



AI - Fluid Engineering and Exploration Laboratory (AI-FEEL)



HEECHANG LIM (임희창), Professor, PhD

Director of the [AI-FEEL\(Fluid Exploration and Eng\) Lab](#)

Professor in Energy Systems Major, PNU

Director of Wind Energy Research Center (WE-TECH)

Chair for the Graduate School of Convergence for Clean Energy Integrated Power Generation (CEIPG)

Chair for Department head of Integrated Energy Power Gen Combustion

< Collaborators in the laboratory >

- **Research professor:** Mustafa Z Yousif
- **PhD students:** YoungWoo Lee, Linqi Yu, Bonhun Gu, Arash Mohammedi, Haifung Zhou, Meng Zhang, Merrera Senbeto Jiren, Tianle Zhang, He Yi
- **Msc students:** JoonHee Won, Yanyun Chen, Fanfan Chun, Zazo Zhu, Cao Yuxiao, Nang Phyu, Han Tan

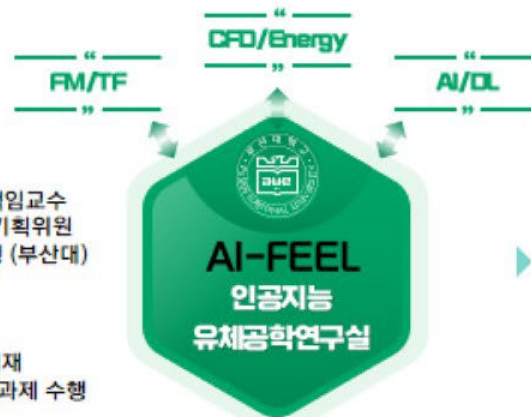
< Research Areas >

- **AI/DL applications** (인공지능/딥러닝 응용)
- **Turbulent boundary layer flow** (열유체 난류유동)
- **Blade/airfoil aerodynamics** (공력, 풍력, 수력발전)
- **Computational Fluid Dynamics** (CFD, 수치유체역학)
- **Active Flow Control, Plasma Actuator**(능동유동제어, 플라즈마 액츄에이터)



Prof HeeChang Lim
PNU SME

- 청정에너지융합발전융합대학원 책임교수
- 에너지기술평가원 인력양성부문 기획위원
- 에기평 인력양성사업 13년간 수행 (부산대)
- 부산대학교 기계공학부 부학부장
- 에너지전공 및 발전공학 학과장
- 부산대 풍력발전연구센터장
- 최근 5년간 SCI급 논문 60여편 게재
- 최근 5년간 70여억원의 산학협력과제 수행



- WT TECH CENTER
- Grad School of Combustion
- CEIPG
- International Collaborative Center for Artificial Intelligence

Artificial Intelligence TEAM

- 인공지능을 이용한 난류유동장 생성 및 재현
- 수퍼해상도기반의 공간시간의 난류유동장 재구성
- 물리정보기반 유체공학 솔루션 기법 개발

1 Post-Doc, 2 PhDstudents, 5 Msc students

Thermo-Fluid Tech Dev TEAM

- 열유체유동의 온도/속도/입력 실험 및 가시화
- 풍동/수동을 이용한 공력/수력 모사실험 및 분석
- 난류경계층 및 물체주위 유동제어 및 분석

1 Post-Doc, 2 PhDstudents, 4 Msc students

CFD/Modelling TEAM

- 난류 열유체유동 CFD 해석 및 기술개발
- CFD 난류모델 및 유동제어 기술개발
- 고레이놀즈 CFD 난류경계층 해석

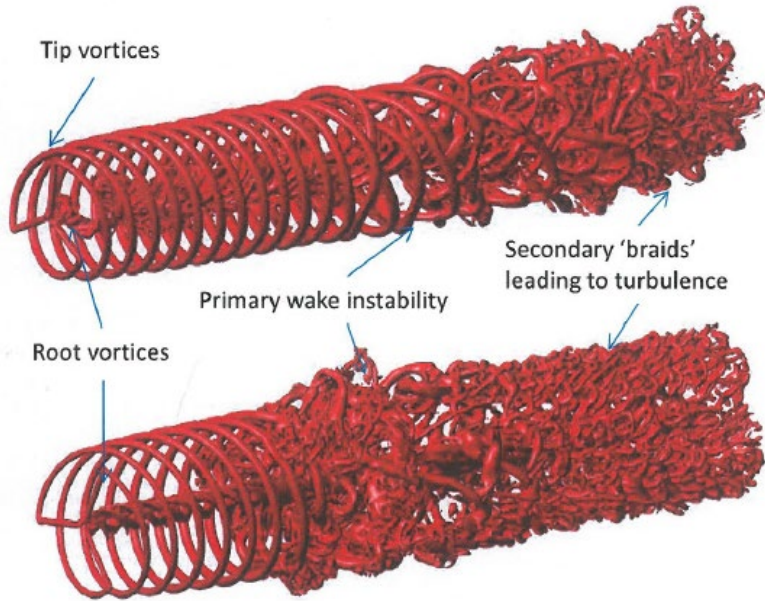
2 PhDstudents, 3 Msc students

Our industrial collaborators

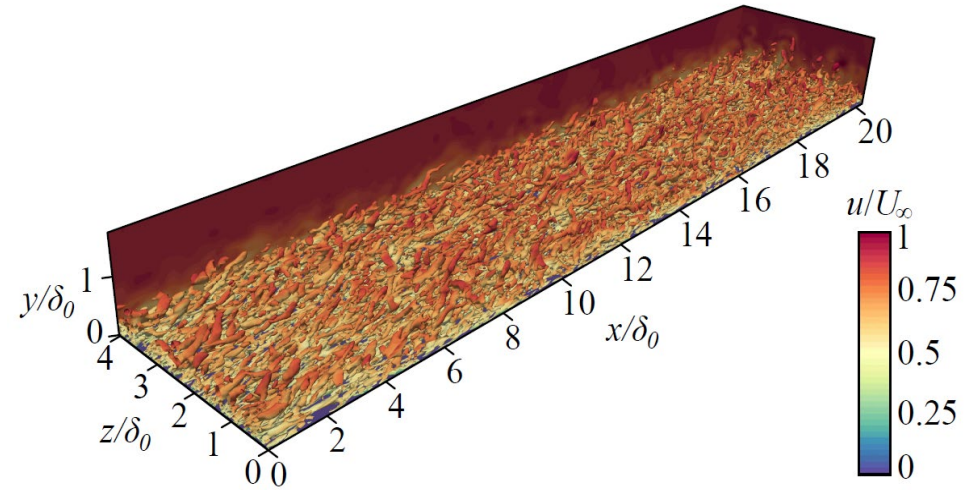
 (주)두산	 남동발전	 남부발전	 (주)파나시아	 LSTME	 (주)태웅	 (주)서원캐스팅	 (주)대창솔루션
 동서발전	 (주)성일터빈	 (주)란타우그룹	 (주)포미트	 (주)그랜드선	 (주)그린테크	 (주)파워테스터	

*AI-FEEL: Artificial Intelligence - Fluid Engineering and Exploration Laboratory

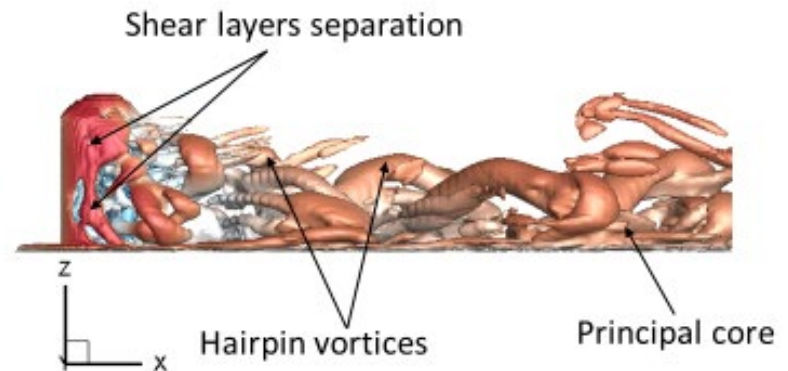
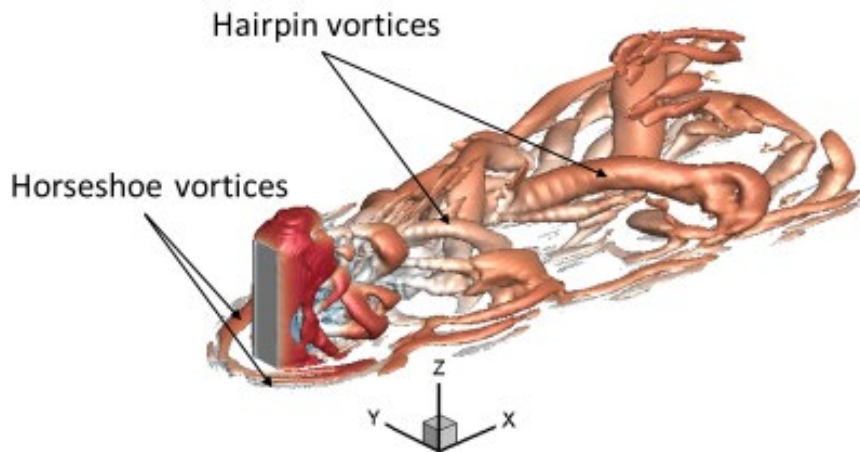
Aerodynamics (블레이드/물체 공력특성)



Wake flow behind turbine blades

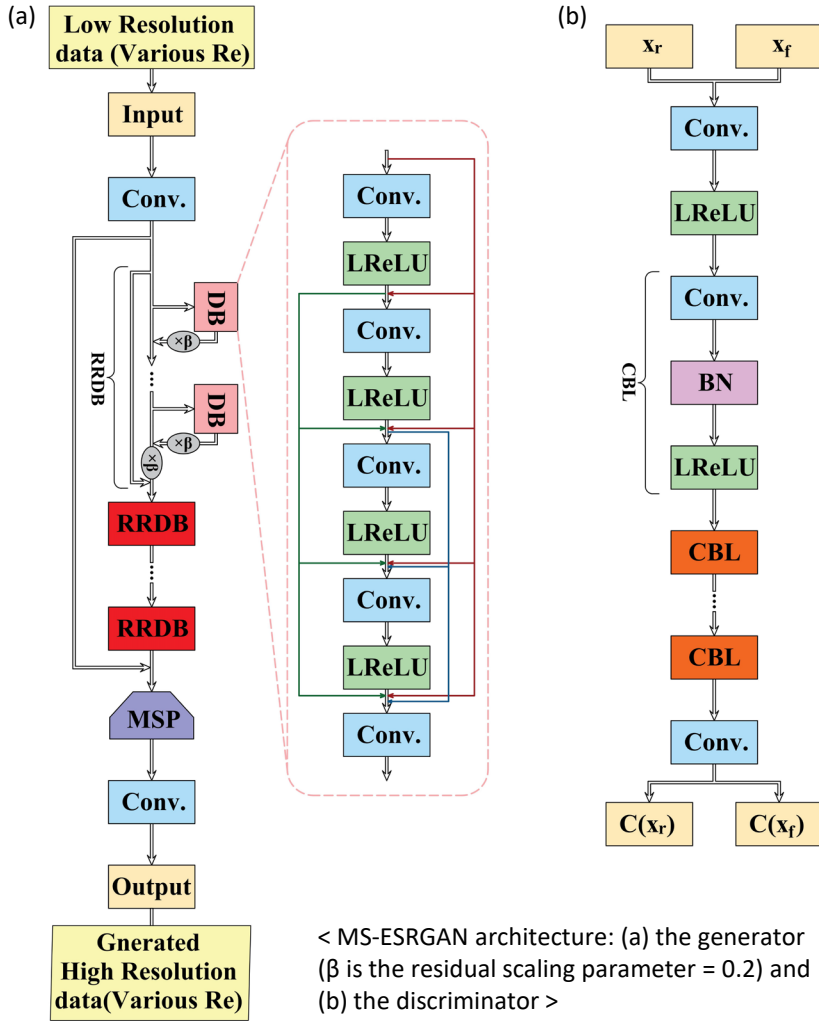


Turbulent Boundary Layer ($Re_\tau = 550$)

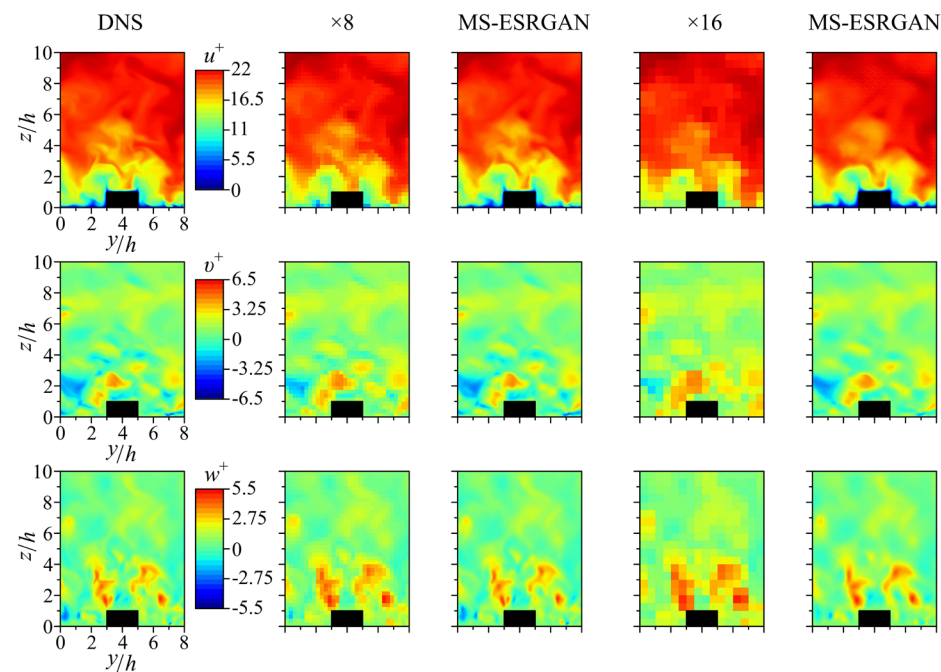
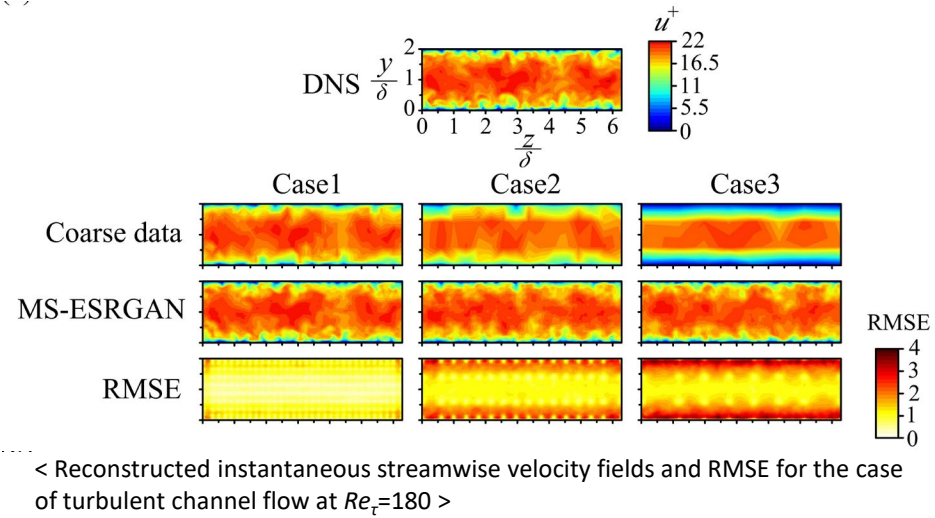


Wake flow behind a finite body

Deep learning for Super-Resolution Reconstruction of Turbulent Flows (딥러닝을 통한 고해상도 난류유동 재현)

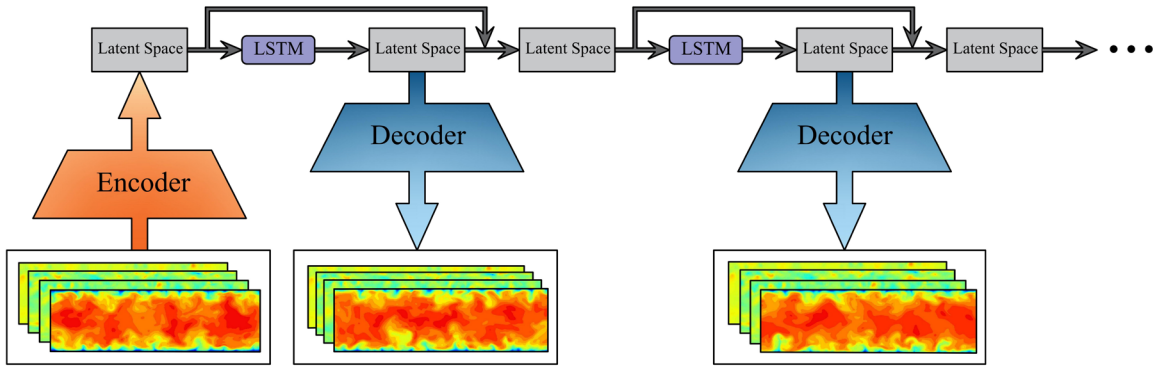


We propose a methodology for reconstructing high-resolution turbulent flow fields using Enhanced Super-Resolution Generative Adversarial Networks.



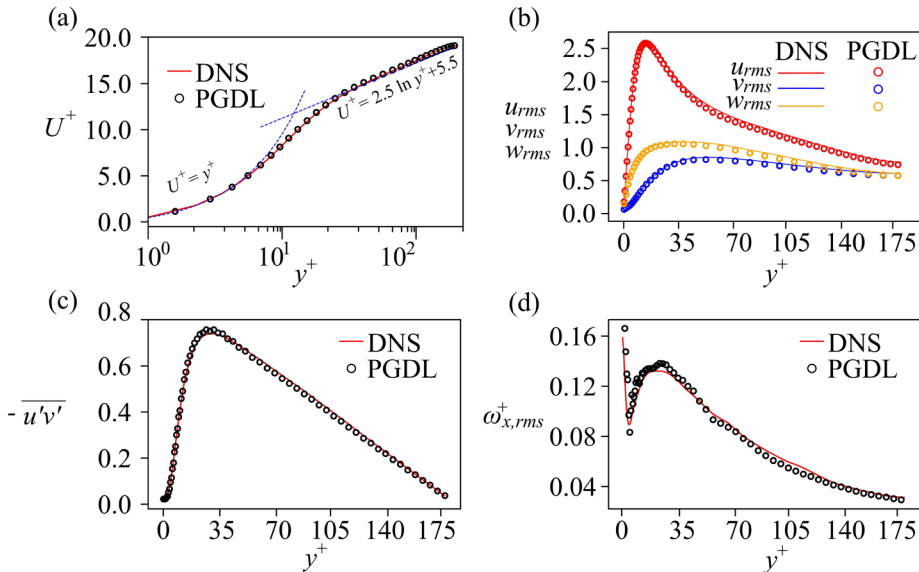
< Reconstructed instantaneous velocity fields at $Re_\tau=850$ of channel flow with large longitudinal ribs >

Physics-guided deep learning for generating turbulent inflow conditions (난류 입구조조건생성을 위한 물리정보기반 딥러닝)

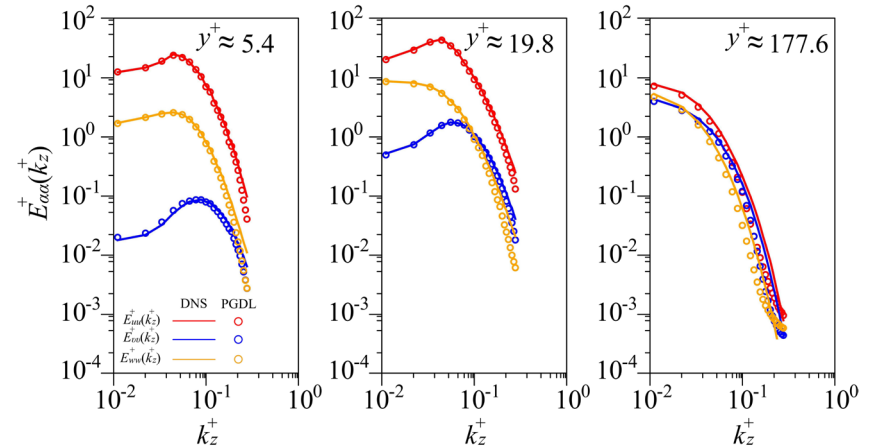


We utilise the combination of a multiscale convolutional auto-encoder with a sub-pixel convolution layer (MSC_{SP} -AE) and a long short-term memory (LSTM) model to generate turbulent inflow conditions.

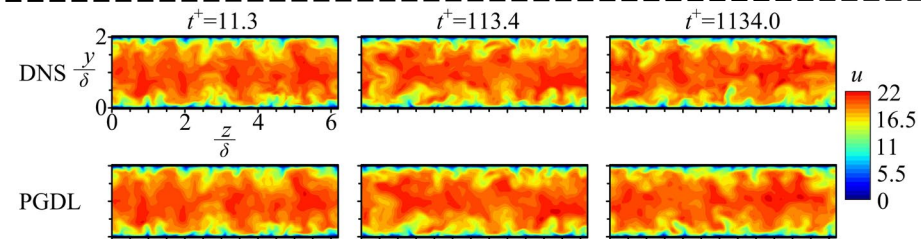
< Schematic of turbulent inflow generation using the proposed PGDL model >



< Turbulence statistics of the flow at $Re_\tau = 180$. (a) Mean streamwise velocity profile. (b) RMS profiles of the velocity components. (c) Mean Reynolds shear stress profile. (d) RMS profile of the streamwise vorticity >

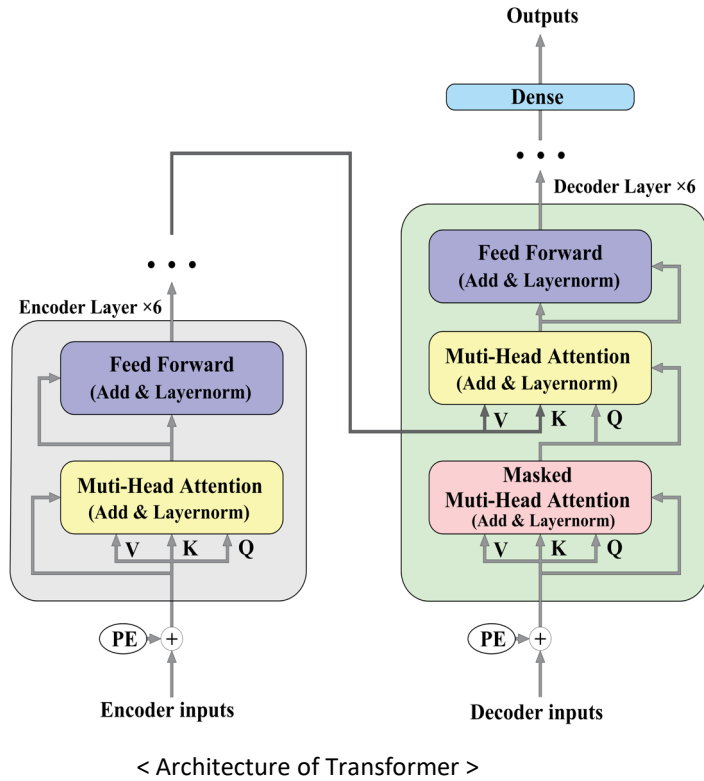


< Spanwise energy spectra for velocity components at $Re_\tau = 180$ >

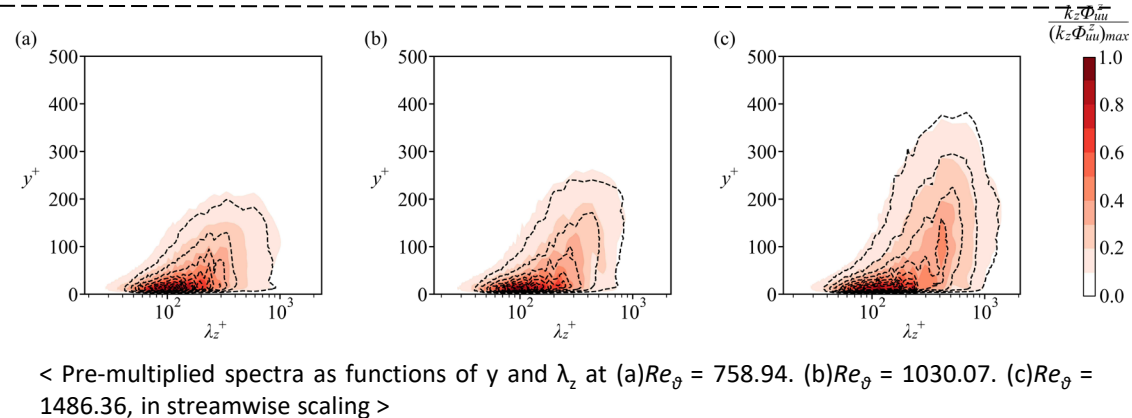
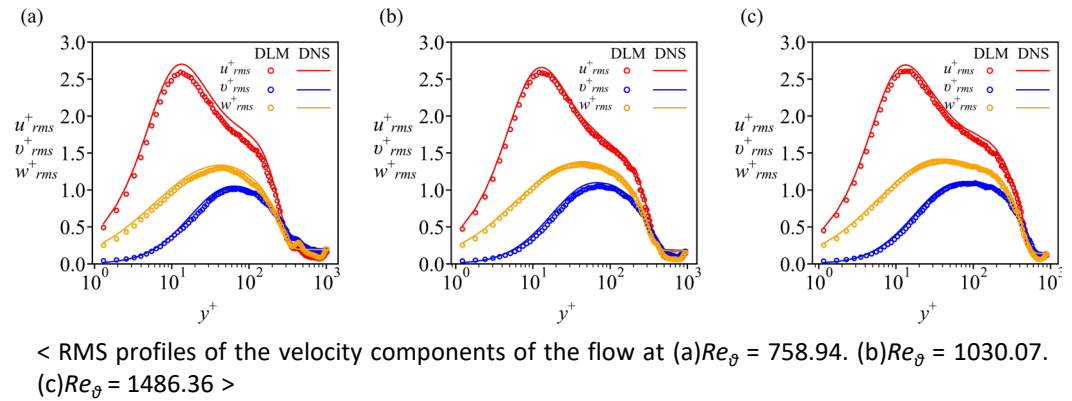
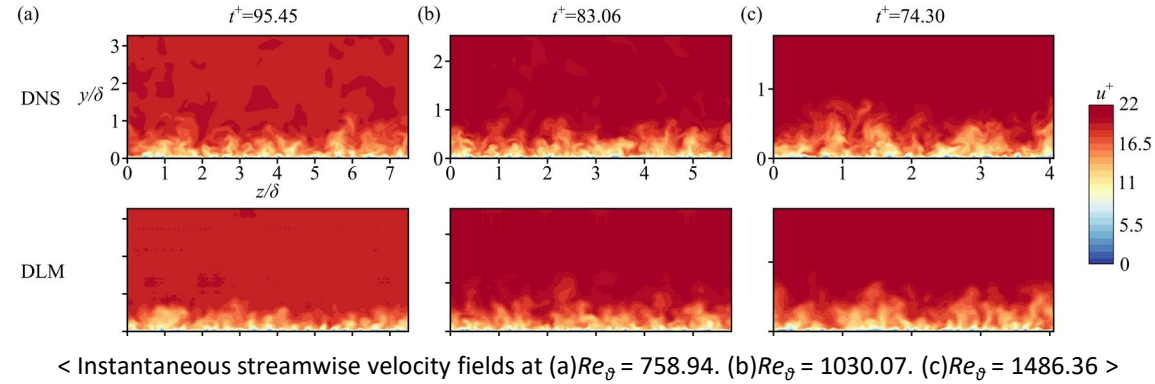


< Instantaneous streamwise velocity fields at $Re_\tau = 180$ >

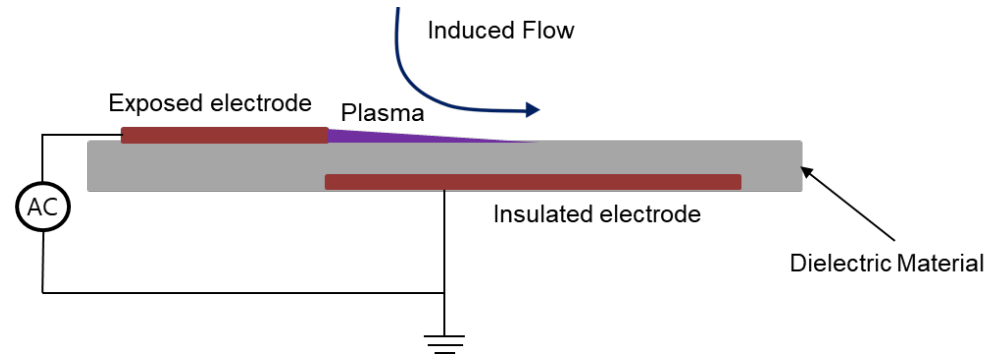
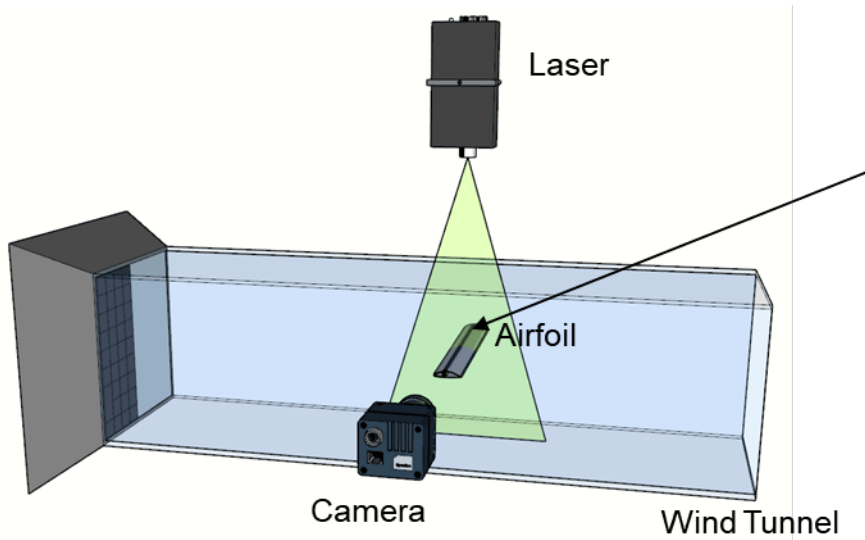
Deep-learning based Prediction of Transitional Turbulent boundary layer (딥러닝 기반 천이 난류유동 예측)



We propose a methodology for generating transition boundary layer using Deep Learning(DL) method. As for the DL model, we use a Transformer network combined with ESRGAN. The architecture of the Transformer is shown above.

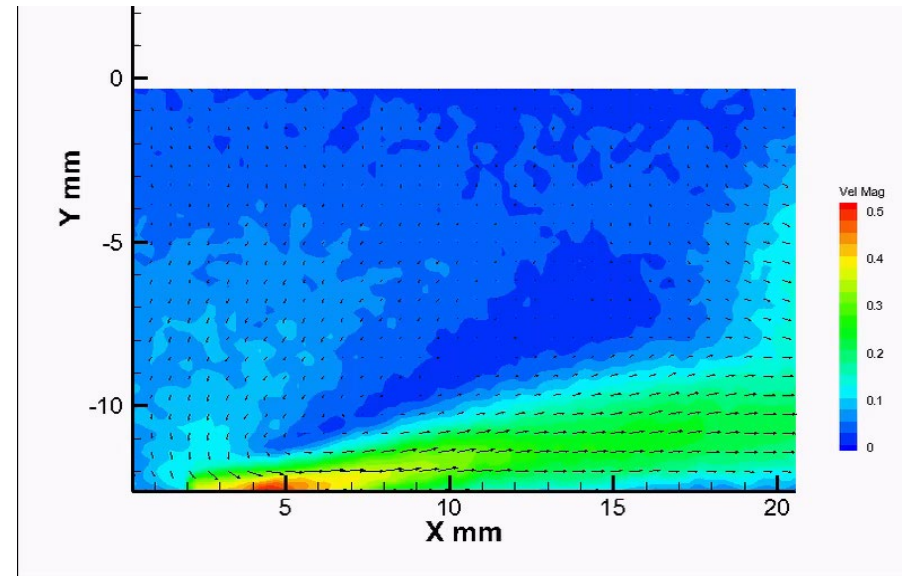


Active Flow Control, Plasma Actuator(능동유동제어, 플라즈마 액추에이터)



< Plasma Discharge >

In order to promote an in-depth understanding of the mechanism of leading-edge flow separation control over an airfoil using a Dielectric Barrier Discharge (DBD) plasma actuator excited by high voltage, an experimental investigation of an airfoil with DBD plasma actuator was performed in a closed chamber and wind tunnel.



< The flow field velocity over the plate >

Active Flow Control, Plasma Actuator(능동유동제어, 플라즈마 액추에이터)



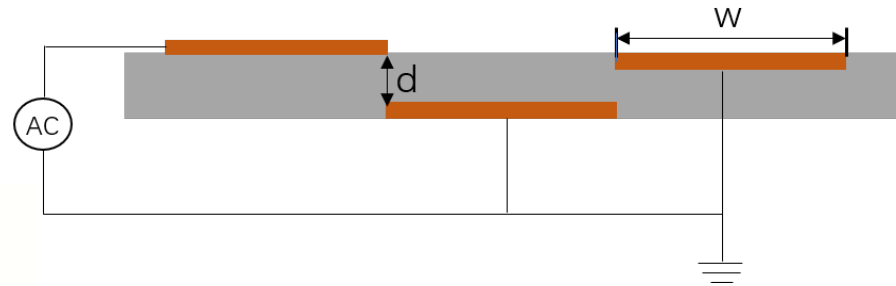
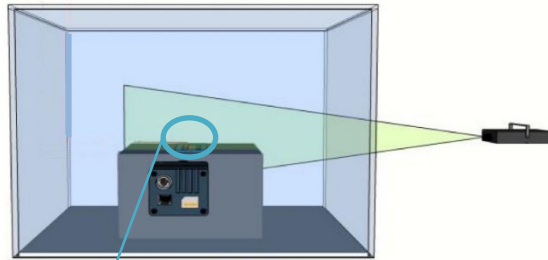
High Voltage Amplifier



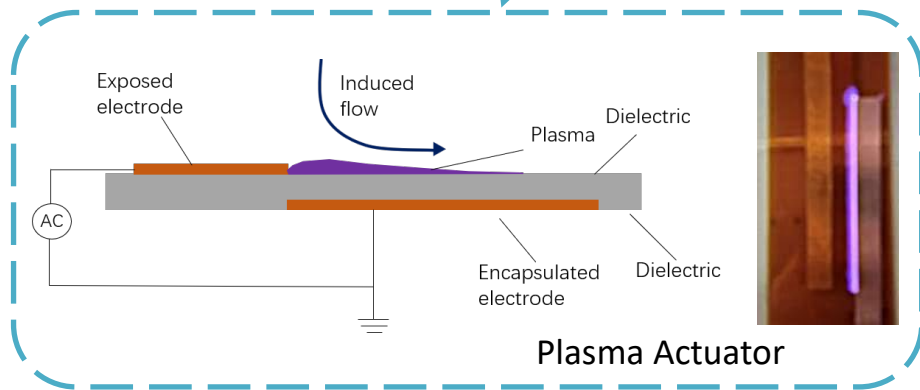
PC



Signal Generator

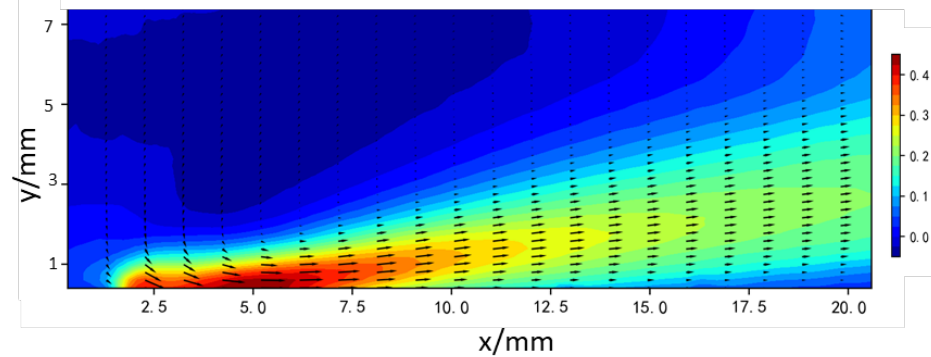


< Multiple encapsulated electrode (MEE) plasma actuator >



Plasma Actuator

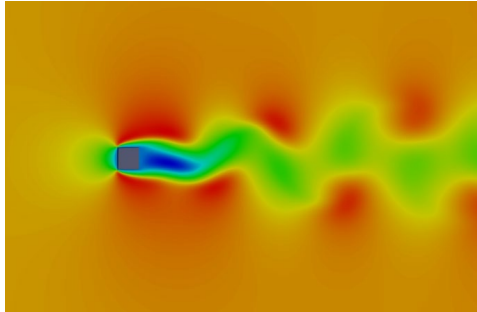
< Experiment setup >



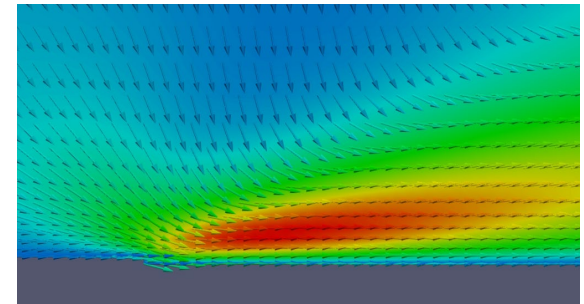
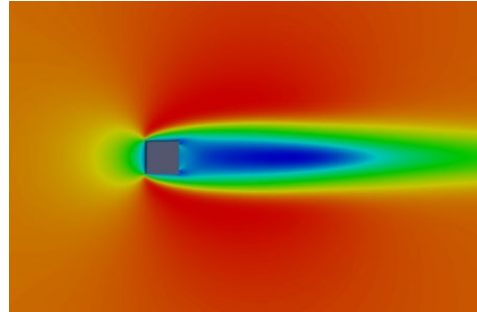
< Velocity magnitude produced by Plasma actuator in quiescent case: $V_{pp} = 10$ kV, $f = 900$ Hz >

Active Flow Control, Plasma Actuator(능동유동제어, 플라즈마 액추에이터)

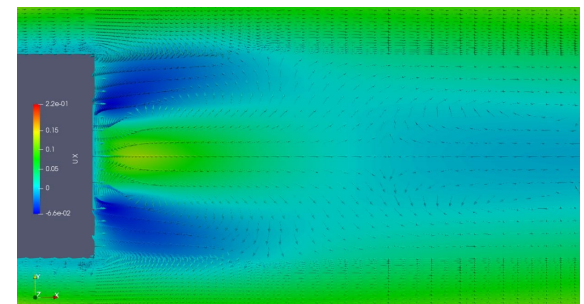
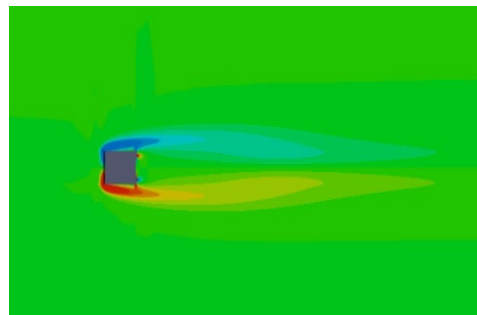
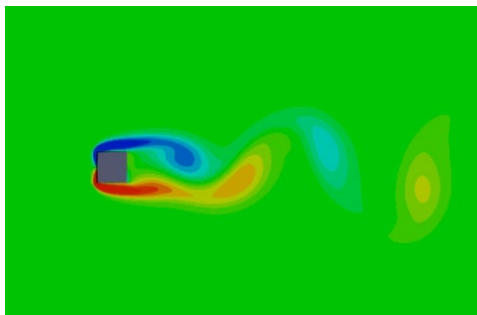
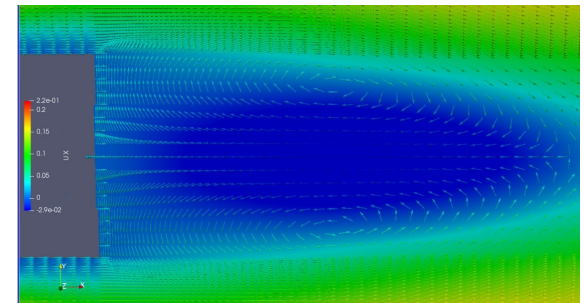
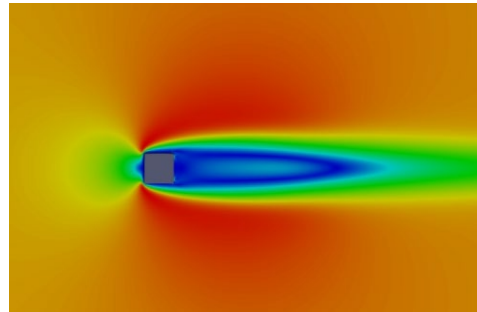
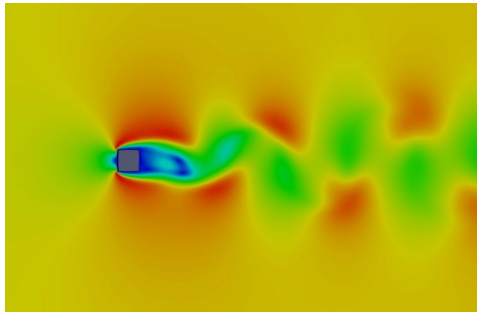
- w/o Control (제어없음)



- w Control (제어상태)



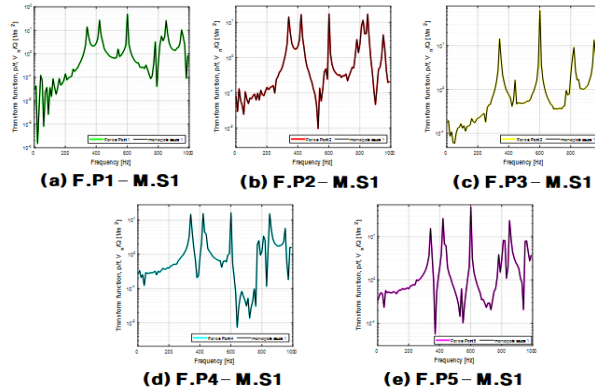
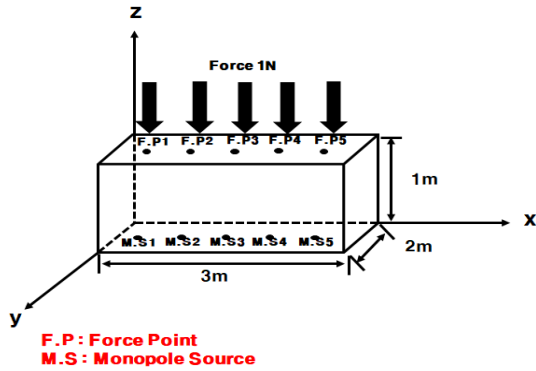
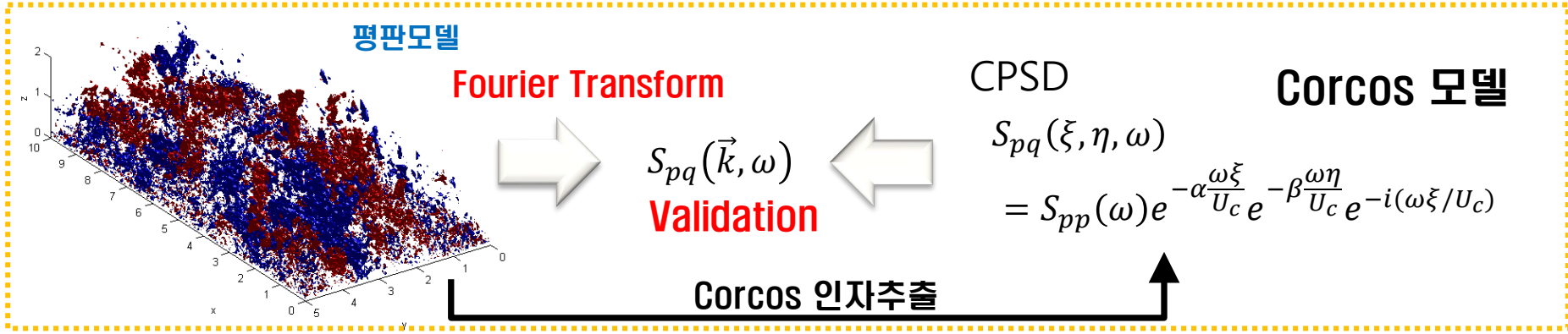
Single plasma actuator (단일 PA)



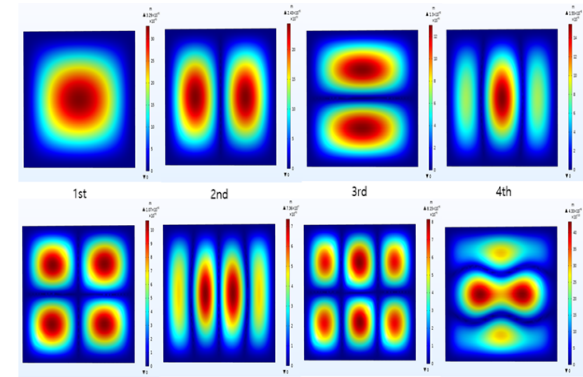
< Numerical simulation of the flow around a square cylinder with plasma actuator >

< Streamwise velocity and velocity vectors behind the square body >

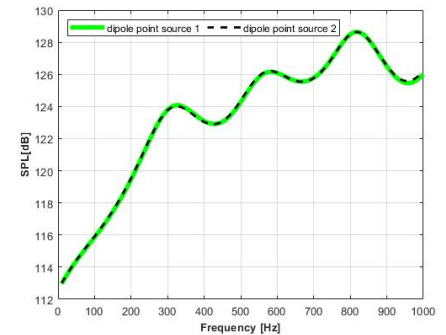
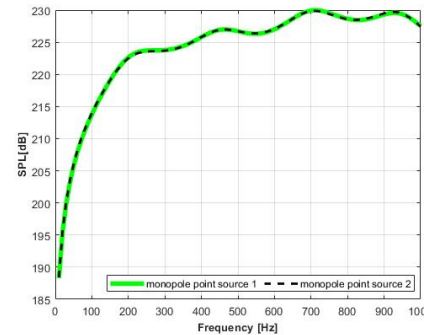
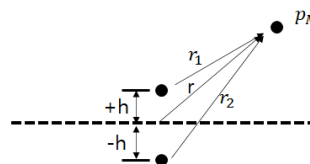
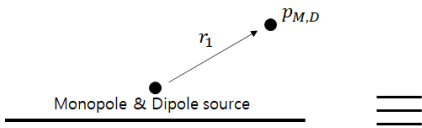
Wall Pressure fluctuation & Noise Predication (벽면변동압력 및 노이즈 예측기 법 개발)



Reciprocity principle

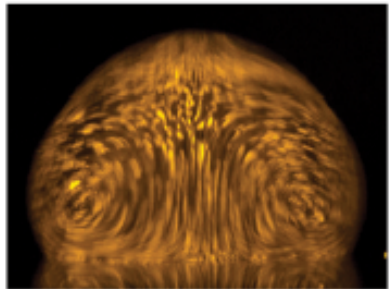
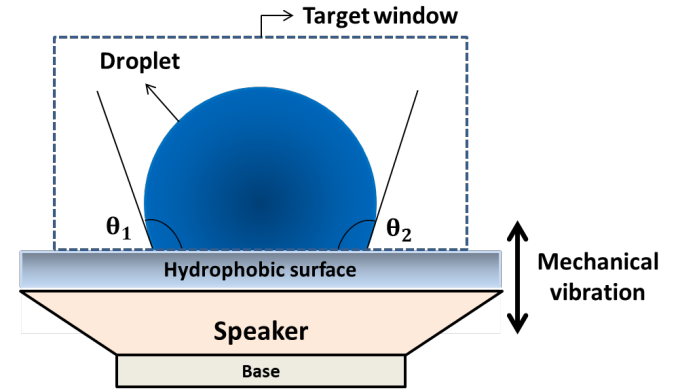
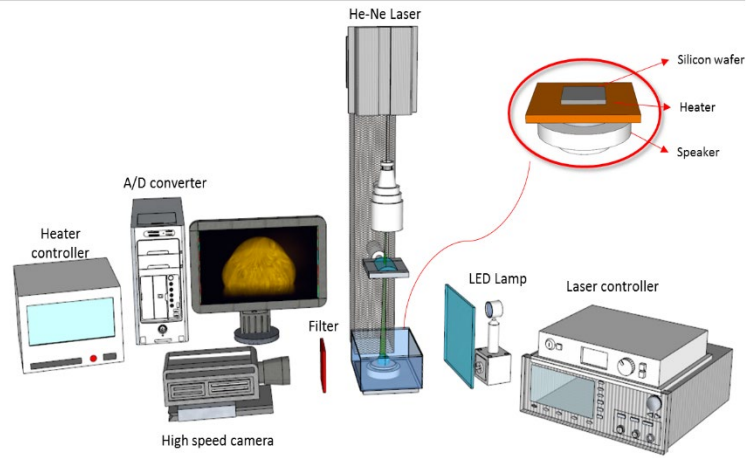


Eigenmode shape of a Rectangular Cavity Model

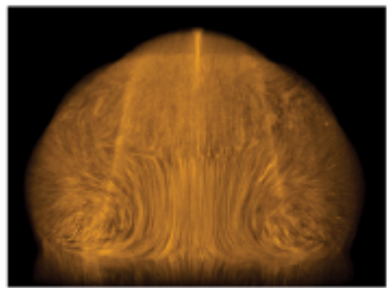


Noise Prediction

Droplets on vib surface (진동표면위 액적변동)



(a) P₂ mode (2V)



(b) P₄ mode (2V)

