CO_2-Responsive Etalon Membranes (CREM) for in-situ analysis of oceanwater

Georgia Kontaxi[1], Gijs Wensink [2], Maja Rücker [2], Hanieh Bazyar[1]

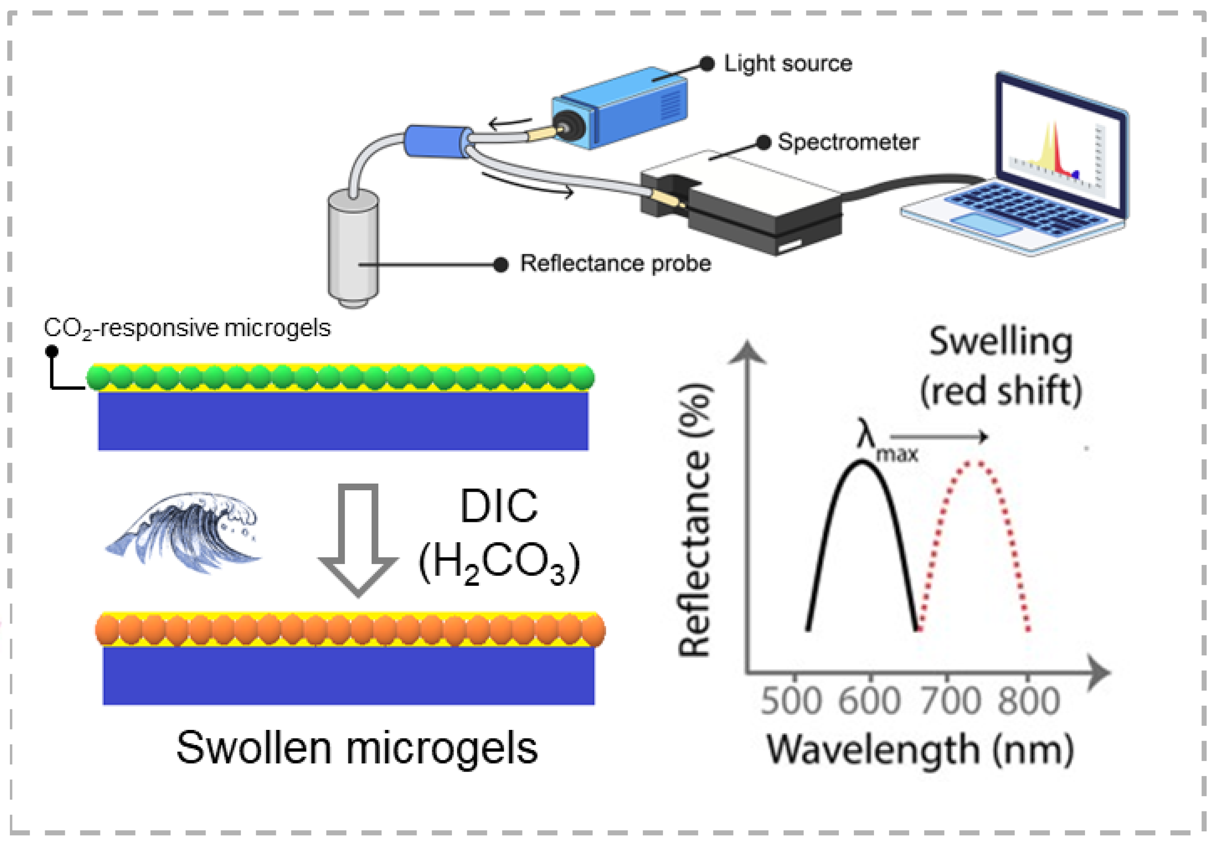
1 Department of chemical engineering, faculty of TNW, TU Delft, The Netherlands
2 Department of mechanical engineering, TU/e, The Netherlands

Introduction and Scope

To achieve the goal of limiting global warming to 2 ºC by 2050, negative emissions technologies (NETs) should be deployed to counterbalance emissions from various sectors, including energy production (1). Indirect ocean capture (IOC) stands as one of these technologies, using controlled pH adjustments in seawater to extract dissolved CO_2 and restore the ocean-atmosphere equilibrium (2). Analysis of ocean water samples is essential to precisely determine the concentration and composition of Dissolved Inorganic Carbon (DIC), a prerequisite for the effective implementation of IOC. Real-time analysis and in-situ detection of DIC in oceanwater with **CREM** would lead to widespread adoption of IOC across diverse locations.

CREM fabrication

We fabricate microfluidic-scale chip membranes based on transparent gold coated Si_3N_4 membranes with etched pores of 4 μm in diameter (Fig.1). Poly(N-isopropylacrylamide) (pNIPAm)-based microgels are spin coated on the gold layer and a top gold layer is deposited upon the microgels forming a microgel-based etalon (3) membrane. Functionalization of pNIPAm microgels with 4-vinyl pyridine (4VP) renders the microgels responsive to CO_2. The microgels will swell/shrink in response to the presence of the analytes leading to a peak shift in the reflectance spectrum.



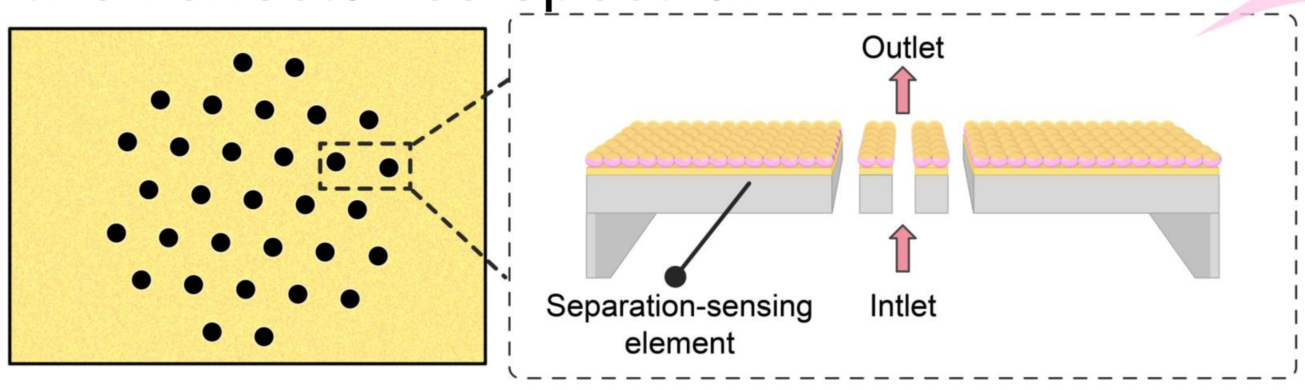


Figure 1: Working principle of CREM for DIC analysis in oceanwater.

CREM characterization

We develop flow cell to facilitate "in-flow AFM" observations (Fig.2). This innovative approach allows us to examine how membranes respond and deform, both topographically and mechanically, providing crucial insights into microgels behaviour. By comprehensively understanding membrane responses, we will optimize designs for continuous DIC level monitoring in ocean water, enhancing the effectiveness of IOC technologies.

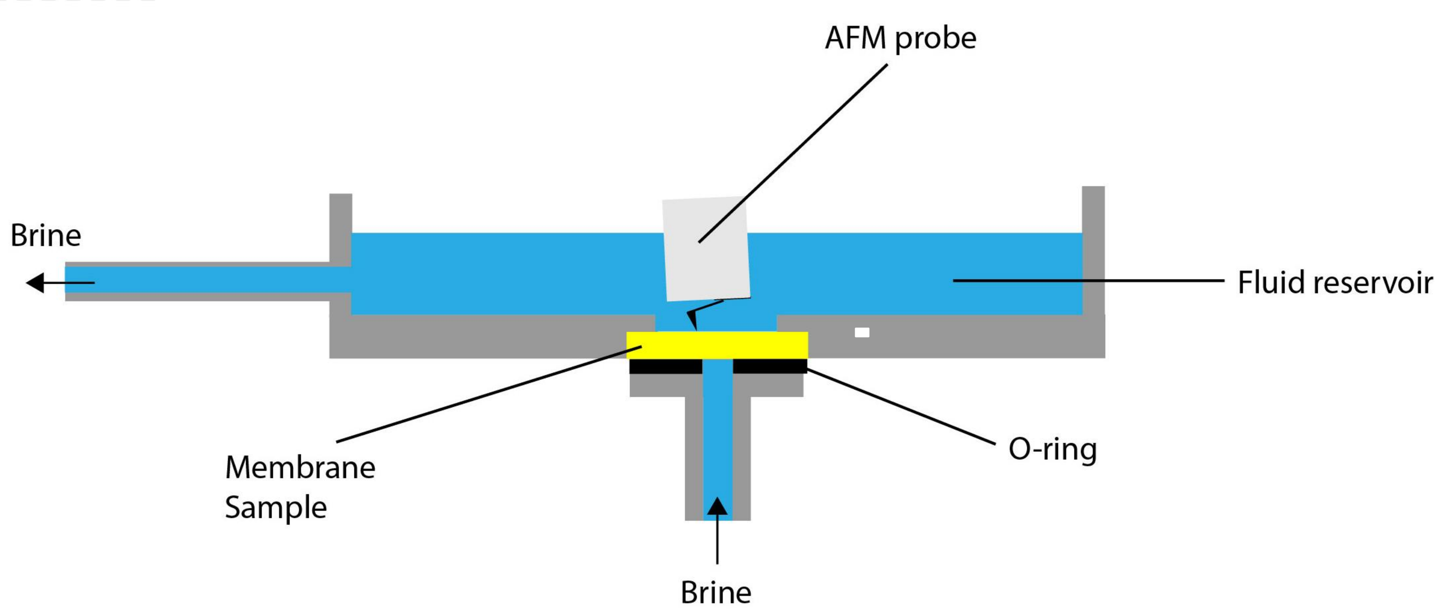
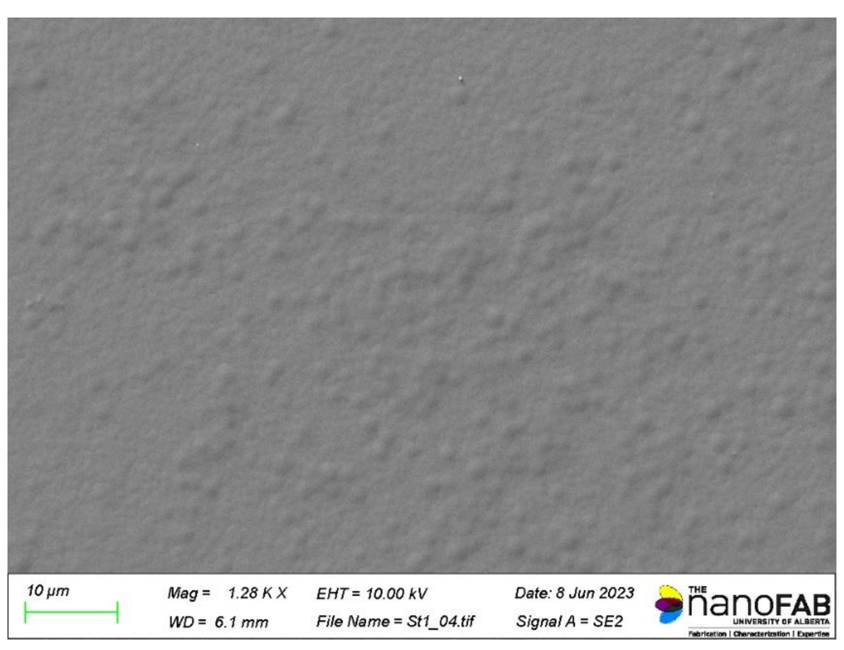
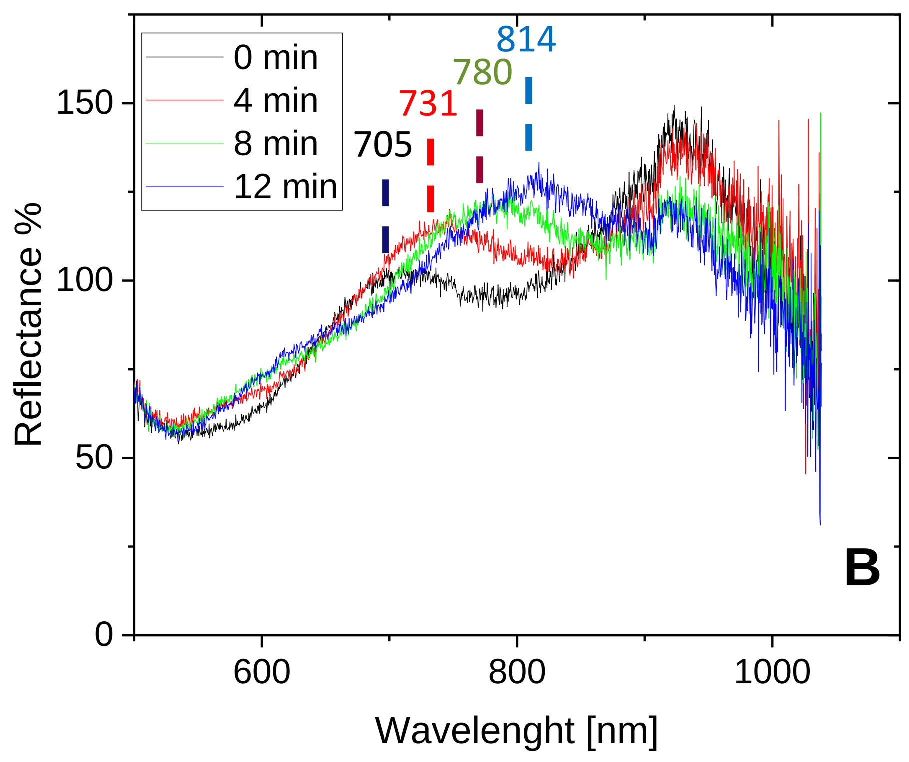


Figure 2: Schematic of flow cell.

Preliminary results

1. Synthesis of polydisperse CO_2-responsive microgels (Fig.3A).
2. Increase of wavelength peak (λ_{max}) in reflectance spectra indicates the swelling behaviour of the microgel beads in presence of CO_2 (Fig.3B).
3. Design of flow cell for "in-flow AFM" measurements (Fig.3C).





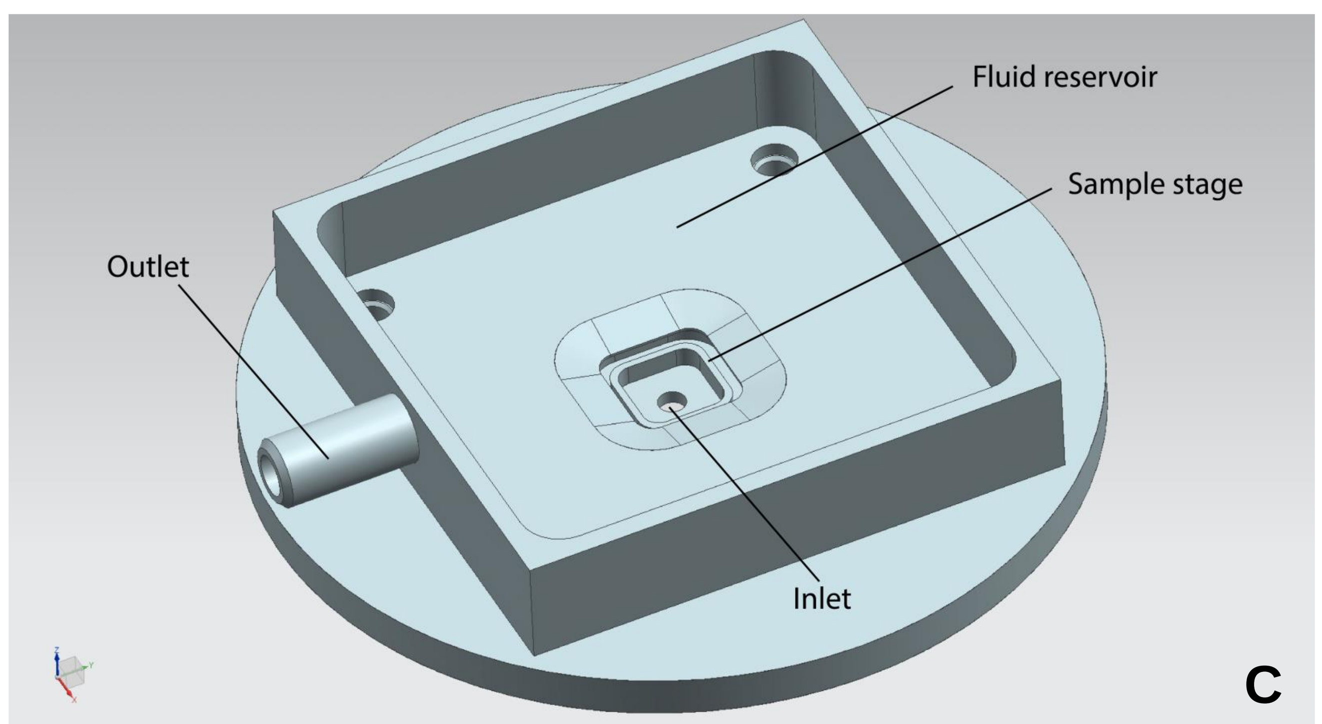


Figure 3: (*A*): SEM image of pNIPAm-co-4VP etalon. (*B*): Peak shift observed in reflectance spectra of the pNIPAm-co-4VP microgel-based etalons with time in presence of CO_2 in gas form (T = 22ºC). (*C*): Design of flow cell for in-flow AFM measurements of CREM.

Next steps

1. Synthesis of monodisperse pNIPAm-co-4VP.
2. CREM responsive to DIC.
3. Fabrication of flow cell for "in-flow AFM" measurements.

References

1. Smith, P., Davis, S., Creutzig, F. Nature Clim Change 2016;6, 42-50.
2. de Lannoy, C. F., Eisaman, M. D., Jose, A. et. al. 2018;70, 243-253.
3. Gao Y, Li X, Serpe MJ. RSC Advances 2015;5(55):44074–87.

Funded by: 4TU energy initiative

g.kontaxi@tudelft.nl