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PUSAN NATIONAL UNIVERSITY



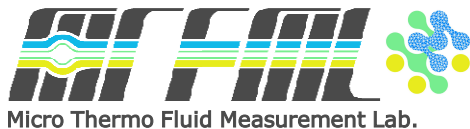
PUSAN NATIONAL UNIVERSITY
SCHOOL OF MECHANICAL ENGINEERING

Research Works in MTFML

Micro Thermo Fluid Measurement Lab.

Pusan National University School of Mechanical Engineering

Eunseop Yeom
2022



친환경 스마트 선박
부품 기술 혁신 센터
Eco-friendly Smart Ship Parts Technology Innovation Center

Micro Thermo Fluid Measurement Lab

Research Experience

POSTECH,	2015.08 - 2016.02	Postdoctoral Research Fellow
Pusan National University (PNU),	2016.03 - 2020.02	Assistant Professor
	2020.03 - present	Associate Professor



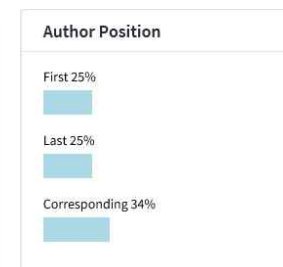
Overview

- In our lab, various micro thermofluid phenomena are investigated based on physics, chemistry and applied mathematics. Specifically, interesting problems involve two-phase flow on hot metal surface, development of 3D printed chip, analysis of complex flows (SOFC, Airway), and thermofluid measurement techniques, and heat transfers in the industrial structures (Refrigerator, Pump). In order to find solution, we use experiments, simulations, and modeling to quantitatively characterize problems. We are looking forward to collaborate with industry and scientists and engineers from many disciplines.
- 본 연구실에서는 다양한 유동 현상을 측정하기 위해 광학 및 전기 센서 장치를 이용하여 열 및 유동 계측 기법을 개발한다. 이를 이용하여 시스템 내 유동으로 인해 발생하는 미세 열전달, 질병 진단을 위한 Biochip을 개발 등을 수행한다. 이러한 해석에는 고온 표면의 충돌 냉각, 연료전지 내 열응력 해석 및 설계 관련된 미세 채널 내부 metal foam 주변의 온도 해석 등 다양한 주제를 다루며, 이를 위해 전산 해석도 수행한다. 이러한 연구를 수행하기 위해 다양한 분야의 전문가와 공동 연구를 수행하고 있다.

Research subjects

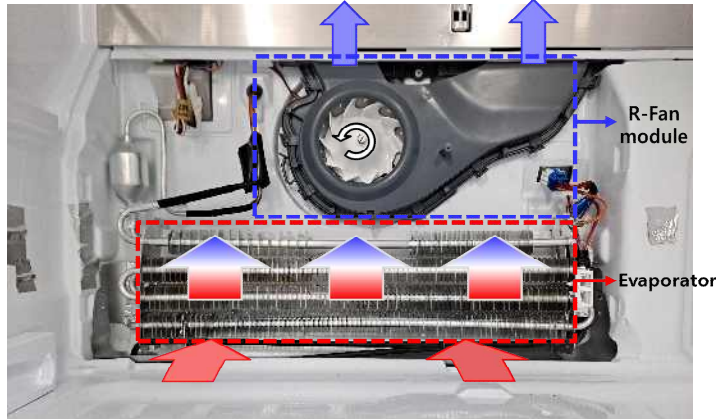
- Development of experimental thermo-fluid Measurement.
- 3D printed chip device for diseases detection
- Micro-heat transfer induced by flow analysis
- Design of solid oxide fuel cell (SOFC)
- Flow analysis for biomedical and industrial applications
- 열-유동 계측 및 가시화 기법 개발
- 질병 진단을 위한 3D 프린팅 칩 개발
- 미세 열 및 유동의 실험 및 전산 해석
- 연료 전지(SOFC) 설계 및 열응력 해석
- 산업 및 의학 응용 유동 해석

Research summary (Web of Science)

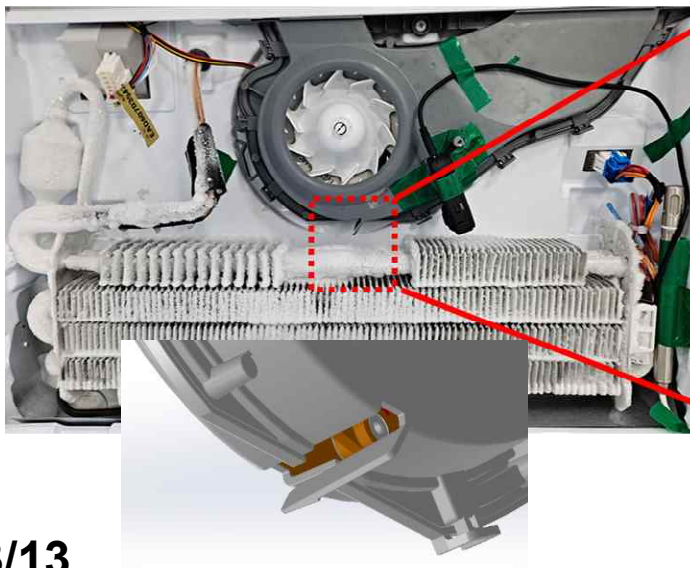


Drain hole for R-fan module in refrigerator

- R-fan module around evaporator

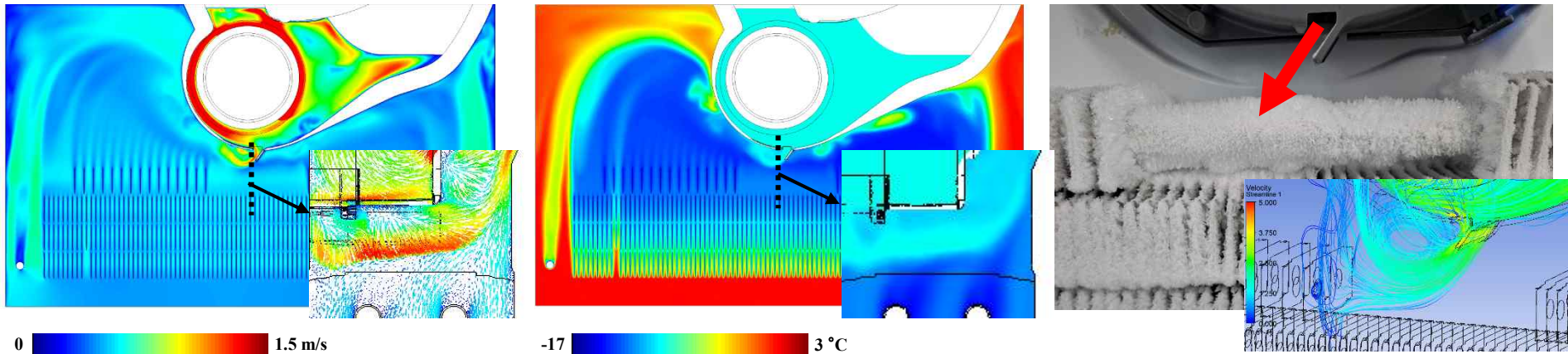


- Drain hole of R-fan module



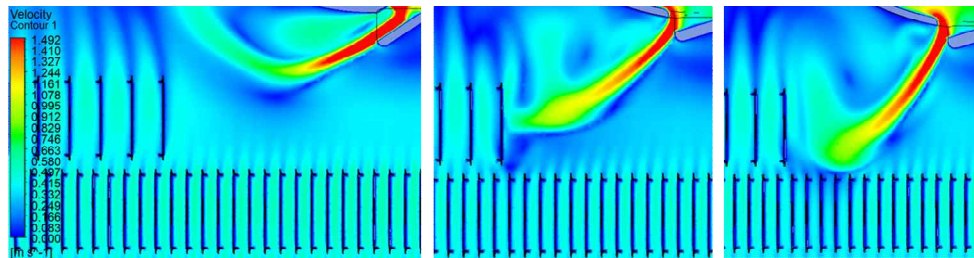
Design of drain hole based on CFD (LG Project)

Simulation results



Design of drain hole of R-fan module

CFD simulation



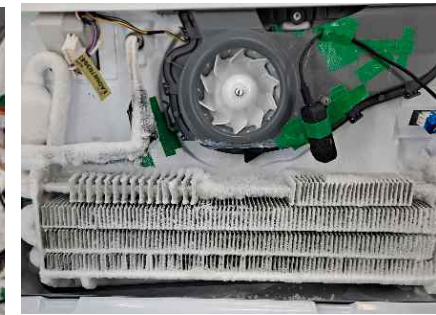
3D printing



Reference model

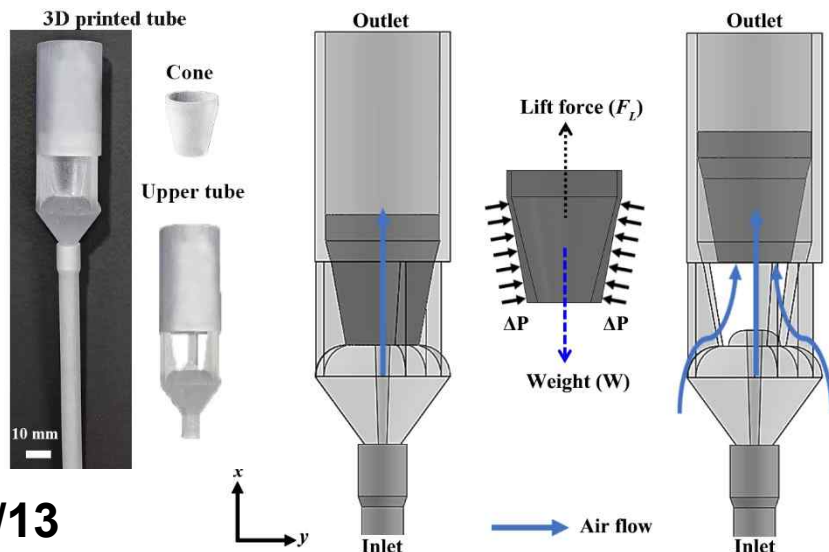
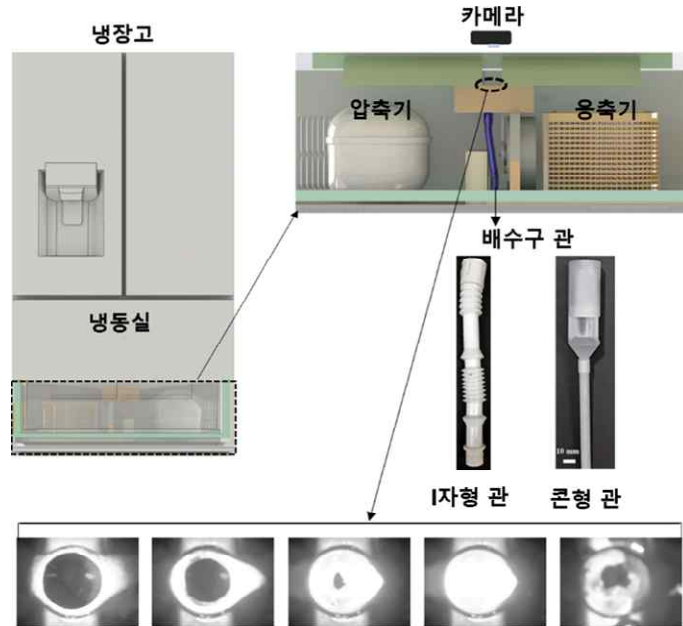


Proposed design

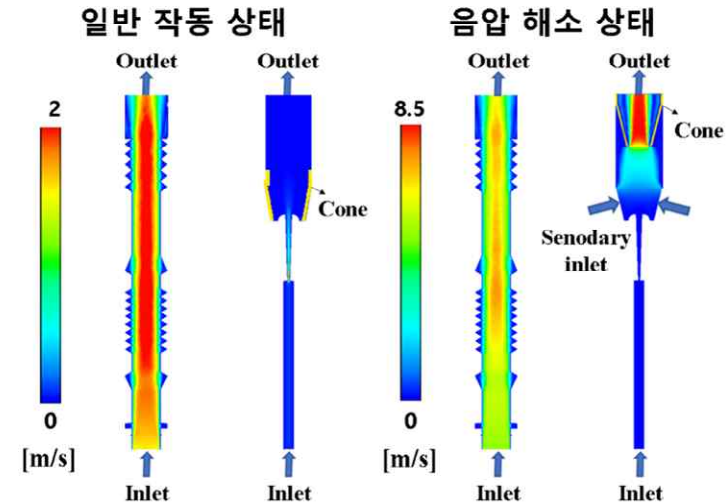


Design of Drain tube in refrigerator (LG Project)

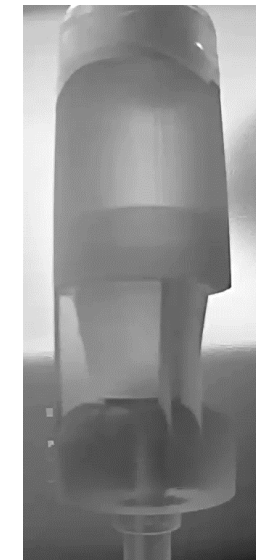
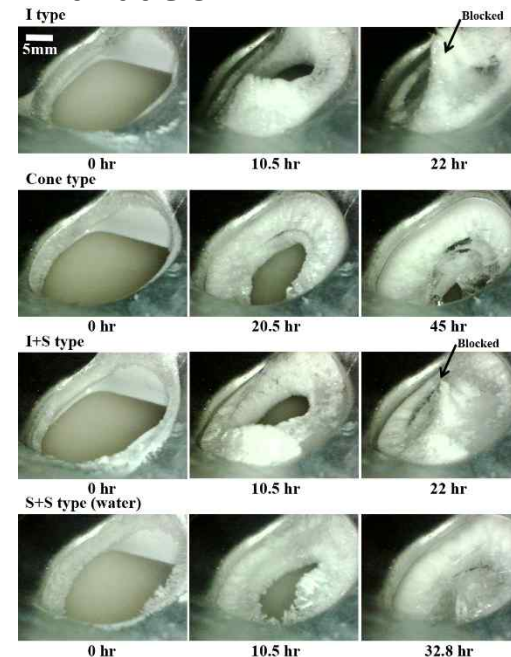
▪ Drain tube in refrigerator



▪ Design through CFD simulation



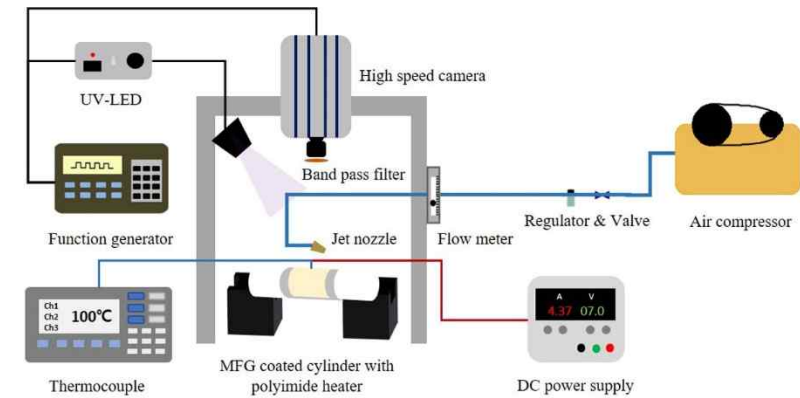
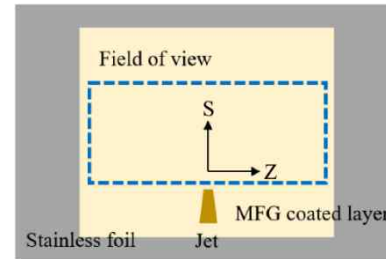
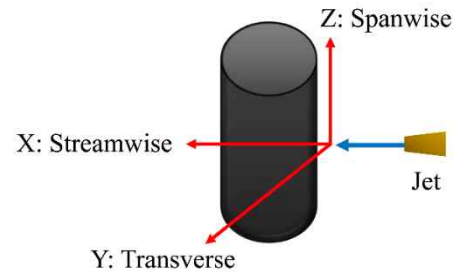
▪ Validation



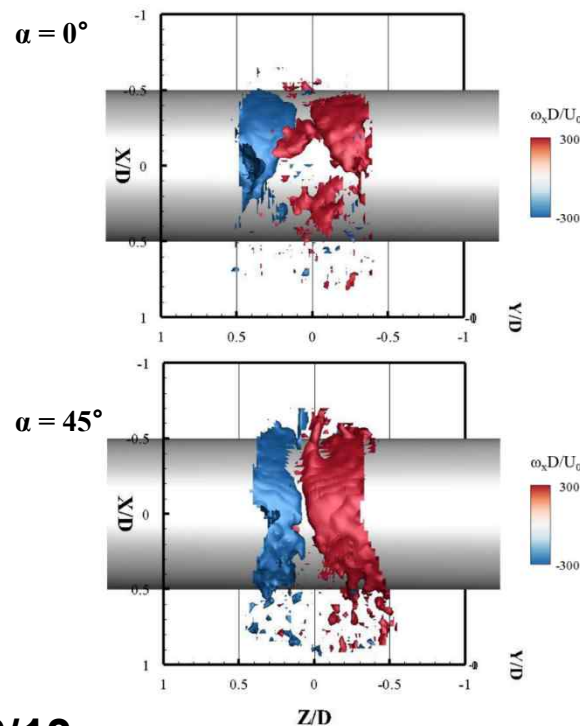
Heat transfer on of impinging jets on curved surface



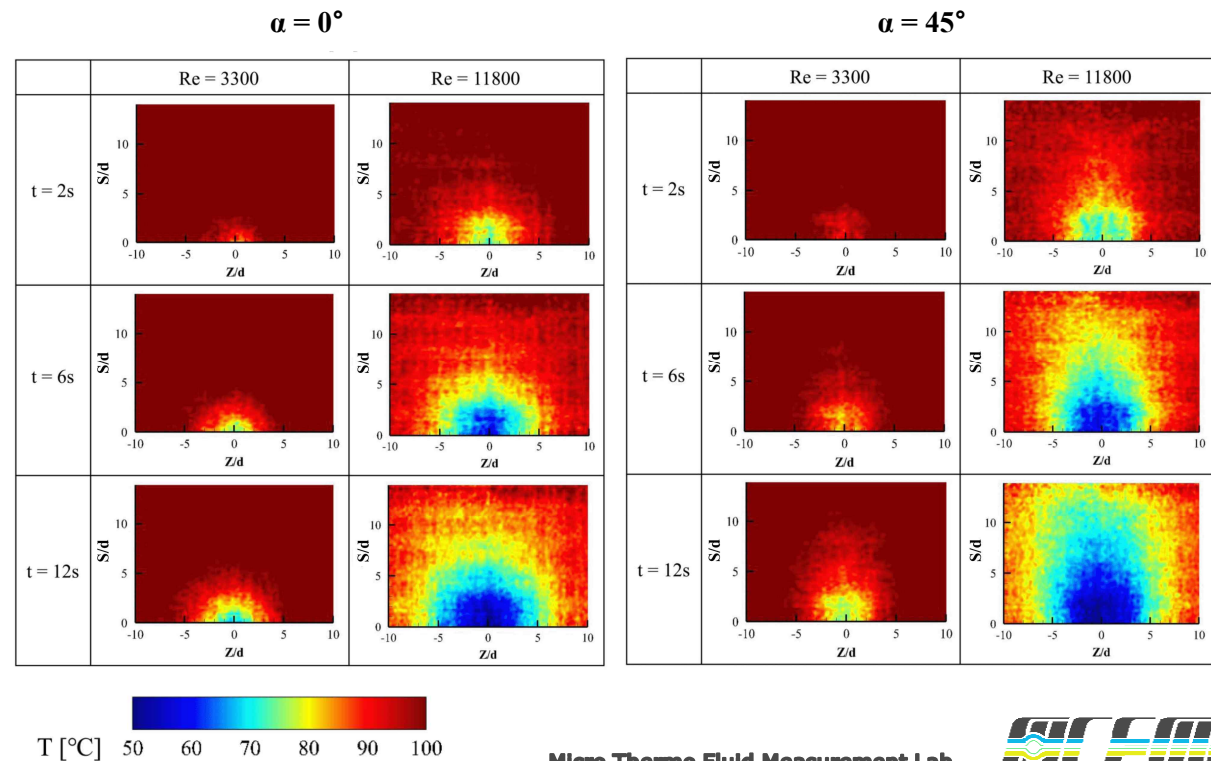
▪ Schematics



▪ Flow characteristics



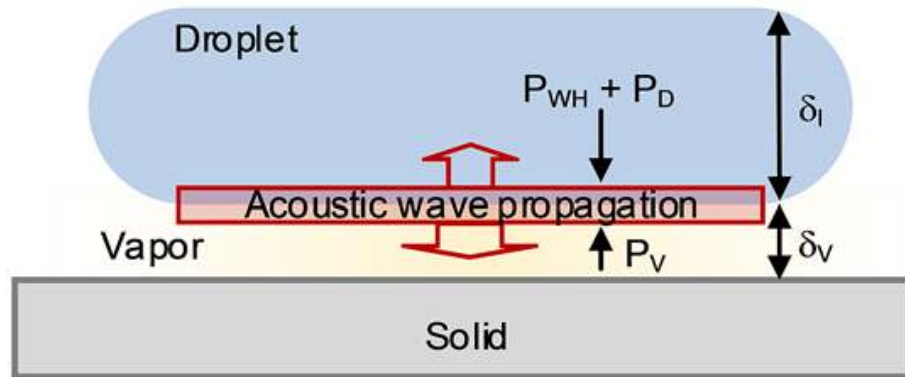
▪ Temperature field



Impact behaviors of drop on hot surface



Leidenfrost Effect

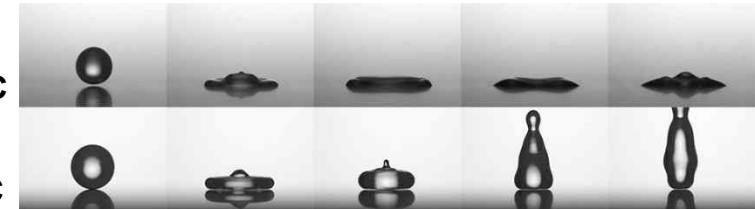


Smooth surface

$We \approx 15$

26.7°C

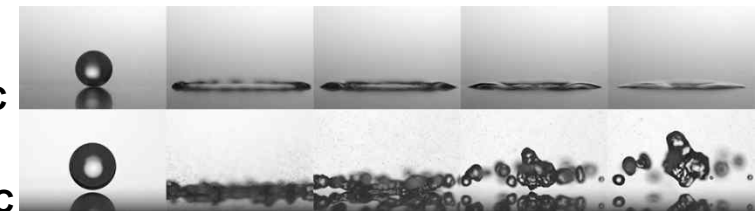
320°C



$We \approx 150$

26.7°C

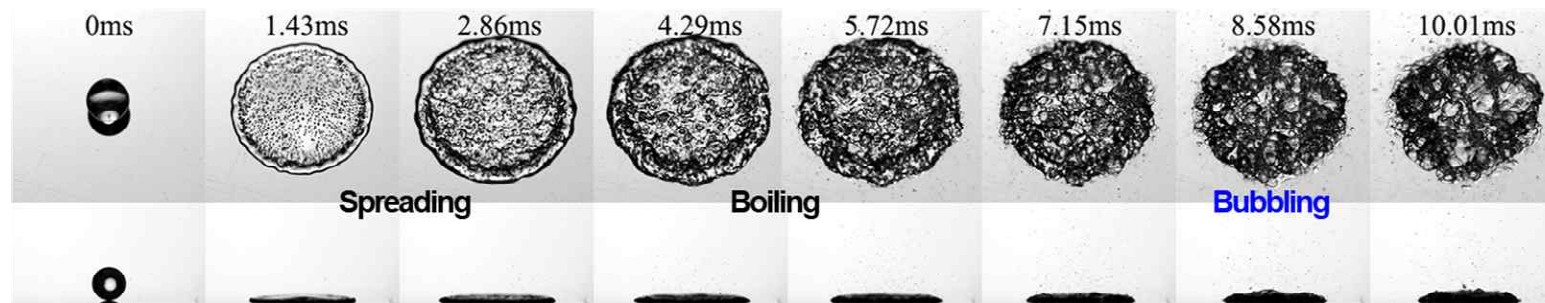
320°C



Splashing, and liquid film was boiling

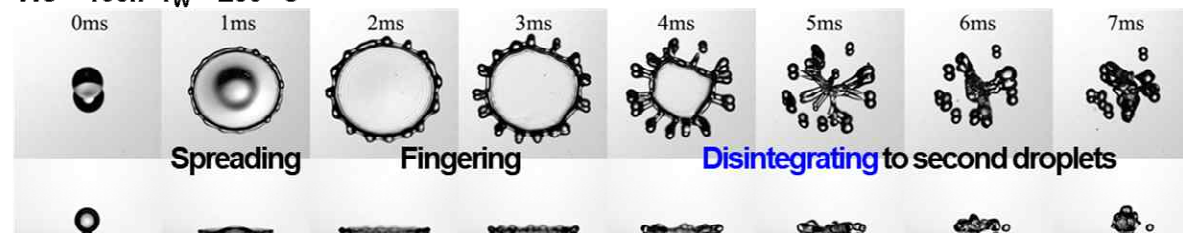
Contact boiling regime

$We = 145.43, T_w = 80^\circ\text{C}$



Film boiling regime

$We = 103.7, T_w = 250^\circ\text{C}$

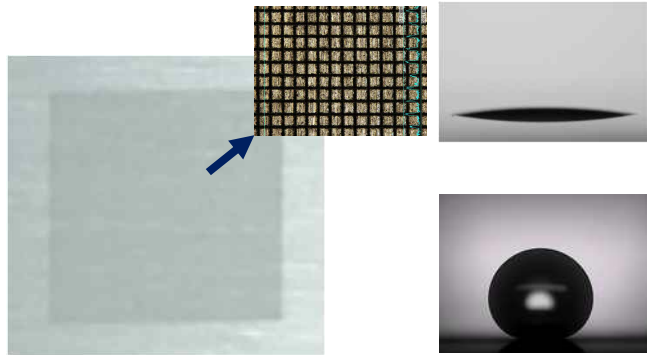


**Reducing
Heat transfer**

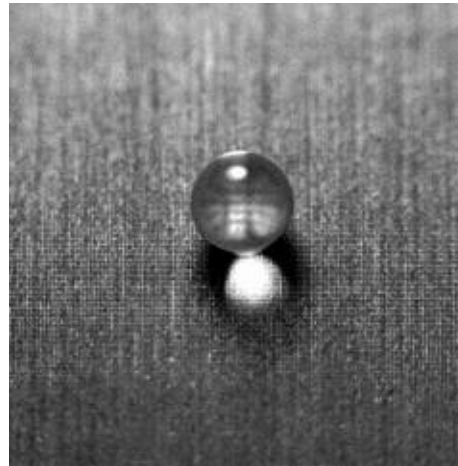
Impact behaviors of drop on structured surface

▪ Roughness Effect

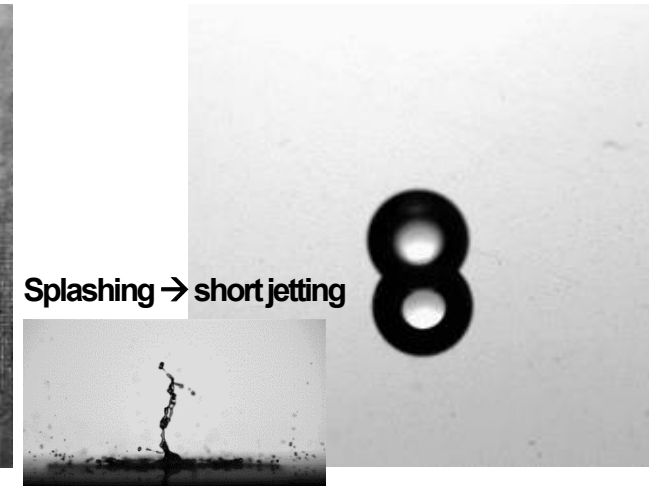
Laser-ablated Al (50 μ m)



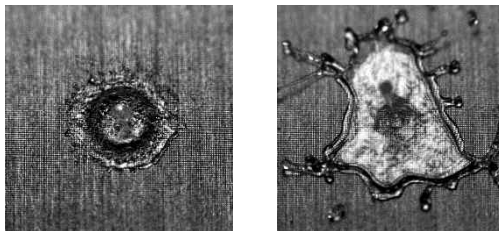
$We \approx 88$
150°C (contact)



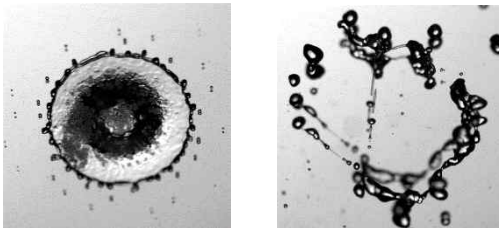
150°C (no contact)



$We \approx 185$
150°C (contact)

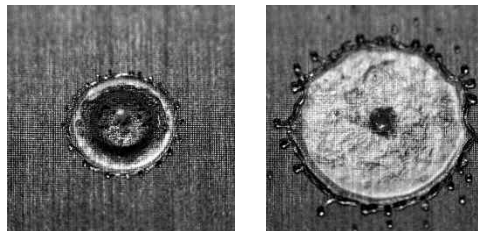


Splashing → short jetting
150°C (no contact)

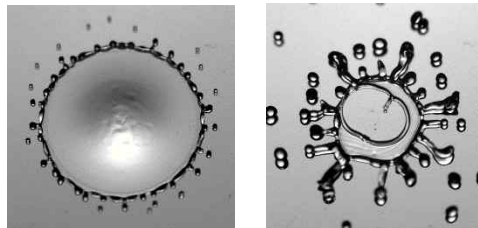


Splashing → short jetting

200°C (contact)

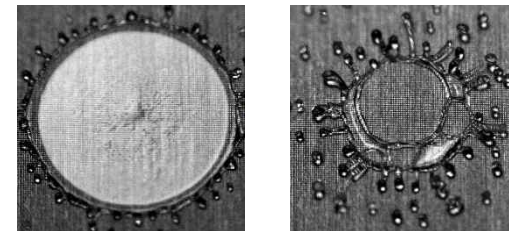


Splashing → partial contact
200°C (no contact)

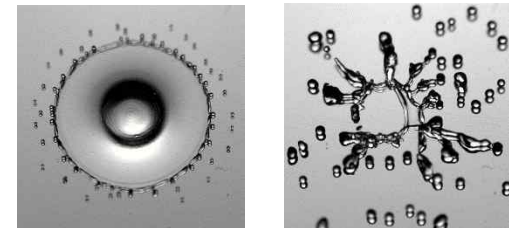


Splashing

$We \approx 240$
250°C (contact)



Splashing → partial contact
250°C (no contact)

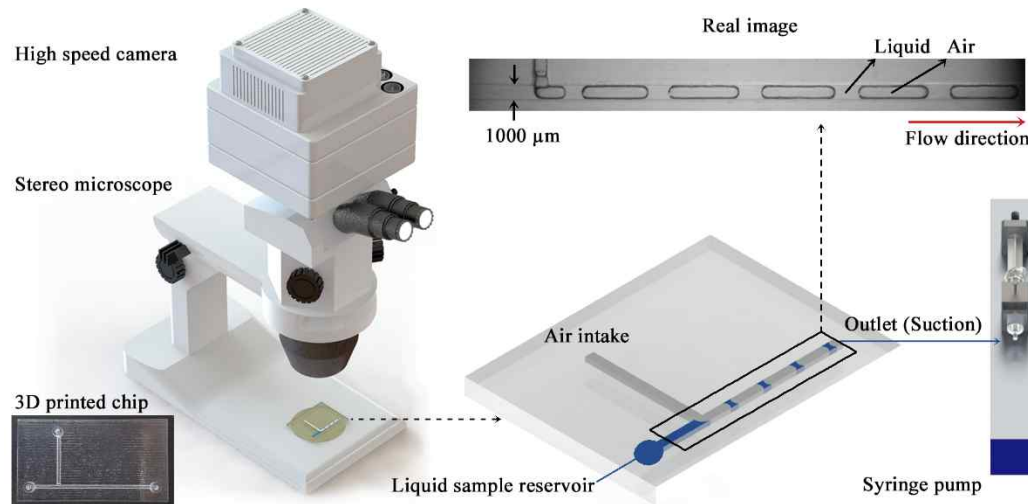


Splashing

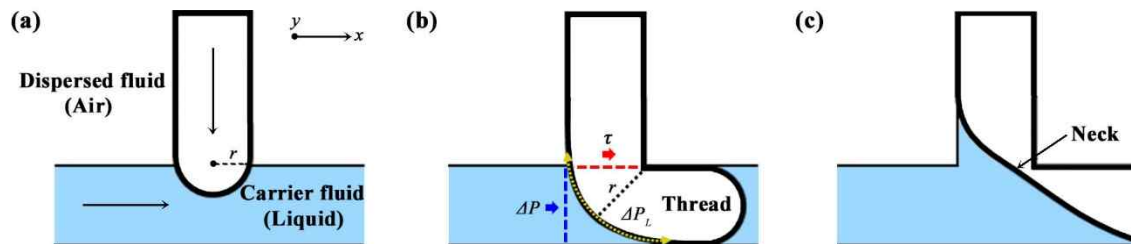
3D printed chip for controlling liquid droplet



▪ Schematics

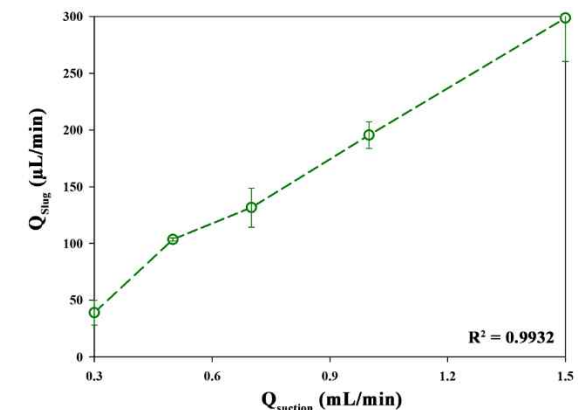
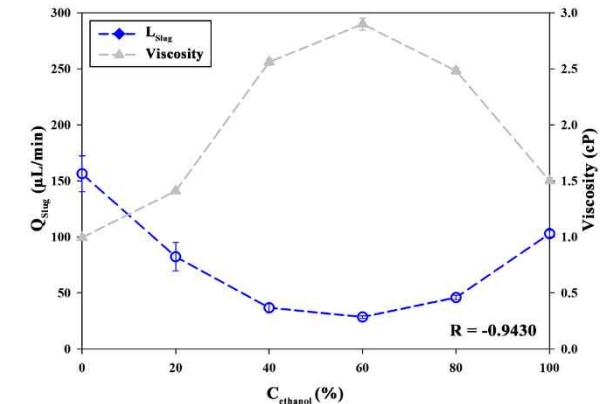


▪ Mechanism



- There are three types of forces acting on the air bubbles for growing and squeezing: **surface tension**, **shear stress**, and **pressure drop**.
- While the **radius** of the dispersed fluid (r) **increases** due to **intake** of the air, Laplace **pressure** of the interface is **reduced**.
- Subsequently, the **collapse** of **neck** produces the segmented flow within two immiscible fluids.

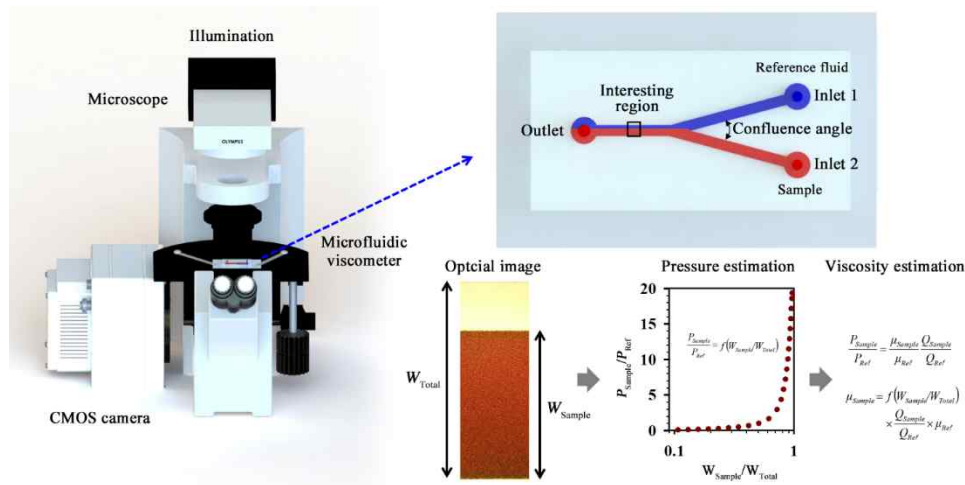
▪ Results



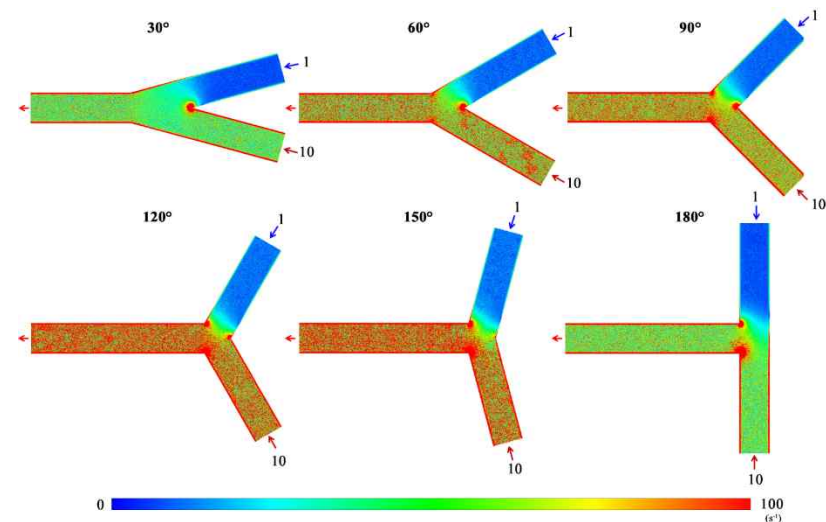
Design of 3D printed viscometer



■ Setup

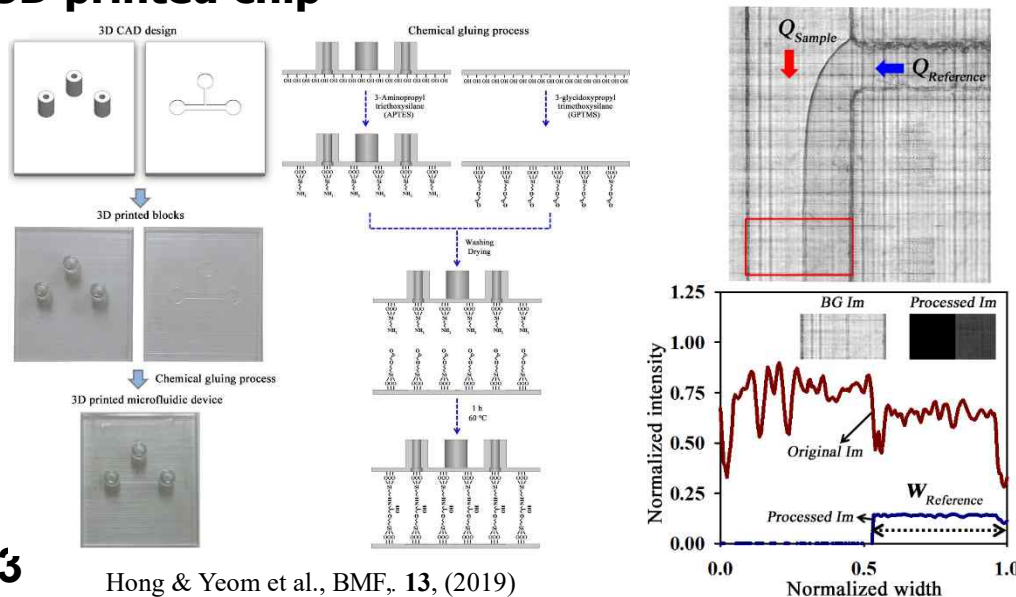


■ Simulations

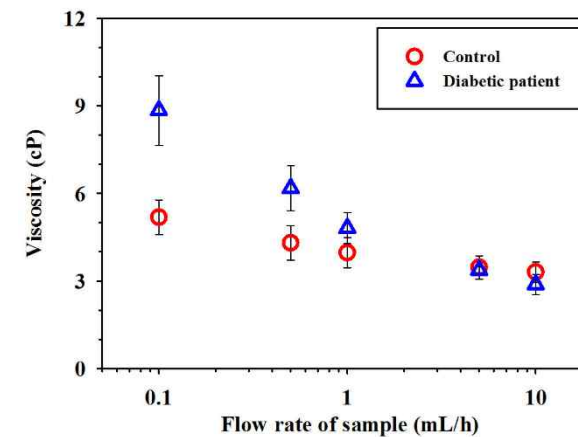


Kang & Yeom et al., Journal of Visualization, 22, (2019)

■ 3D printed chip



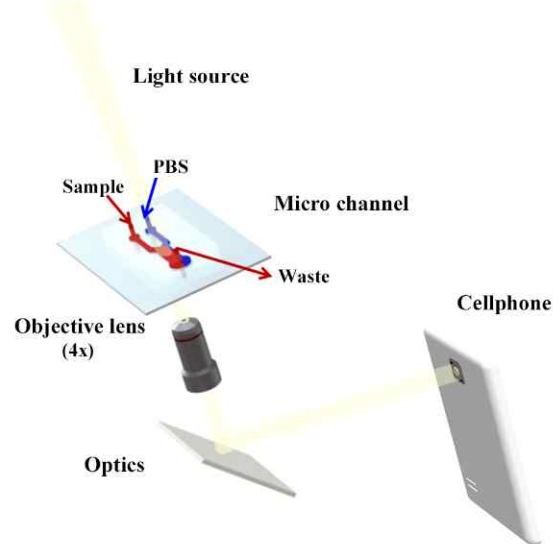
Diabetic patient



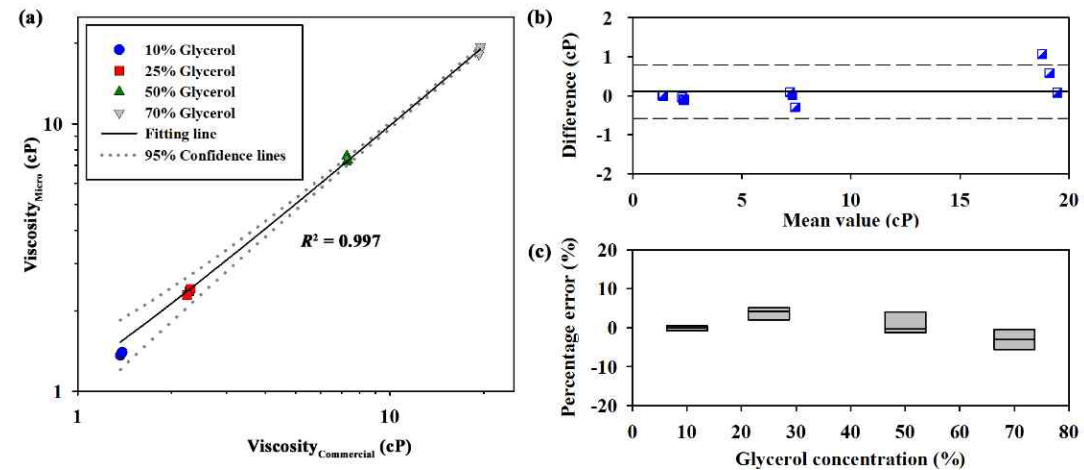
Application for smartphone



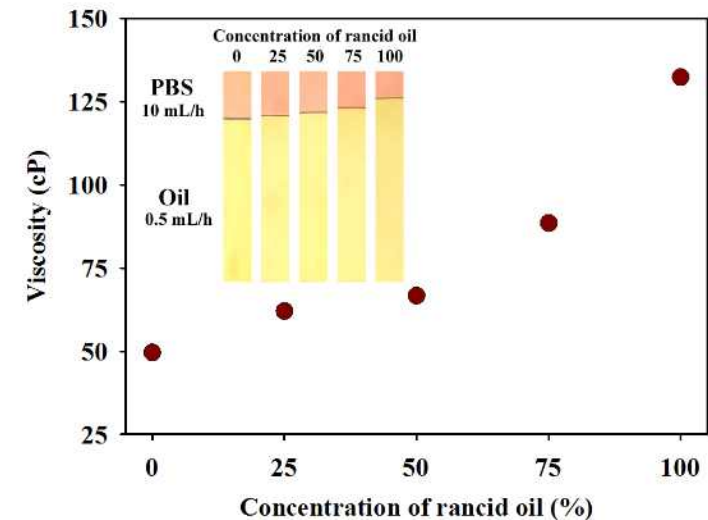
■ Setup



■ Verification of smartphone base measurement



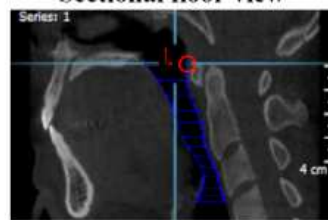
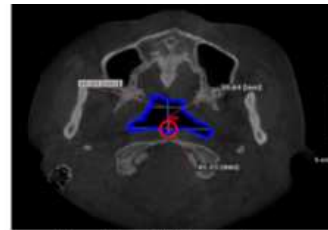
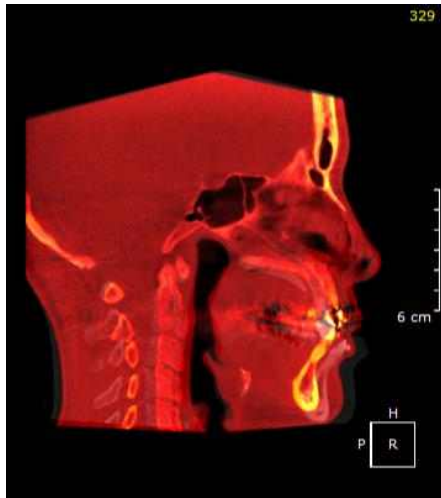
■ Discrimination of rancid olive oil



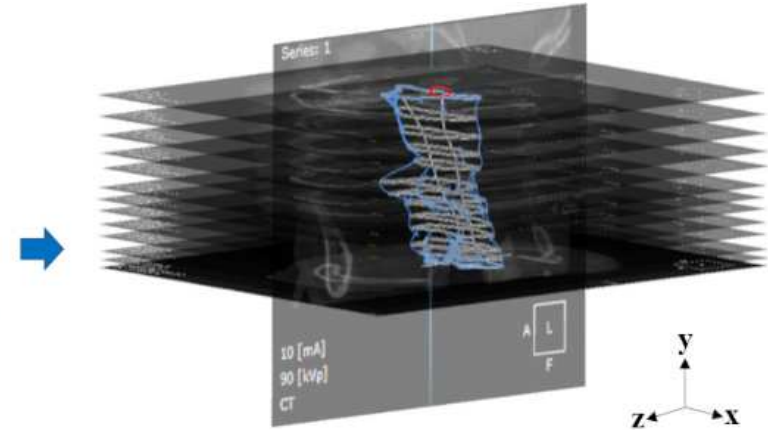
Simulation for bimaxillary orthognathic surgery (양악수술)



- Pre-surgery and post-surgery CT
- Procedure of the 3D reconstruction of airway

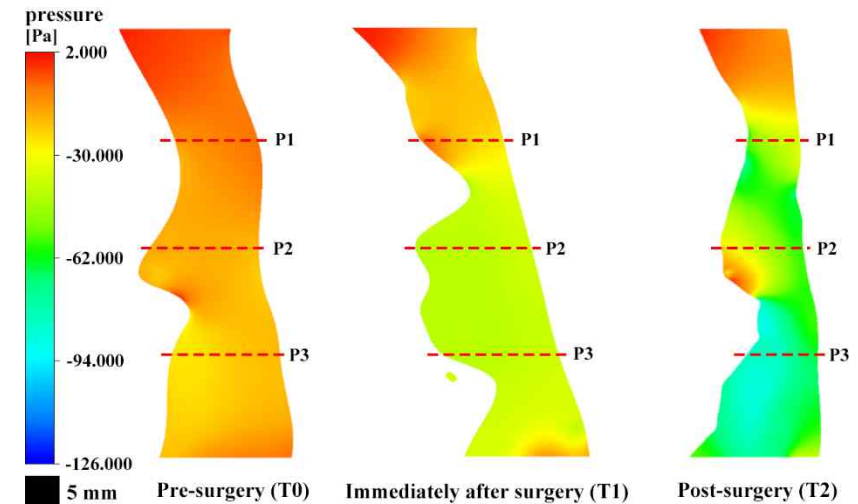
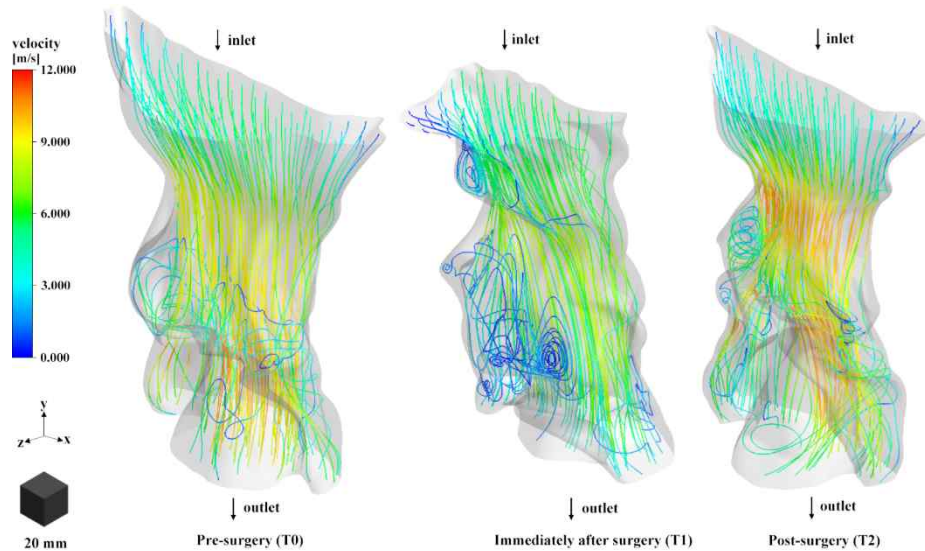


Sectional side view



Reconstructed 3-dimensional CT image

- 3D stream in the 3D reconstructed model
- Pressure distribution



Publications in 3 years

1. J. Fan, and **E. Yeom***, “Numerical investigation on thermal hydraulic performance of supercritical LNG in PCHEs with straight, zigzag, and sinusoidal channels”, *Journal of Visualization*, *in press*
2. D. Kwon, D. Kang, The-Hung Dinh, Doo-Man Chun, and **E. Yeom***, “Central liquid jet emanating from an impacting drop on superheated laser-ablated surfaces”, *International Journal of Heat and Mass Transfer*, Vol. 183, No.1, pp. 122053, 2022.02.01
3. T. Cai, Y. Z. Yan, J. Jung, J. Han, **E. Yeom**, Y. Im, T. Lee, D. Peng, Y. Liu, C. S. Ha and K. C. Kim*, “Phosphorescence-based Temperature and Tactile Multi-functional Flexible Sensing Skin”, *Sensors and Actuators A: Physical*, Vol. 332, No.5, pp. 113205 2021.12.01
4. D. Kwon, and **E. Yeom***, “Shape evaluation of highly overlapped powder grains using U-Net-based deep learning segmentation network”, *Journal of Visualization*, Vol. 24, No.5, pp. 931-942, 2021.10.01.
5. S. Kang, D. Kim, S. Lee, D. Kang and **E. Yeom***, “Design of drain tube with movable shutter in household refrigerators”, *International Journal of Refrigeration*, Vol.130, No.1, pp. 76-86, 2021.10.01.
6. H. Hong, J. M. Song*, and **E. Yeom***, “Micro-vibrational erythrocyte sedimentation rate (ESR) for sensitive measurement of erythrocyte aggregation”, *Journal of Visualization*, Vol.24, No.4, pp. 749-760, 2021.08.01.
7. D. Kwon, D. Kang, and **E. Yeom***, “Impact and boiling characteristics of an impinging ethanol drop on a heated Al alloy surface”, *International Journal of Heat and Mass Transfer*, Vol. 169, No.1, pp. 120927, 2021.04.01
8. M. Kim, D. Kim, and **E. Yeom*** “Measurement of three-dimensional flow structure and transient heat transfer on curved surface impinged by round jet”, *International Journal of Heat and Mass Transfer*, Vol. 161, No.1, pp. 120279, 2020.11.01.
9. M. Kim, D. Kim, **E. Yeom***, and K.C. Kim* “Experimental study on heat transfer and flow structures of feedback-free sweeping jet impinging on a flat surface”, *International Journal of Heat and Mass Transfer*, Vol. 159, No.1, pp. 120085, 2020.10.01.
10. J.M. Song, H. Seo, N.R. Choi, **E. Yeom*** and Y.D. Kim* “Application of computational fluid dynamics analysis after bimaxillary orthognathic surgery”, *Applied Sciences*, Vol. 10, No.5, pp. 1676, 2020.03.02.
11. Y.K. Ha, H. Hong, and **E. Yeom***, J. M. Song*, “Numerical study of the pulsatile flow depending on non-Newtonian viscosity in a stenosed microchannel”, *Journal of Visualization*, Vol. 23, No.1, pp. 61-70, 2020.02.01.
12. D. Kwon, S. Lee, and **E. Yeom***, “Experimental investigation on water-repellency and anisotropic wettability of microgrooved polymer surfaces”, *Experiments in Fluids*, Vol. 60, No.11, pp. 169, 2019.11.01
13. MM Hossain, NG Gurudatt, KD Seo, DS Park, H Hong, **E. Yeom**, JH Shim and Y.B. Shim*, “Electrodynamic force derived in-channel separation and detection of au nanoparticles using an electrochemical AC microfluidic channel”, *Analytical Chemistry*, Vol. 91, No.1, pp. 14109–14116, 2019.09.26.
14. M. Kim, Y. Li, D. Peng, **E. Yeom***, and K.C. Kim*, “Flow and surface pressure field measurements on a circular cylinder with impingement of turbulent round jet”, *Experimental Thermal and Fluid Science*, Vol. 105, No.1, pp. 67-76, 2019.07. 01.
15. D. Kwon, D. Kang, and **E. Yeom***, “Impact behaviors of a millimetric impinging drop on a superheated Al alloy surface”, *Journal of Visualization*, Vol. 22, No.2, pp. 321-327, 2019.04.01