CHALMERS TEKNISKA HÖGSKOLA AB
412 96 Göteborg, 031 772 10 00
www.chalmers.se

Spatial identification of PTFE through a GDL substrate by confocal Raman spectroscopy

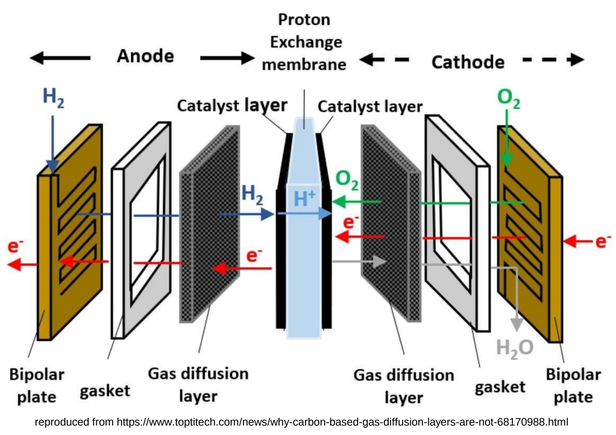
1. Scope

The scope of the project was to determine the distribution of Polytetrafluoroethylene (PTFE) through a gas diffusion layer (GDL) using Raman scattering in the confocal mode.

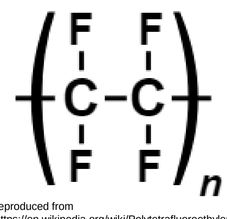
2. Theory

Gas diffusion layer

A GDL is a porous structure made of woven carbon fibers and is part of the Membrane Electrode Assembly. Its main function is to regulate reactant gas flow and manage water transport. The Micro Porous Layer (MPL) on the front of the GDL increases surface area and porosity, enhancing reactant diffusion and catalyst utilization. Hydrophobic PTFE binds the MPL, keeping water within the membrane but outside the catalyst layer. Additionally, the GDL facilitates heat transfer during cell operation.



reproduced from https://www.toptitech.com/news/why-carbon-based-gas-diffusion-layers-are-not-68170988.html



reproduced from https://en.wikipedia.org/wiki/Polytetrafluoroethylene

Chemical structure of a PTFE

Raman spectroscopy

Raman spectroscopy is a vibrational spectroscopic technique by which chemical compounds can be identified by analysis of the back scattered light. In practice, a sample is illuminated with monochromatic light (a laser) and the resulting energy shifts in the scattered light reveal molecular vibrations unique to specific chemical bonds and molecular structures.

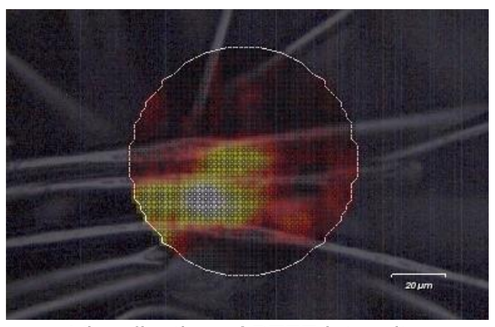
3. Method

1. The Raman spectrometer was calibrated using a silicon standard (520.6 cm^{-1} peak) for wavelength alignment.
2. Spectra were acquired with an exposure time of 25 s and 1% laser power of a RM laser (785 nm). The Raman shift from PTFE and carbon was found at 1200 cm^{-1} in the center.
3. A circular area of 30x30 µm was defined for mapping, with a 2 µm step size (1425 data points).
4. Baseline correction was performed to improve peak integration. The PTFE peak was identified at 734 cm^{-1} within a range of 717-748 cm^{-1}. The carbon was characterized by 1276-1389 cm^{-1} (D-band) and 1514-1671 cm^{-1} (G-band).
5. Color-coded maps were generated to visualize the spatial distribution of PTFE and carbon across the scanned area.

4. Results

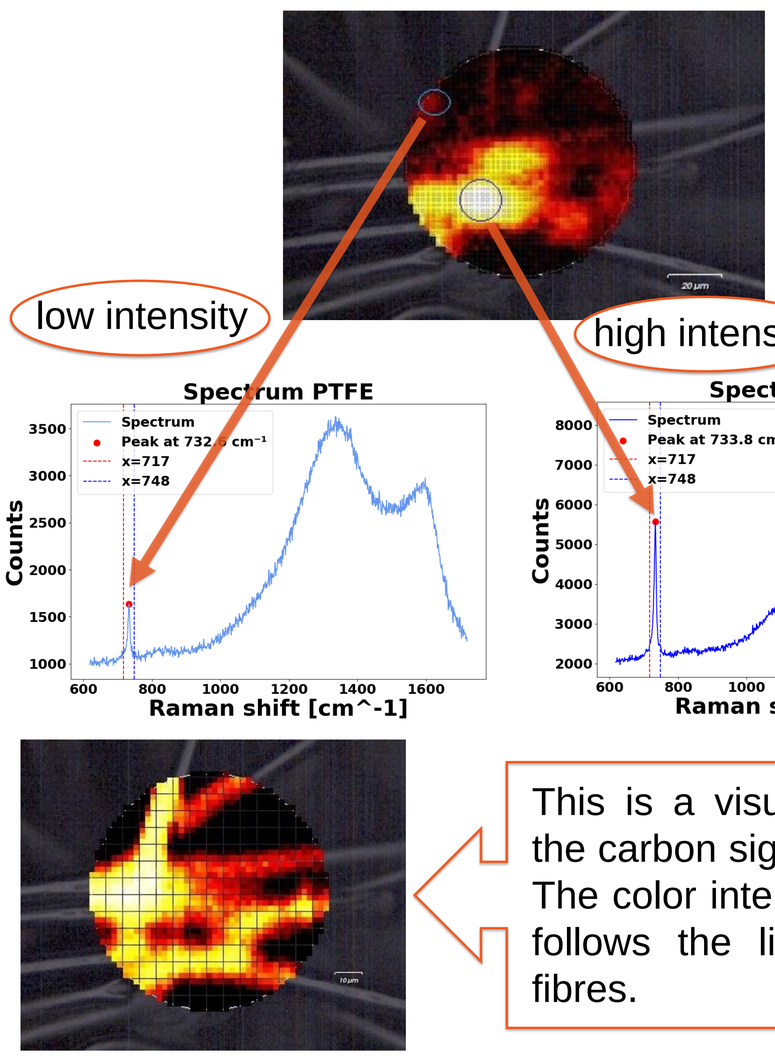
The results are visualized as heat maps. Visible in the maps is the signal of raman shift in a chosen range. As suspected the PTFE stuck more easily to areas where the carbon fibres were close to each other, damaged or crossing.

Carbon fibres of an area with presumably large quantities of PTFE



Visualization of PTFE intensity. Lighter color means more intense signal

The heat map of the picture below is the signal in the range marked in the plots, around 700 cm^{-1}. It has two circled areas. The larger circle has an intensity of around 5500 counts of raman shift while the area in the small circle only has 1500. Almost 4 times less intense we believe it is because the weak signal is from a deeper layer of the GDL.



This is a visualisation of the carbon signal instead. The color intensity clearly follows the lines of the fibres.

5. Conclusion

In this project, we employed confocal Raman spectroscopy to spatially map the distribution of PTFE through a gas diffusion layer (GDL) made of carbon fibers and containing 20 wt% of PTFE. This understanding is crucial for optimizing GDL hydrophobicity in PEM fuel cells, which impacts water management and oxygen transport efficiency.

Supervisor:
Anna Martinelli, Dylan Schulz
Department of Applied Chemistry
Chalmers university of technology

Authors:
Pathompron Jaikwang
Maike Poll
Malin Lindgren

Project 10: Local identification of PTFE through a GDL substrate by spectroscopic methods

Course name:
TRA275 Fuel Cell Systems

CHALMERS UNIVERSITY OF TECHNOLOGY

Sources:
https://www.fuelcellstore.com/gas-diffusion-layers
http://fuelcellstore.com/blog-section/component-information/what-is-the-purpose-of-a-gdl
https://www.renishaw.com/en/what-is-raman-scattering--25805
Raman Spectroscopic Mapping of the Carbon and PTFE Distribution in Gas Diffusion Layers (2010) - A. J. Mendoza et al.