

전자기기계시스템진동 및 음향설계실험실

Sound and Vibration Design of Electromagnetic-Mechanical System Lab

목표 : Multi-physics 전문가 양성



부산대학교 기계공학부
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SCHOOL OF MECHANICAL ENGINEERING



1 – Lab introduction – Lab member



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학력 및 약력

- Univ. of California at Berkeley 박사학위
취득(1994년)
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- (주) EM-TECH 창립 및 대표이사
(2001년~2012년)



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박지훈
JI
HUN
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M.S student

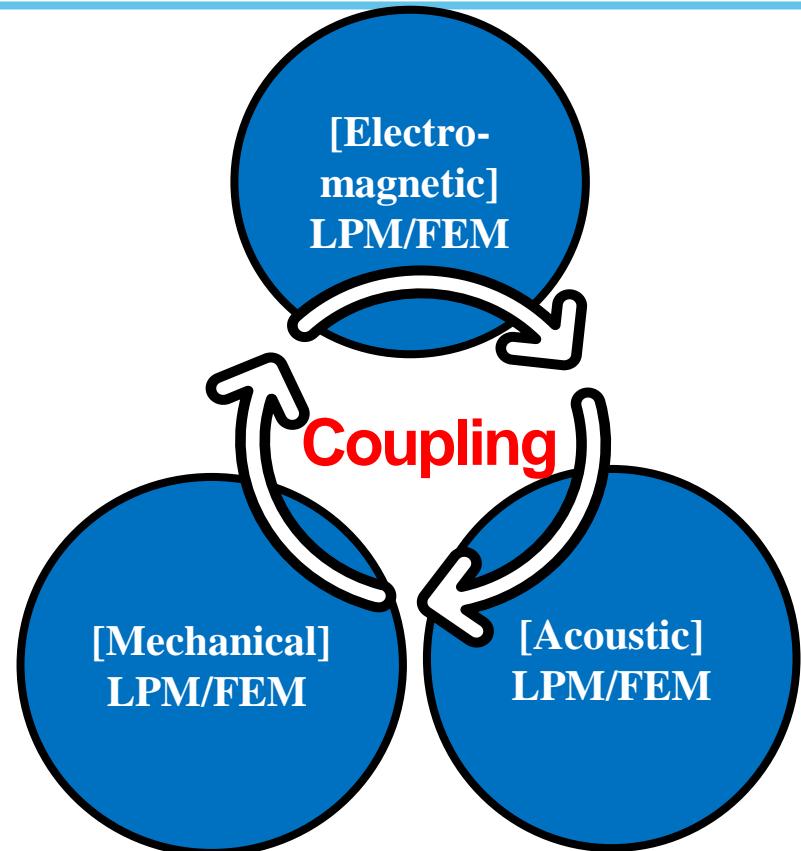


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1 – Lab introduction– Lab research project

Research method



- Electromagnetic-mechanical-acoustic coupling analysis
- Structure design of multimedia device

LPM : Lumped Parameter Method

FEM : Finite Element Method

Research project



- Actuator system



- Speaker system



- Earphone system



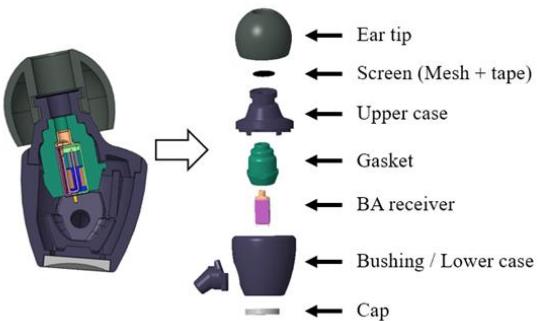
- Linear vibrator
- Vibration motor
- SoD (Sound on Display)

- Neck band passive speaker
- Microspeaker
- Zeolite

- BA driver
- Dynamic receiver
- Hybrid earphone
- 2-way earphone

1 – Lab introduction – Industrial Project (2016~)

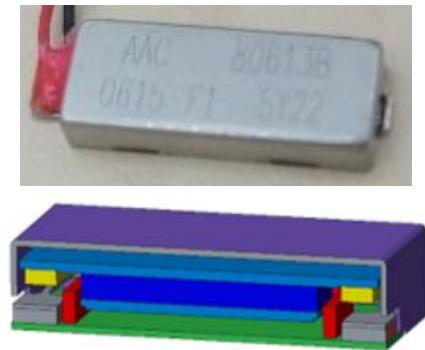
BA 및 Micro-Passive Speaker의
최적설계기법 개발
(2016~2017)



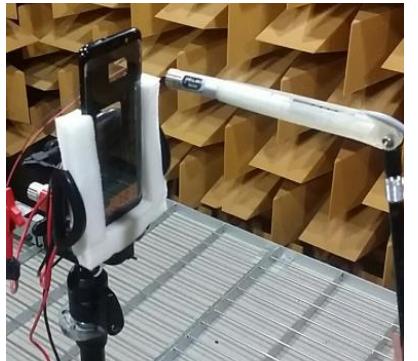
Micro-Passive Speaker의 최적설계
기법을 이용한 넥밴드형 스피커 개발
(2017~2018)



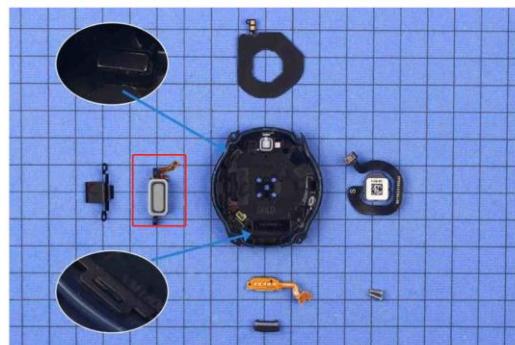
리시버와 진동모터의 역할을 동시에
수행할 수 있는 복합 부품의 개발
(2018~2019)



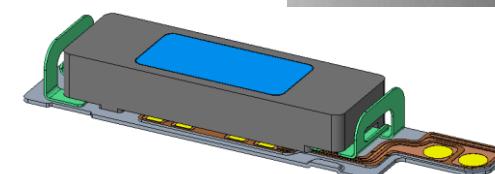
Full-Wide Screen LCD의 실현을 위한
스마트폰용 복합 부품의 개발
(2019~2020)



폭 슬림 이중 사출 LSR 웨어러블
마이크로 스피커 개발
(2020~2021)

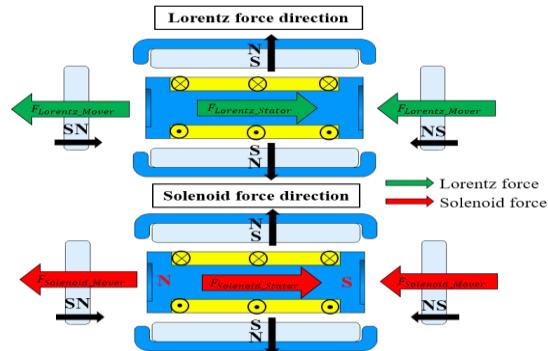
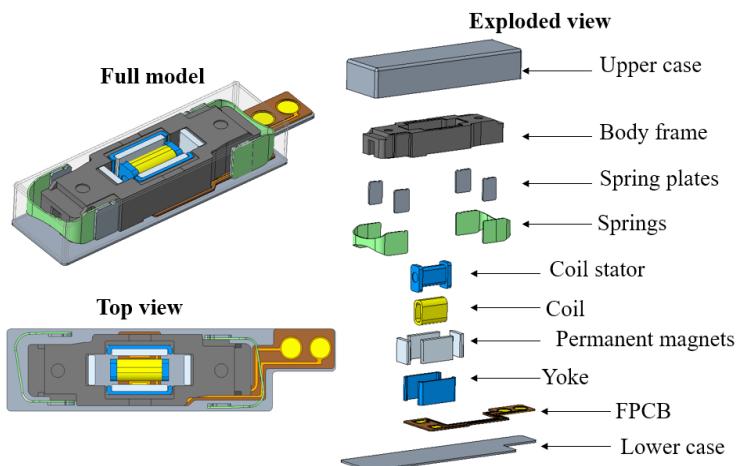


스마트폰 용 수평 진동 haptic 모터 개발
(2021~)



1 – Lab introduction– Lab research project

Vibration motor (Horizontal)



- Point
 - Horizontal vibration
 - 4 magnets
 - Designed for smartphone

Neck band speaker with passive vibrator

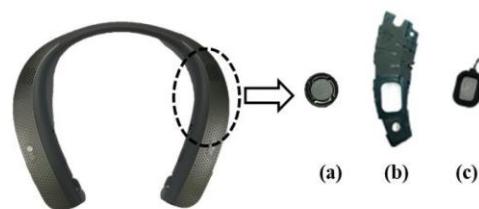
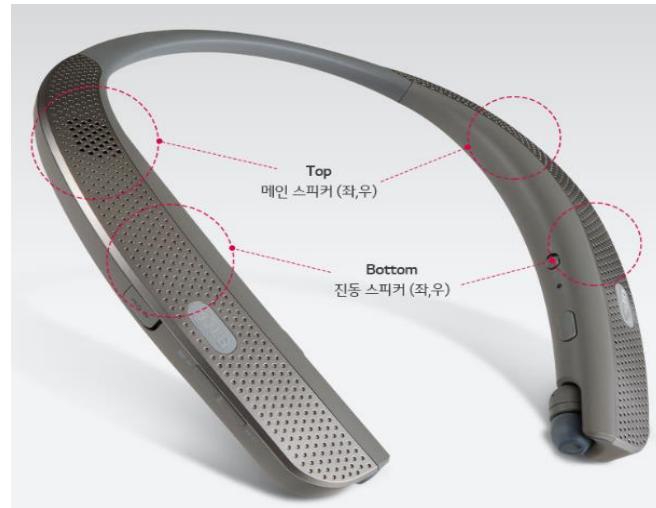
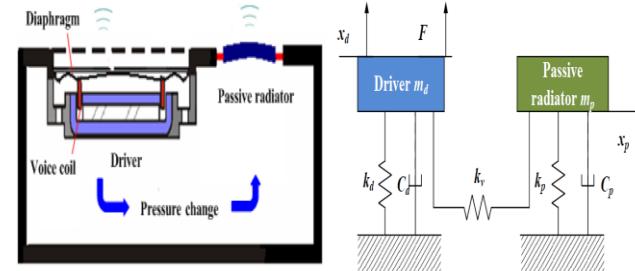


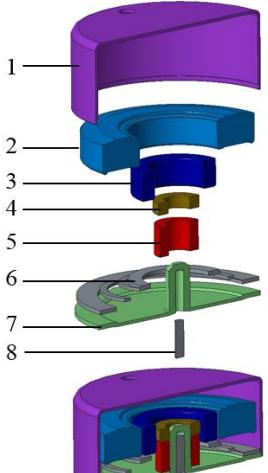
FIGURE 1. A typical neckband speaker (a) Linear vibrator, (b) speaker box, and (c) microspeaker driver.



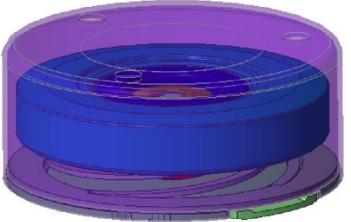
- Point
 - Passive vibration due to the air pressure force in speaker box
 - Speaker –Sound radiation
 - Passive Vibrator- Generate vibration

1 – Lab introduction– Lab research project

Vibration motor (Vertical)



(a) Exploded view of Motor



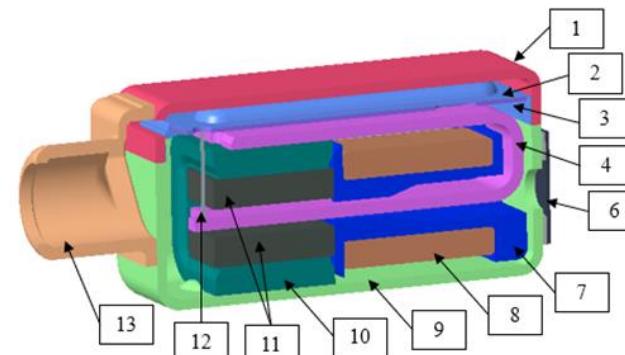
(b) Projection view of Motor

- 1. Upper Cover
- 2. Mass
- 3. Magnet
- 4. Pole Cover
- 5. Coil
- 6. Spring
- 7. Lower Cover
- 8. Shaft

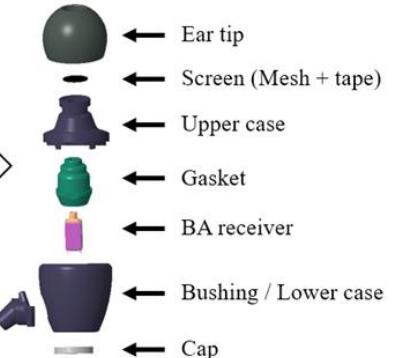
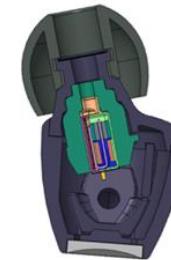


- Point
 - One set of coil and magnet
 - Simple structure

Balance Armature (BA) driver



- 1. Front cover
- 2. Side diaphragm (SDP)
- 3. Center diaphragm (CDP)
- 4. Armature
- 5. PCB
- 6. Screen
- 7. Bobbin
- 8. Voice coil
- 9. Back cover
- 10. Magnet housing
- 11. Permanent magnet (PM)
- 12. Pin
- 13. Spout



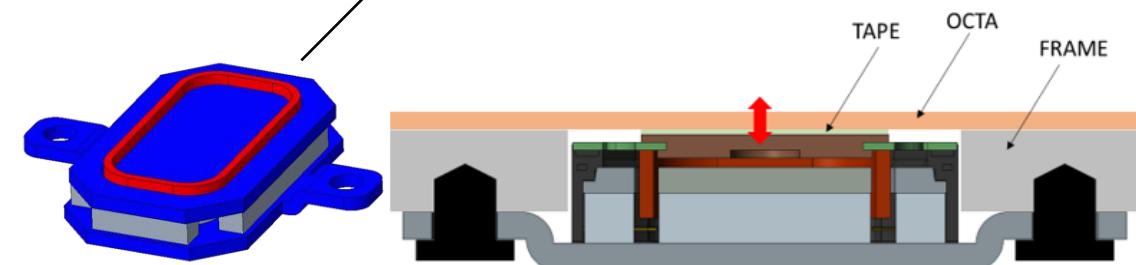
- Point
 - Armature and diaphragm vibrate due to magnetic force
 - Fast response: Rapid vibration due to small current
 - Excellent high frequency response

1 – Lab introduction– Lab research project

Sound on display: Actuator



Actuator in Display



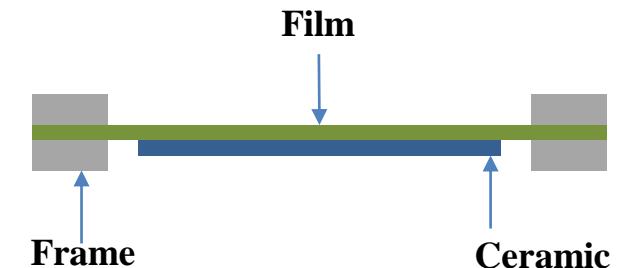
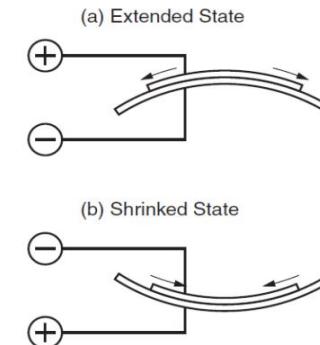
► Point

- Full-Wide Bezel-Less Display
- Dynamic receiver removed
- Screen vibration cause by actuator

Sound on display: Piezo



Piezo Actuator in Display

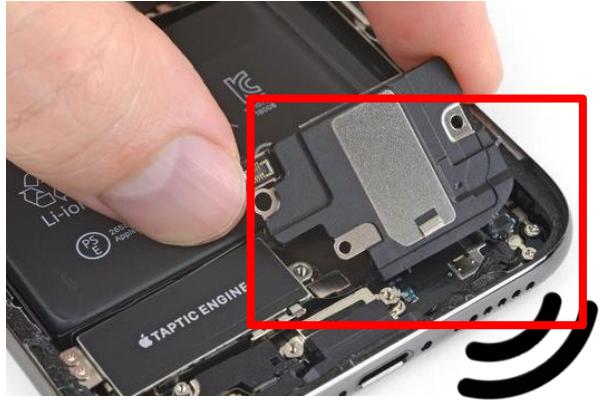


► Point

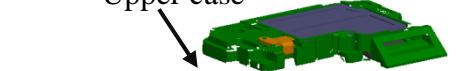
- Full-Wide Bezel-Less Display
- Dynamic receiver removed
- Screen vibration cause by piezo actuator

1 – Lab introduction– Lab research project

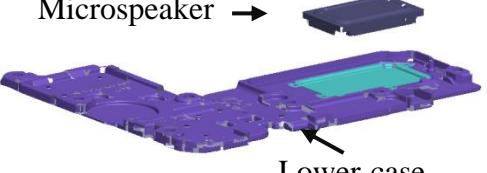
Smartphone side firing speaker module



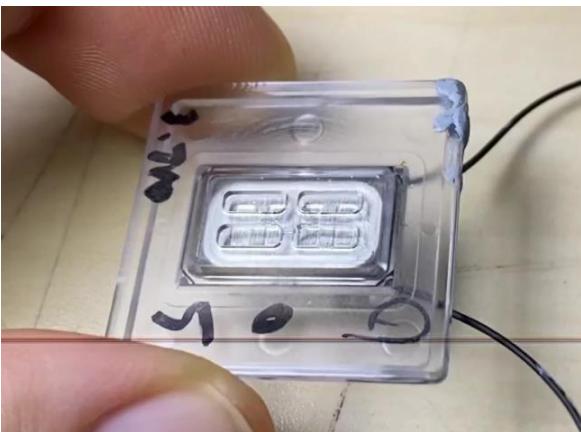
Upper case



Micspeaker



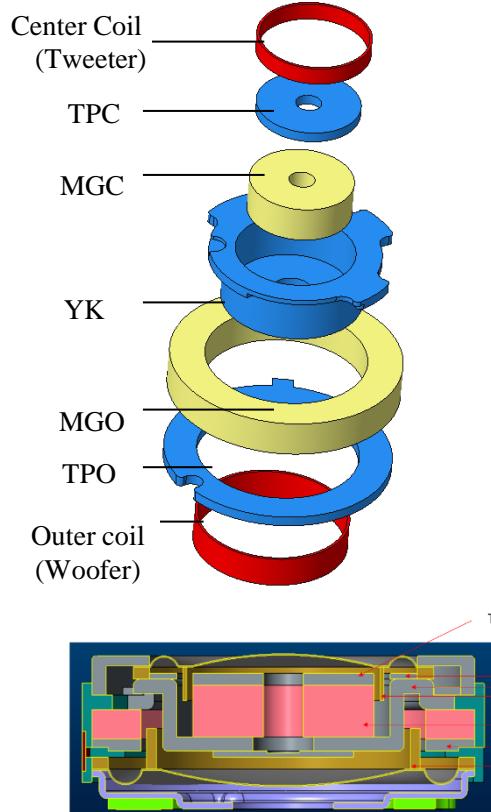
Lower case



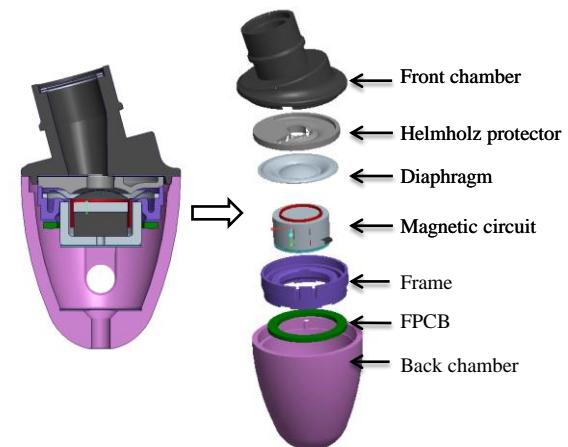
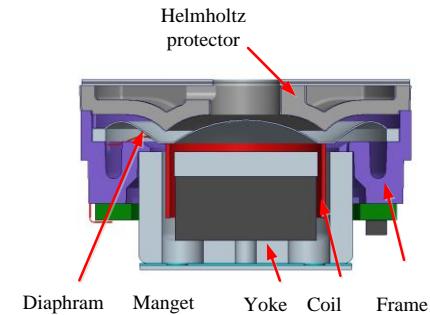
► Point

- Thickness limitation due to smartphone thickness
- Side firing speaker adopted.

Dynamic, 2-way Earphone



2-way earphone



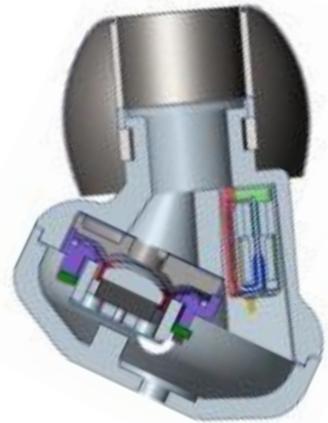
Dynamic earphone

► Point

- Coil and diaphragm vibration due to Lorenz force
- 2 way micspeaker for performance enhancement

1 – Lab introduction – Lab research project

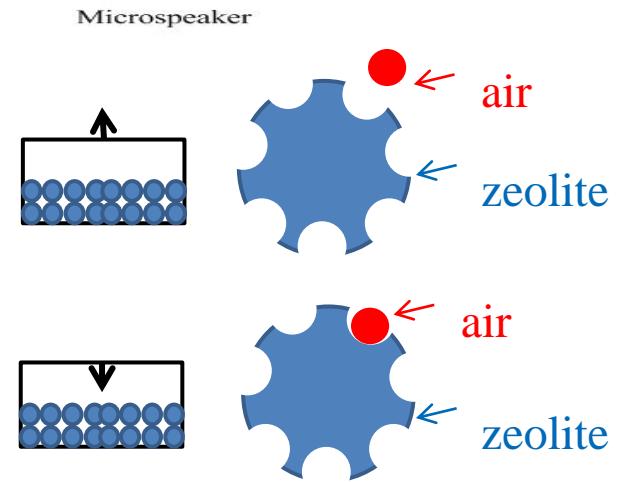
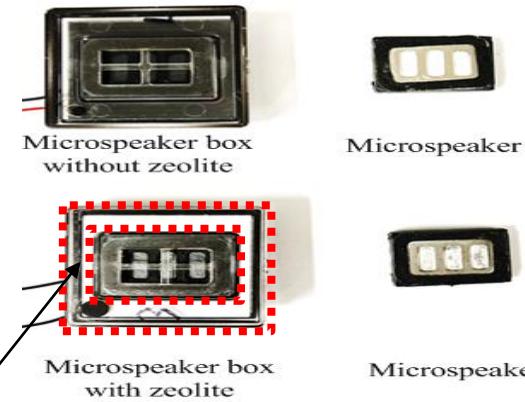
Hybrid earphone



▶ Point

- BA receiver focus on high frequency
- Dynamic receiver: Focus on low frequency
- Hybrid: Combine the advantage, better performance

Zeolite in speaker box



▶ Point

- Diaphragm compress inner air of box
→ Zeolite absorb air molecule
- Diaphragm compress outer air of box
→ Zeolite release air molecule
- Zeolite increase the back volume → Better Performance

2 – Applications

E-cigarette



Linear vibration motor



Front view Side view

Vibration motor

Smartwatch



Smartwatch speaker (5 atm)



Automobile



Linear vibration motor



Smartphone

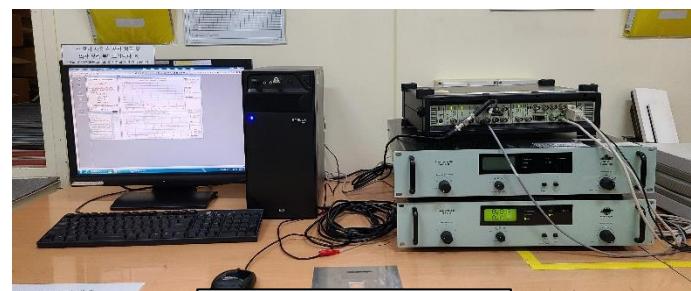
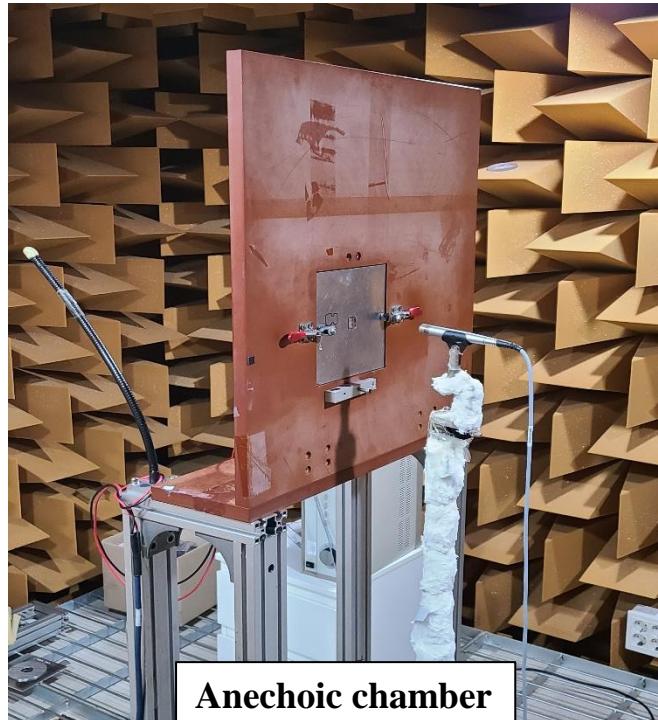


Microspeaker (top, bottom)

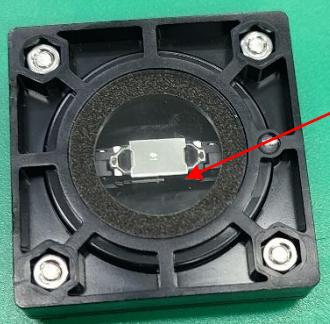


2 – Experiments

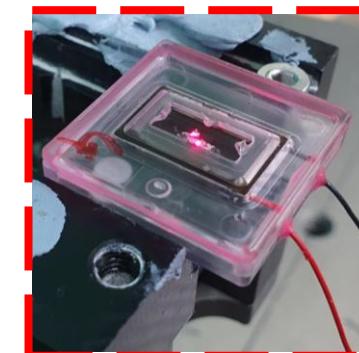
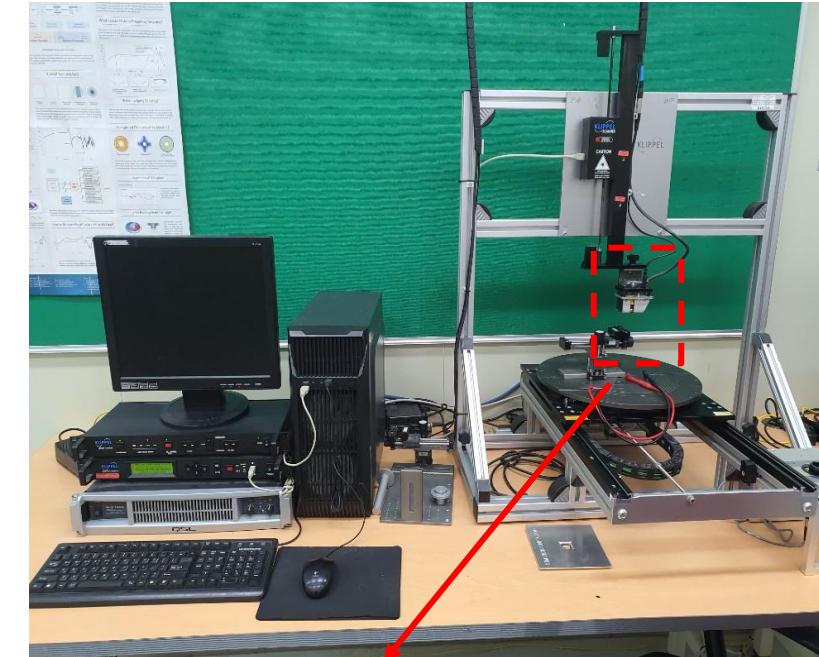
SPL Measurement



Waterproof test



Klippel

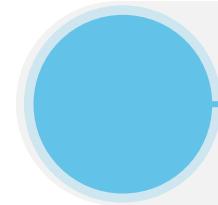


3 – Publications (2022)

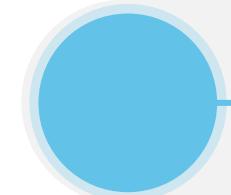
1. Y. W. Jiang, D. P. Xu, Z. X. Jiang, J. H. Kim, K. H. Park, and S. M. Hwang, "Analysis and Application of Screens for Acoustic Impedance in a Speaker Box with a Passive Radiator to Decrease Standing-Wave Influence," *Appl. Sci.*, vol. 10, no. 2, pp. 866, Jan. 2020.
2. Z. X. Jiang, K. H. Park, Y. W. Jiang, D. P. Xu, and S. M. Hwang, "Analysis and Design of a New Linear Vibration Motor Used to Reduce Magnetic Flux Leakage in In-Vehicle Infotainment," *Appl. Sci.*, vol.10, no. 10, pp. 83370, May 2020.
3. K. H. Park, Z. X. Jiang, and S. M. Hwang, "Development of Direct-Vibration Actuator for Bezel-Less Display Panels on Mobile Phones," *Appl. Sci.*, vol. 10, no 14, pp. 4975, July 2020.
4. Z. X. Jiang, K. H. Park, and S. M. Hwang, "Design and Analysis of Novel Low-Cost Linear Vibration Motor for an Electronic Cigarette," *Appl. Sci*, vol.10, no. 24, pp. 8915, Dec. 2020.
5. K. H. Park, Z. X. Jiang, and S. M. Hwang, "Design and Analysis of a Novel Microspeaker with Enhanced Low-Frequency SPL and Size Reduction," *Appl. Sci.*, vol. 10, no 24, pp. 8902, Dec. 2020.
6. Z. X. Jiang, K. H. Park, and S. M. Hwang, "Design of a Width Slim Linear Vibration Motor Used for Automotive LCD Display Panel" *IEEE Transactions on manetics.*, Vol. 1, no 1, pp.99, May. 2021.

Writing (2022~)

1. Z. X. Jiang, K. H. Park and S. M. Hwang, " Dual Coil Microspeaker with Reduced Back Volume," *IEEE Transaction on Magnetics*. 2022
2. Z. X. Jiang, J. H. Park and S. M. Hwang, "Analysis and prediction of mid-high peak frequencies for microspeaker with side firing front chamber," *CEFC Transaction on Magnetics*. 2022.
3. Z. X. Jiang, J. H. Park, D. P. Xu and S. M. Hwang, "Eleromagnetic-mechanical coupling analysis of linear haptic motor considering cogging force effect," *IEEE Transaction on Magnetics*. 2022.



Q&A



— Thank you