FUSION - A Knowledge Management System for Fuel Cell Optimization

Jane Hunter, Kwok Cheung, Suzanne Little, John Drennan*
Distributed Systems Technology CRC, The University of Queensland
St Lucia, Queensland, 4072, Australia
*Centre for Microscopy and Microanalysis, University of Queensland
Email: jane@dstc.edu.au

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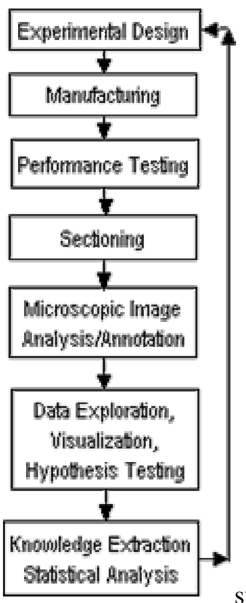
Introduction

Fuel cells are highly complex multi-component systems. Their efficiency depends on their internal nanostructure and the complex chemical and physical processes occurring across their internal interfaces. Significant advances in the accurate modeling of fuel cell components (electrodes, membrane and catalyst layers) can be achieved by improved analysis and assimilation of existing data and more systematic, controlled design and monitoring of tests and experiments. Within the FUSION project [1], we are employing the latest information technologies to provide a robust knowledge mining system for collaborative teams of fuel cell scientists.

System Description

The system enables data generated at each stage in the life cycle of a fuel cell (Figure 1), to be precisely captured, indexed, processed and archived within a secure, online distributed database. This process is made more complex by the distributed nature of the collaborators. The manufacturing and performance testing data is captured by staff at Ceramic Fuel Cells Limited (Victoria). The sectioning and microscopic image analysis are carried out by staff at the Centre for Microscopy and Microanalysis (CMM) in Queensland. MySQL is used as the persistent repository for storing the manufacturing, performance and microscopy data. Access is via a secure Web interface that requires a login id/password.



A graphical user interface combined with statistical analysis of existing data, drives the design of new experiments. Controllable parameters can be specified and tasks can be allocated to specific experimenters (e.g., the mixing, slip batching, tape casting and firing steps in electrolyte manufacture). Executing an experimental design invokes a workflow management process (built using Web Services and BPEL4WS) which tracks the different activities within an experiment, notifies experimenters when they have tasks to complete and validates and records data associated with each subtask. Manufacturing data includes the chemical compositions of the source materials, milling time, drying time, temperature profile etc. Performance data includes strength, density and conductivity graphs. Advanced sectioning techniques and electron microscopes generate precise 2D and 3D tomographic images. MATLAB is used to process the digitized images and extract low-level features such as grain sizes, colors, textures and shapes. An innovative Rules-By-Example interface, which uses ontologies for semantic indexing and RuleML to infer rich semantic descriptions of image regions, enables advanced search and querying. A sophisticated data exploration and visualization interface [2] correlates the manufacturing, performance and microstructural data. Users can specify the parameters, range of data and images to be displayed and the preferred format of presentations (e.g., animated slideshow or tiled thumbnails). Figure 2 illustrates the results of a presentation that synchronizes a slide show of images with a plot of corresponding data. This interface also enables new hypotheses or predictive models to be derived, saved, shared and refined as more data is acquired. Users may also specify graphically where more data is required and new experiments inititiated.

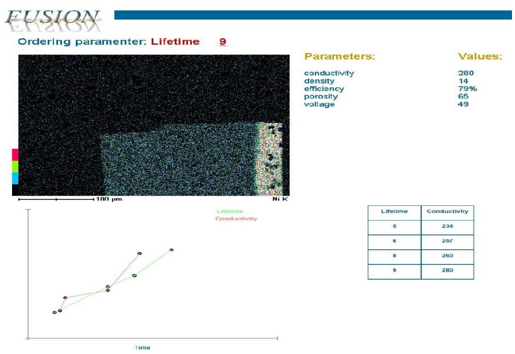


Figure 2. Synchronized presentation of images and data

Conclusions

FUSION provides an integrated knowledge management system for fuel cells which ensures the capture of the highest quality manufacturing, performance and microstructural data. User feedback has been extremely positive, indicating that the system enables faster interpretation of large image and data sets and rapid formulation of more accurate fuel cell models. The consequences are expected to be shorter development cycles, improved performances and lower costs for fuel cells.

References

[1] J.Hunter, J.Drennan, and S.Little. "Realizing the Hydrogen Economy through Semantic Web Technologies" IEEE Intelligent Systems, 19, 1, 2004

[2] J.Hunter, K.Falkovych and S.Little. "Next Generation Search Interfaces - Interactive Data Exploration and Hypothesis Testing", ECDL2004,. UK, Sept 2004.