototype systems applicable to both optical and infrared methods to study wide area defect detection of moving test pieces such as fuel cell membranes and solar cells. NREL will collaborate with Acumentrics to apply this expertise to develop defect mapping capabilities for a tube cell configuration that will ultimately be usable for production quality inspection.