Unlocking Fuel Cell Potential: Raman Spectroscopy Insights

Today, the issue of **hydrogen** plays a central role in energy transition strategies. Whether considering low or high-temperature fuel cells, Raman spectroscopy emerges as a powerful tool to explore these technologies and support renewable energy production.

This non-destructive and non-invasive characterization technique provides crucial chemical and structural information about various components of a fuel cell, such as the gas diffusion layer (GDL), electrodes, electrolytes, interconnects and sealing materials, as well as fuels themselves. It proves extremely valuable in various aspects: contributing to the understanding of different manufacturing stages, **including the selection of raw materials, optimization & validation of the production process, as well as the understanding of the operation of the fuel cell.**

Indeed, the mechanisms of electrochemical reactions occurring during the fuel cell's operation directly impact its performance and lifespan. Thus, understanding these mechanisms becomes essential. Whether for real-time tracking of phenomena in situ/in operando or post-mortem analysis, Raman spectroscopy stands out as an exceptional diagnostic tool for fuel cells.

To know more on this topic, click here.

Electrochemical and Raman spectroscopic evaluation of catalyst durability for the start/stop operating condition of PEFCs

M. Hara, M. Lee, C.-H. Liu, B.-H. Chen, Y. Yamashita, M. Uchida, M. Watanabe

This study delves into the critical role of cathodic catalyst materials in Polymer Electrolyte Fuel Cells (PEFCs) and explores the durability of carbon-supported Pt catalysts, comparing carbon black (CB) and graphitized carbon black (GCB). Through electrochemical and Raman spectroscopic methods, Pt/GCB catalysts showed superior corrosion resistance and longer half-lives during voltage step cycle testing compared to Pt/CB. Micro-Raman spectroscopy was used to assess degradation by analyzing changes in Raman band area ratios, revealing differences in degradation rates among GCB-supported catalysts.

Consistency between Raman spectra-derived degradation rates and electrochemical measurements highlights the efficacy of Raman spectroscopy in investigating catalyst corrosion. These findings underscore the significance of understanding catalyst degradation mechanisms for advancing PEFC development. The study emphasizes micro-Raman spectroscopy's utility in elucidating catalyst degradation, crucial for optimizing fuel cell technology towards more efficient energy conversion.

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in situ optical measurements of solid oxide fuel cell electrode surfaces, and probing the oxidation of solid oxide fuel cell anodes using in situ Raman spectroscopy

Brightman, E.; Maher, R.; Duboviks, V.; Heck, C.; Cohen, L.F.; Brandon, N. P. , 2012

This article introduces a miniaturized heated stage for in situ optical measurements of solid oxide fuel cell (SOFC) electrode surfaces, enabling comprehensive investigation of anode oxidation processes using in situ and in operando Raman spectroscopy. The prototype configuration allows combining electrochemical and optical spectroscopy for detailed study of electrochemical processes, crucial for understanding reaction mechanisms and addressing durability and impurity tolerance challenges in SOFC anodes. Initial investigation focuses on the oxidation state of a Ni-CGO cermet electrode during reduction, with continuous collection of Raman spectra centered on the NiO characteristic band.

Results show NiO band intensity initially increases during reduction, followed by rapid disappearance concurrent with a sharp drop in electrochemical potential, indicating that the establishment of an electrically conductive path precedes complete NiO reduction. The coupled Raman spectroscopy apparatus presents significant potential for diverse experiments, including studying reaction kinetics and mechanisms.

Operando µ-Raman Study of the Actual Water Content of Perfluorosulfonic Acid Membranes in the Fuel Cell

Peng, Z.; Badets, V.; Huguet, P.; Morin, A.; Schott, P.; Tran, T. B. H.; Porozhnyy, M.; Nikonenko, V.; Deabate, S.. J.

Raman microscopy offers a unique capability to investigate the water content of polymer fuel cell membranes, critical for their functionality. This study focuses on perfluorosulfonic polymer electrolytes, crucial components in fuel cell operation, whose water content affects conductivity and gas permeability. Operando µ-Raman spectroscopy is employed to monitor local water distribution across Nafion® and Aquivion™ membranes under various operating conditions.

Results show linear water depthprofiles with higher content at the cathode side, influenced by relative humidity, gas stoichiometry, and current density. Membrane dehydration, induced by temperature rise with increased current, affects proton mobility and thus fuel cell performance. Aquivion™ exhibits superior water retention due to higher sulfonic group density, suggesting lower ohmic losses. This study highlights the importance of effective thermal management for fuel cell optimization, with operando µ-Raman spectroscopy offering insights into membrane hydration behavior and aiding in system modeling and optimization.

RamanFest: Save the Date

The 11th International Conference on Advanced Applied Raman Spectroscopy (**RamanFest2024**) will feature presentations from world-leading Raman experts and researchers using the technique across varied applications within life science, materials science, and energy and environmental analysis. It will bring together the world's Raman community to share, learn and discuss how Raman spectroscopy is being applied to today's problems and pioneering tomorrow's capabilities.

This event is brought to you by the Phantoms Foundation and HORIBA.

When: November 12-13, 2024
Where: Paris/France

Upcoming deadlines
Abstract Submission (oral request): June 28, 2024
Author Submission Acceptance Notification: July 05, 2024
Abstract Submission (Poster request): October 14, 2024
Early Bird Registration Fee: September 23, 2024

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