

Study on the Optical Measurement of CO₂ Clathrate Hydrate Membrane Thickness

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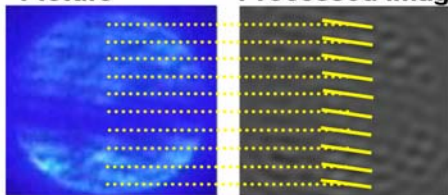
- Conclusion/Summary -

The experiments are conducted to investigate the hydrate membrane behavior near the melting temperature at 5MPa and 10MPa. In the experiment, the hydrate membrane thickness is measured by the optical interferometry system. As the result, following results are obtained.

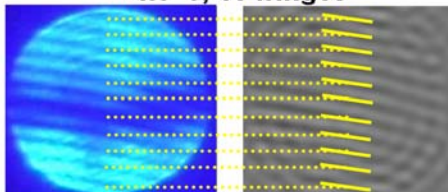
- The hydrate membranes show the tendency that The wrinkles begin to become on the membrane and the surface begin to become white for the sub-cooling temperature about 1~0°C from melting point.
- It is demonstrated that the CO₂ hydrate membrane thickness at high-pressure and low temperature can be measured by using optical interferometry method.
- The measurement results of the hydrate membrane thickness is **7.34~8.14 μm at 276.0K and 277.9~278.9K**, **7.34~8.88 μm at 281.0~281.9K** and **8.14~10.34 μm at 282.9~283.2K at 10MPa**.
- The present measurement results suggest that the thickness of the hydrate membrane is related to the temperature.

- Interference fringe -

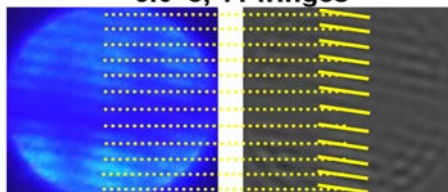
• Picture • Processed image



4.9 °C, 10 fringes

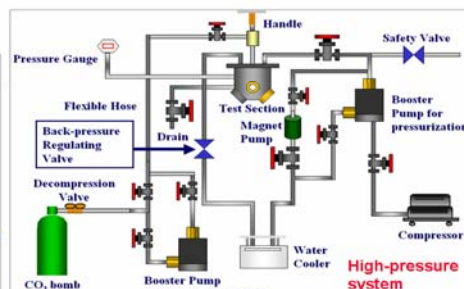
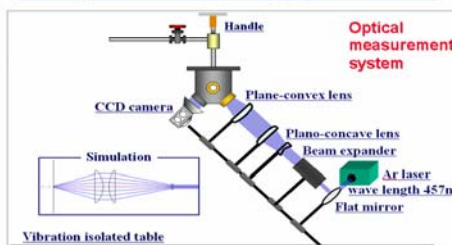


8.6 °C, 11 fringes



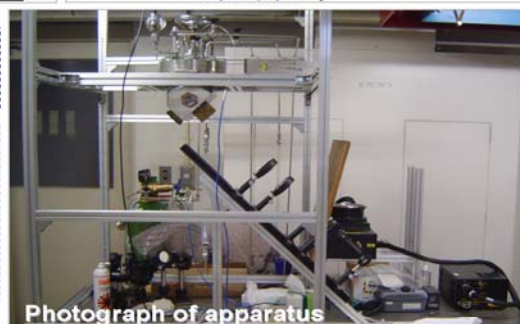
10.1 °C, 12 fringes

- Experimental apparatus -

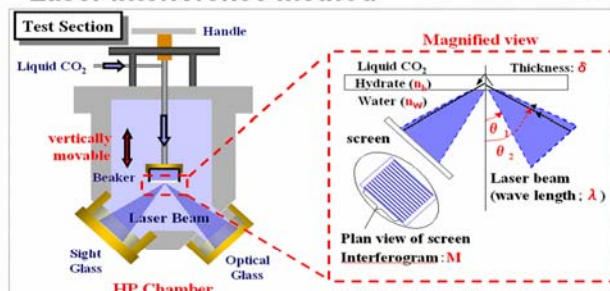


In the optical measurement system, the laser light path and the laser intensity can be controlled.

In the high-pressure system, the inner pressure can be controlled to the max pressure 10 MPa and make flow with the inner pressure constant by using the back-pressure pump with the booster pump driven by air compressor.



• Laser interference method



The laser-light interference is adopted to measure the hydrate membrane.

In the laser interference method, the spread laser light is converged on the top of the hydrate membrane surface. The interference fringes are generated on the hydrate membrane by the difference of the laser phase reflected on the top of the membrane and on the bottom (light interference).

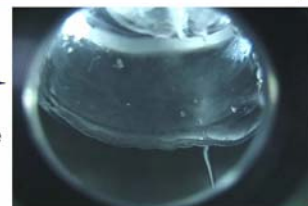
• Relational expression $\rightarrow \delta = \frac{\lambda M}{[\phi(\theta_1) - \phi(\theta_2)]}$, $\phi(\theta) = 2\sqrt{n_h^2 - n_w^2} \sin^2 \theta$

- Behavior of CO₂ hydrate near the melting temperature -



From sub cooled temperature 1 °C

The wrinkles begin to become on the membrane and the surface begin to become white.



- Measurement results at pressure 10 MPa -

Experimental condition

- Apparatus condition ; 10MPa, 276K~284K, λ=457nm
- Laser light condition ; θ₁=36.7°, θ₂=53.3°
- Refractive index ; n_{water} = 1.37, n_{hydrate} = 1.31 (Refractive index of air hydrate)

