

# Proton-Conducting Membranes Prepared by Plasma Polymerization for Reducing Methanol Permeation in DMFCs

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## Overview

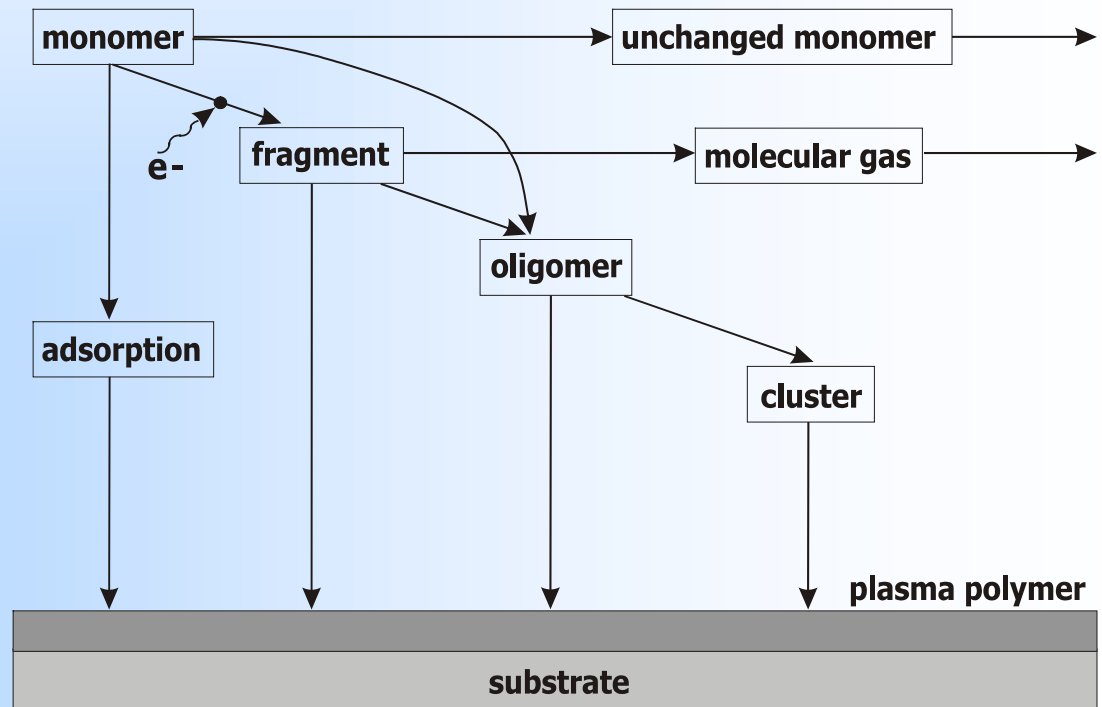
- Motivation
- Plasma polymerization
- TFE/H<sub>2</sub>O plasma-polymerized membrane
- Methanol permeation measurements
- Results
- Outlook

## Motivation

- Miniaturized fuel cells as source of energy for portable systems
- Plasma-polymerized thin films
  - ▶ Reduction of the membrane resistance
  - ▶ Reduction of methanol and water permeability
  - ▶ Improved membrane/catalyst/electrode interface

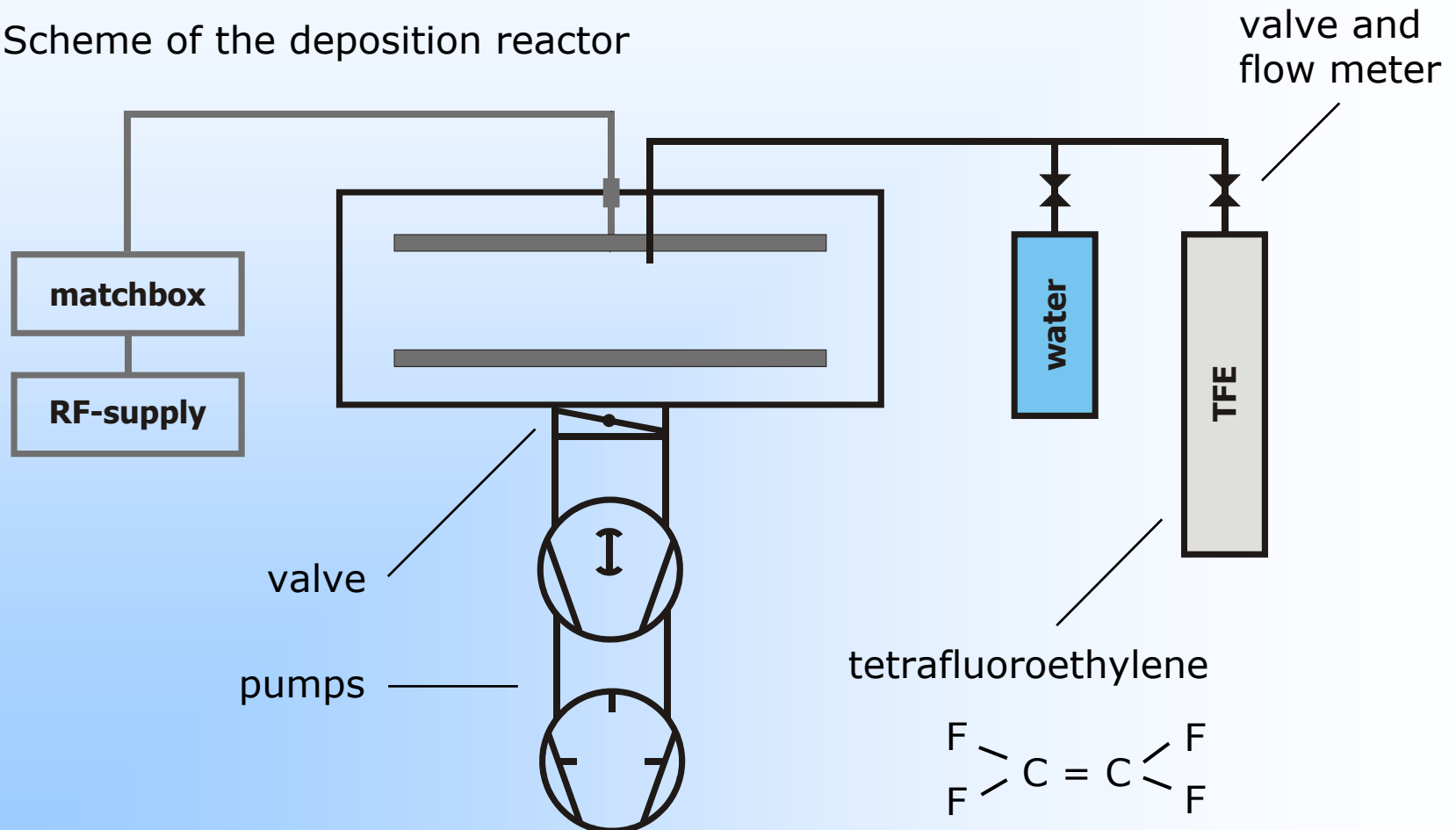
## Plasma polymerization

- Activation, dissociation and ionization of monomers, molecules and gases in a plasma
- Fragments of monomers and gases can form oligomers and clusters which deposit on the substrate
- Process is controlled by the process parameters: pressure, monomer flow, bias voltage, power density, and temperature

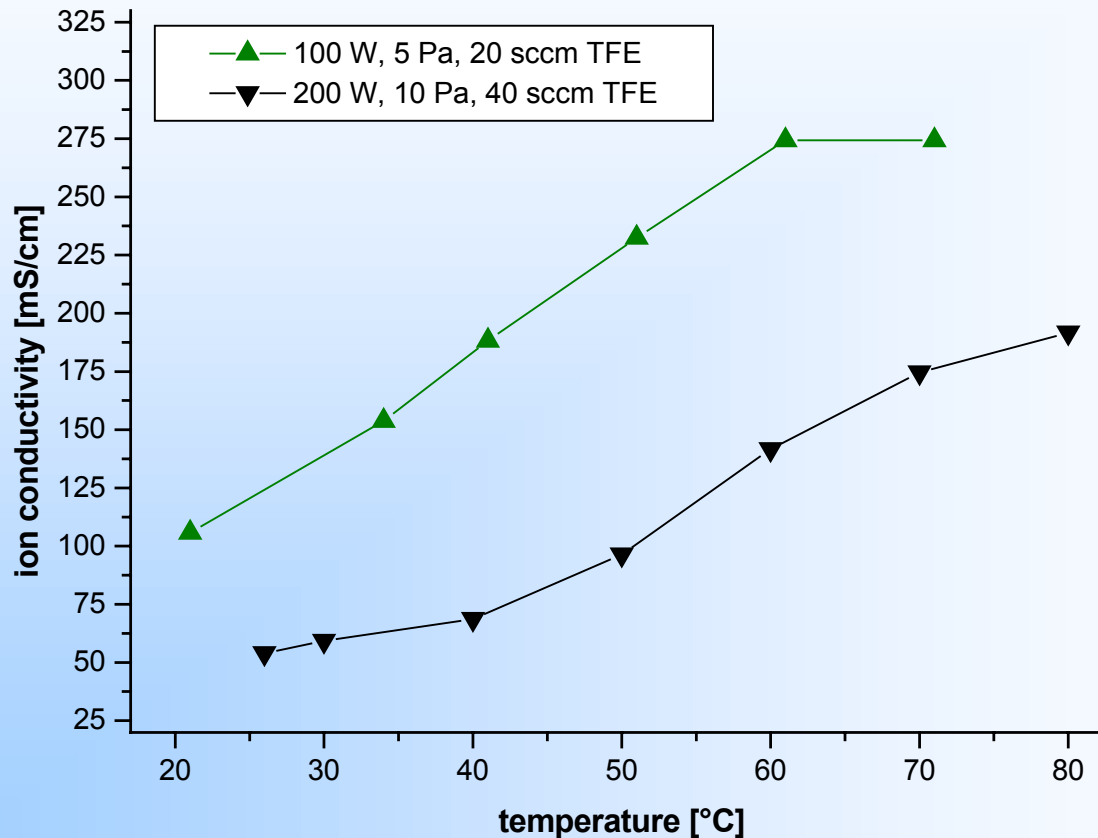


# TFE/H<sub>2</sub>O plasma-polymerized membranes

Scheme of the deposition reactor

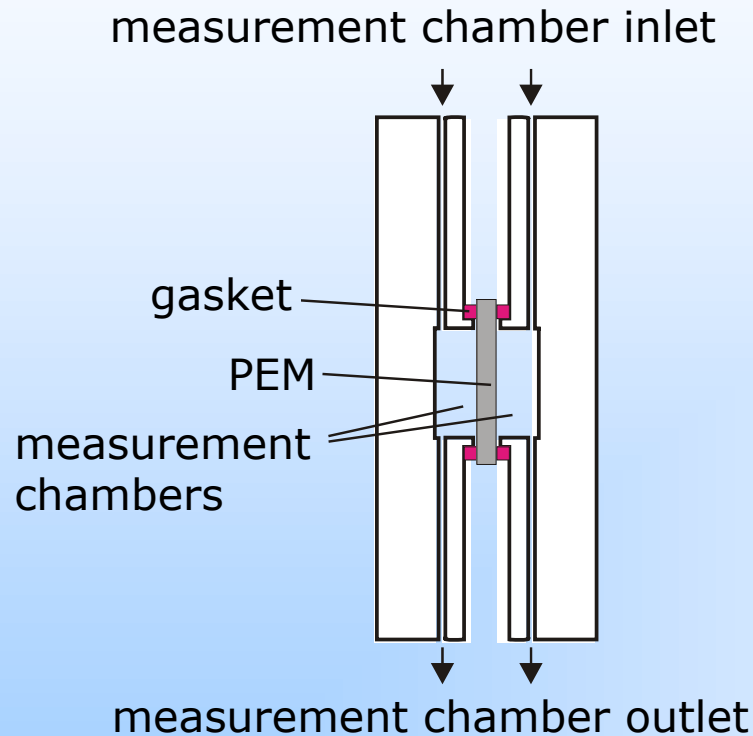


## TFE/H<sub>2</sub>O plasma-polymerized membranes



- Ion conductivities range from 10 – 160 mS/cm at 30°C
- Controlled by deposition condition; decreased by H<sub>2</sub>O depletion in the plasma

## Methanol permeation measurements



$c_p$  ... concentration permeate

$c_s$  ... concentration  $\text{CH}_3\text{OH}$

$V$  ... volume (15 ml)

$l$  ... membrane thickness

$A$  ... membrane area

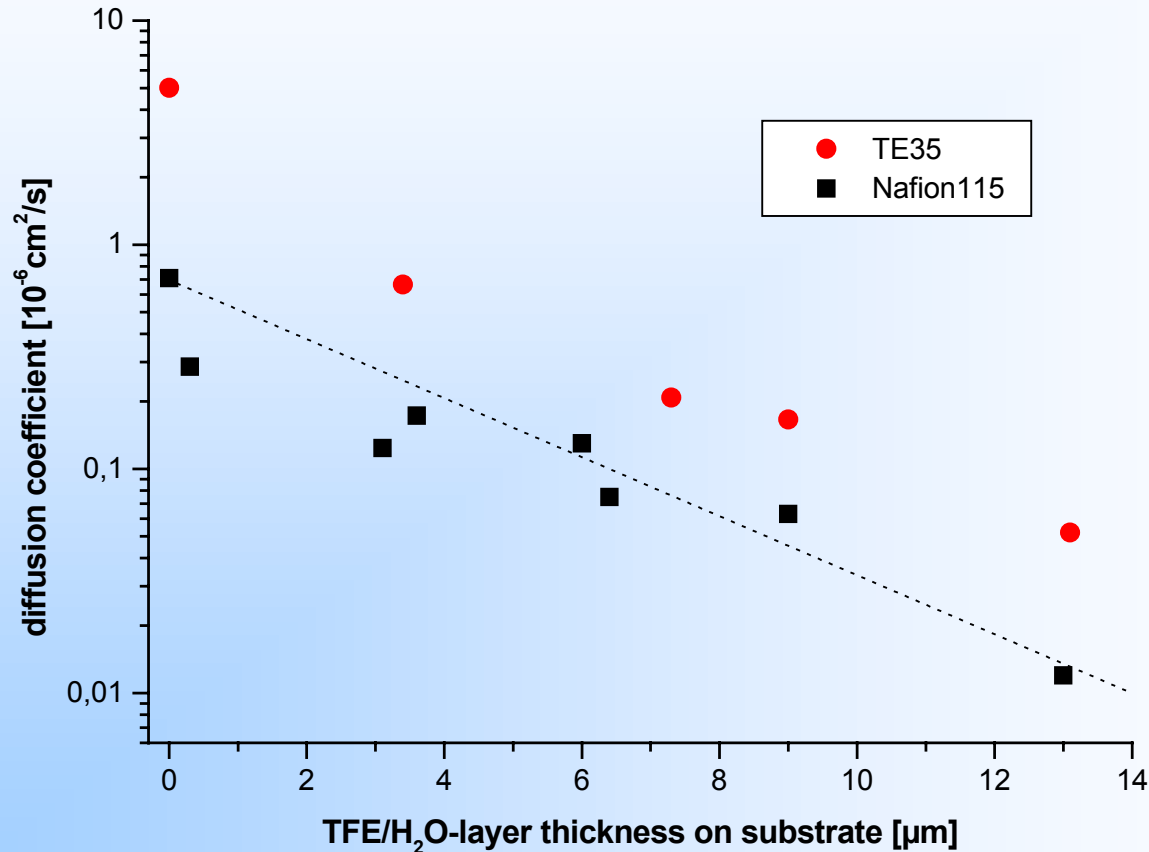
$t$  ... time (20 to 60 min)

permeability:

$$p = \frac{c_p}{c_s} \cdot \frac{V_p \cdot l}{A \cdot t}$$

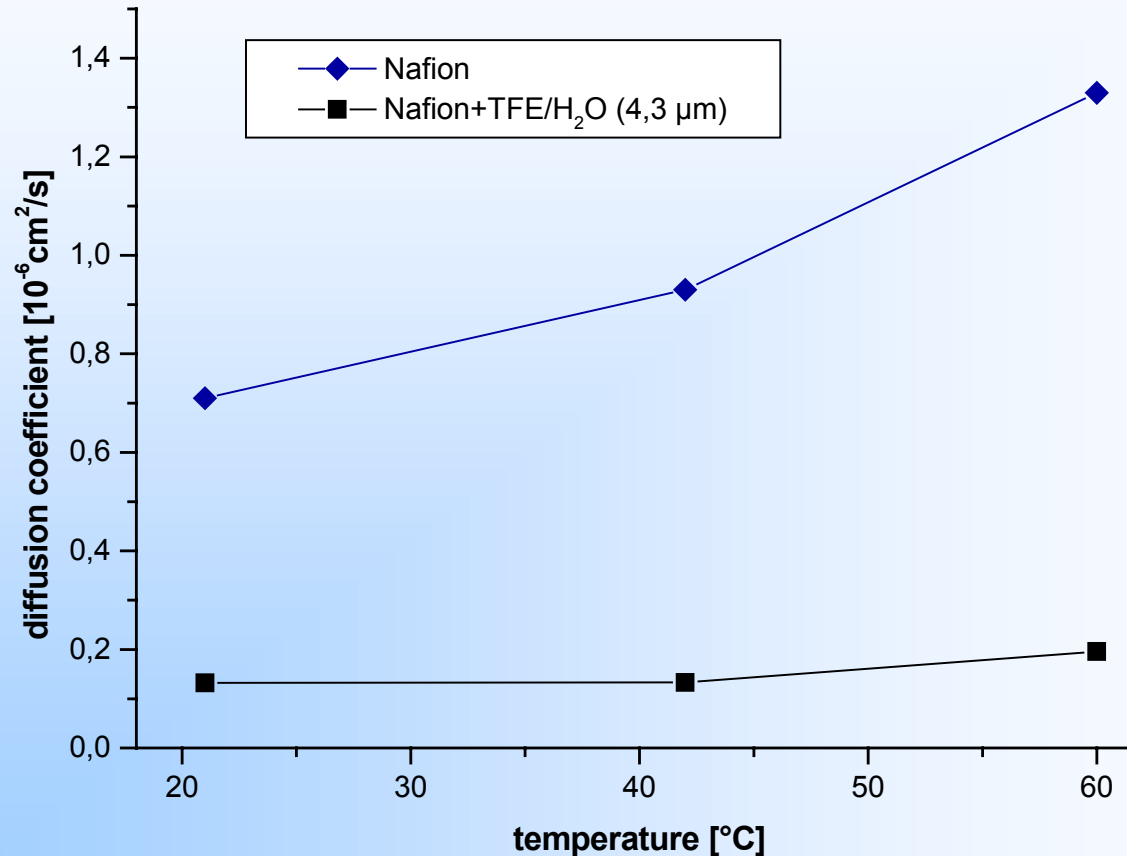
Measurements with 3M  $\text{CH}_3\text{OH}$  and TFE/ $\text{H}_2\text{O}$ -layers on Nafion 115 (DuPont) and TE35 (Teflon-membrane, 0.2  $\mu\text{m}$  pores, S&S) by gas chromatography (parameters for all TFE/ $\text{H}_2\text{O}$  processes: 200W, 10 Pa, 40 sccm TFE, 3 g/h  $\text{H}_2\text{O}$ )

## Results



- Methanol diffusion coefficient decreases with layer thickness on substrate
- Approximately 60-fold decrease for a TFE/H<sub>2</sub>O-layer of 13 μm thickness

## Results



- Increase of methanol permeability with temperature
- Reduced permeability and increase by plasma-polymerized barrier layer

## Outlook

- Further increase of the film deposition rate
- Verification of results by testing membrane electrode assemblies:
  - ▶ Deposition of stand-alone plasma-polymerized membranes on qualified electrode material substrates (low surface roughness)
  - ▶ Application of plasma-polymerized membranes as barrier layers on conventional membranes to reduce methanol permeability