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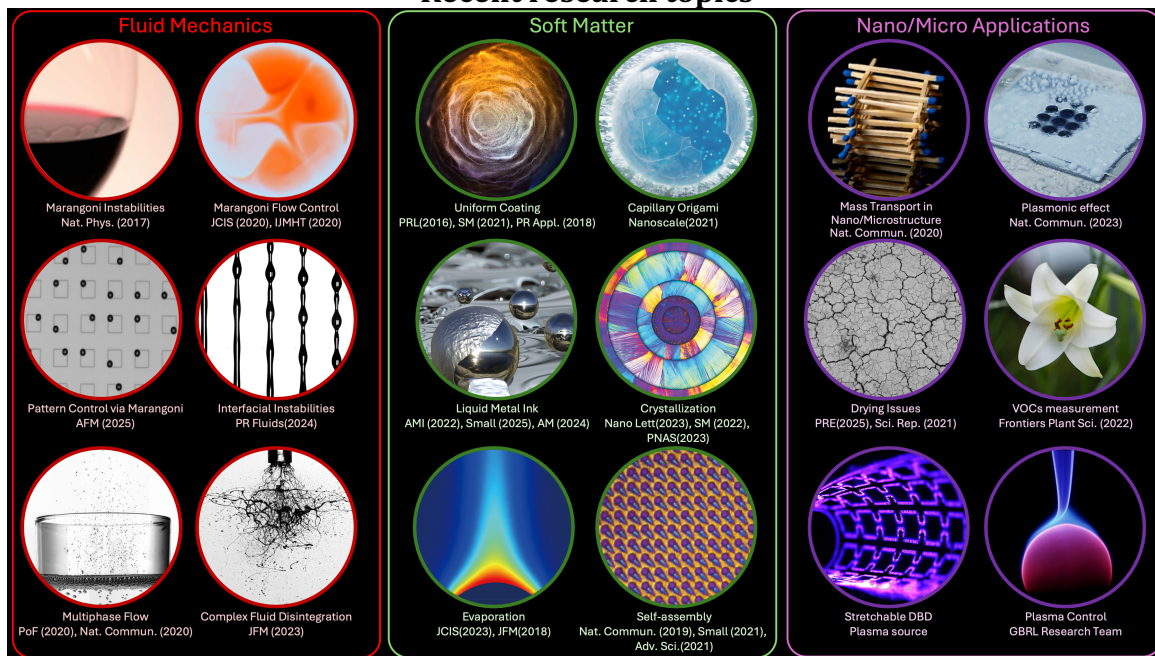
Summary of Research

My research lies at the intersection of *experimental fluid mechanics*, *soft matter hydrodynamics*, and *interfacial instabilities*, with a focus on uncovering novel physicochemical phenomena at interfaces. Using advanced optical diagnostics and custom-built setups, my group investigates multiscale interfacial dynamics of complex fluids from nano- to macro-scales.

We address both fundamental and applied problems, including controlling coffee-ring effects for uniform coatings, removing micro/nano-scale particles from surfaces, studying fluid dynamics relevant to semiconductor processes, developing conformal liquid metal coatings, and creating flexible devices for electromagnetic field modulation. We are also pioneering liquid-metal-based plasma distribution control for future metamaterial applications. Complementing experiments with scaling laws, theoretical modeling, and data-driven analysis, we aim to deepen the understanding and control of complex interfacial flow systems.

To date, I have secured over **about USD 6.7 million (KRW 9 billion) in research funding**, and I published **71 journal papers** including Nat. Phys. (1), Nat. Comm. (5), Phys. Rev. Lett. (3), Small (2), Adv. Mater. (1), ACS Nano (1), Adv. Func. Mater. (1), Adv. Sci. (1), Nano Lett. (3), PNAS (1), PRF (1), J. Fluid Mech. (7), and so on. Total citation is 2990, **H-index is 27**, and **FWCI is 1.5 in Engineering and 1.89 in Physics**.

Recent research topics



Research topic keywords: Physicochemical soft matter hydrodynamics, flow visualization, colloids and interfaces, multiphase flows, micro- and bio-fluidics, and interfacial instabilities.

Summary of Education

I have developed and taught a diverse portfolio of courses in mechanical engineering, with a strong focus on fluid dynamics and hands-on experimentation. Notably, I established two original courses: Experimental Thermo-Fluid Engineering and Interfacial Flow. Since 2017, I have delivered more than 20 undergraduate and graduate-level lectures, including Fluid Mechanics, Capstone Design, and Laboratory for Mechanical Engineering. My average lecture evaluation score is 4.36/5.0 since joining KAIST, and I received the Best Teaching Award for Experimental Thermo-Fluid Engineering in 2020 and Fluid Mechanics in 2023. Recently, I introduced a new lecture, *Sports Fluid Mechanics*, which explores fluid mechanical phenomena in various sports and integrates advanced concepts with practical applications.

In terms of graduate advising, 4 Ph.D. and 11 Master's students have completed their degrees under my supervision. I am currently advising 5 Ph.D. students, 4 Master's students, 2 undergraduate researchers, and 1 visiting international student.

To further advance educational leadership in fluid mechanics, I have recently developed a new course titled Sports Fluid Mechanics. This innovative course connects fundamental fluid dynamics to real-world sports phenomena and aims to position the curriculum at the forefront of global educational initiatives in the field. It provides an intuitive entry point to core concepts while reinforcing the practical value and interdisciplinary relevance of fluid mechanics.

Professional Experience

- Sept. 2021 – Present: **Associate Professor**, Department of Mechanical Engineering, KAIST
- Mar. 2022 – Jan. 2023: **Visiting Scholar**, School of Engineering and Applied Sciences, Harvard University
- Jan. 2019 – Present: **Editorial Advisory Board Member**, Experiments in Fluids
- Mar. 2017 – Aug. 2021: **Assistant Professor**, Department of Mechanical Engineering, KAIST
- April 2022 – Mar. 2023: **Leader of Cross-Generation Collaborative Laboratory**, KAIST
- Feb. 2013 – Feb. 2017: **Postdoctoral and Associate Research Scholar**, Department of Mechanical and Aerospace Engineering, Princeton University, in the laboratory of Professor Howard A. Stone

Education

- Ph.D., Mechanical, Maritime and Materials Engineering (Feb. 2013)
 - Delft University of Technology, Netherlands
 - Thesis: Moving Liquid Droplets with Inertia: Experiment, Simulation, and Theory (Advisor: Jerry Westerweel)
- M.S., Mechanical Engineering (Feb. 2008)
 - Korea Advanced Institute of Science and Technology, South Korea
 - Thesis: Control of Electroosmotic Flow in a Microchannel by Using Thermal Field (Advisor: Jae Min Hyun)
- B.S., Mechanical Engineering (Feb. 2006), *Summa cum laude*
 - Kumoh National Institute of Technology, South Korea

Scientific Publications

▷ Journal covers



▷ Five selected journal papers (Corresponding author underlined)

- 1) **Interfacial Instability (Theory+Experiment):** H. Kim, K. Muller, O. Shardt, S. Afkhami and H.A. Stone, "Solutal-Marangoni flows of miscible liquids drive transport without surface contamination," *Nat. Phys.* **13**, 1105–1110 (2017) [IF = 22.727, JCR Q1 (1.19%), Citation: 139]
- 2) **Metamaterials (Experiment):** J. Pyeon, S. Park, J. Kim, J.-H. Kim, Y.-J. Yoon, D.-K. Yoon, H. Kim, "Plasmonic metasurfaces of cellulose nanocrystal matrices with quadrants of aligned gold nanorods for photothermal anti-icing," *Nat. Commun.* **14**:8096 (2023) (Selected as Editors' Highlights for Materials science and chemistry and Inorganic and physical chemistry) [IF = 14.7, JCR Q1 (5.6%), Citation: 11]
- 3) **Pattern & Coating (Theory+Experiment):** J. Pyeon, K. M. Song, Y. Jung, and H. Kim, "Self-induced solutal Marangoni flows realize coffee-ring-less quantum dot microarrays with extensive geometric tunability and scalability," *Adv. Sci.* **2104519** (2022) [IF = 15.1, JCR Q1 (6.8%), Citation: 31]
- 4) **Complex Fluid Atomization regarding COVID-19 (Theory+Experiment):** B. T. Gidreka and H. Kim, "Effects of physical property changes of expelled respiratory liquid on atomization morphology," *J. Fluid Mech.* **960**, A10. (2023) (Cover) [IF = 3.6, JCR Q1 (6.2%), Citation: 6]
- 5) **Micro Flow Control (Theory):** J. Ryu, J. Kim, J. Park, and H. Kim, "Analysis of vapor-driven solutal Marangoni flows inside a sessile droplet," *Int. J. Heat Mass Transf.* **164**, 120499 (2021) [IF = 5.431, JCR Q1 (10.51%), Citation: 23]

▷ Full list of SCI/SCIE journal papers (Corresponding author underlined)

- 1) J. Ryu, C. Diddens, D. Lohse, H. Kim, "Vapour-driven solutal Marangoni flow transition across the vapour-liquid equilibrium at the droplet contact line," Accepted in *J. Fluid Mech.* (2025)
- 2) J. Pyeon, H. Lee, W. Choi, S. Park, H. Kim, "Versatile Liquid Metal Composite Inks for Printable, Durable, and Ultra-Stretchable Electronics," *Small*, **2501829** (2025) (Cover)
- 3) Y. Cho, J. Pyeon, H. Jang, G. Y. Kim, J. Kang, B.-G. Park, H. Kim, Y. S. Jung, "Roulette-Inspired Physical Unclonable Functions: Stochastic yet Deterministic Multi-bit Patterning through the Solutal Marangoni Effect," *Adv. Func. Mater.*, **2424079** (2025)
- 4) Y. Yang, C. Zhang, H. Kim, R. Chen, "Nucleation-percolation transition in clay desiccation cracking," *Phys. Rev. E* **111**, L053501 (2025)
- 5) G. Song, K. Jang, W. Song, W. Choi, S. Song, H. Kim, "Cyclone negative pressure pump for efficient purification of airborne contaminants," *Indoor Environments* **2**, 100073 (2025)
- 6) J. Ko, J. Kim, K. Ki, S. Moon, H. Jeon, J. H. Park, M. Golla, C. J. Chun, J. S. Kim, A. Lee, H. Kim, S. S. Park, T. S. Shim, and S.-J. Park, "Shape-dependent locomotion of DNA-linked magnetic nanoparticle films," *Nano Lett.* **25**(1), 419-425 (2025)
- 7) H. Jeon and H. Kim, "A single theoretical model for breakup of viscous thread with and without a fiber," *Phys Rev. Fluids* **9**, 084005 (Selected as Editor's suggestion) (2024)
- 8) T. Lee, J.-H. Kim, C. S. Ng, A. Andreu, I. Kim, W. Lee, H. Kim, P.-C. Su, Y.-J. Yoon, Prediction of curing depth

- dependence on CNT nanofiller dispersion for vat photopolymerization 3D printing, *Chemical Engineering Journal* 482(15), 149110 (2024)
- 9) D. H. Lee, T. Lim, J. Pyeon, H. Park, S.-W. Lee, S. Lee, W. Kim, M. Kim, J.-C. Lee, D.-W. Kim, S. Han, **H. Kim**, **S. Park**, **Y.-K. Choi**, "Self-mixed biphasic liquid metal composite with ultra-high stretchability and strain insensitivity for neuromorphic circuits," *Advanced Materials*, 2310956 (2024)
 - 10) J. Pyeon, S. Park, J. Kim, J.-H. Kim, Y.-J. Yoon, **D.-K. Yoon**, **H. Kim**, "Plasmonic metasurfaces of cellulose nanocrystal matrices with quadrants of aligned gold nanorods for photothermal anti-icing," *Nat. Commun.* 14:8096 (2023) (Selected as Editors' Highlights for Materials science and chemistry and Inorganic and physical chemistry)
 - 11) J. Lee, T. G. Lee, H. N. Lee, **H. Kim**, Y. K. Kang, **S. Ryu**, **H. J. Chung**, "Simple and multiplexed detection of nucleic acid targets based on fluorescent ring patterns and deep learning analysis," *ACS Appl. Mater. Interfaces* 15(47), 54335-54345
 - 12) S. Sun, N. Xue, S. Aime, **H. Kim**, J. Tang, G. H. McKinley, H. A. Stone, **D. A. Weitz**, "Anomalous crystalline ordering of particles in a viscoelastic fluid under high shear," *Proc. Natl. Acad. Sci. U.S.A.* 120(40) 2304272120 (2023)
 - 13) M. Kuk, J. Pyeon, **H. Kim**, "Vapor distribution changes evaporative flux profiles of a sessile droplet," *J Colloid Interf. Sci.* 652, 646-652 (2023)
 - 14) S.-J. Park, M.-S. Lee, M. E. Kilic, J. Ryu, H. Park, Y. I. Park, **H. Kim**, **K.-R. Lee**, **J.-H. Lee**, "Autonomous Interfacial Assembly of Polymer Nanofilms via Surfactant-Regulated Marangoni Instability," *Nano Lett.* 23(11), 4822-4829 (2023)
 - 15) G. Ryu, **I. Park**, **H. Kim**, "Liquid metal micro- and nanodroplets: Characteristics, fabrication techniques, and applications," *ACS Omega* (2023) (Cover)
 - 16) B. T. Gidreka and **H. Kim**, "Effects of physical property changes of expelled respiratory liquid on atomization morphology," *J. Fluid Mech.* 960, A10. (2023) (Cover)
 - 17) **H. Kim**, "Multiple Marangoni flows in a binary mixture sessile droplet," *Phys. Fluids.* 34(12) 122102-1 (2022)
 - 18) A. Yarin, I.V. Roisman, **H. Kim**, and **C. Tropea**, "Topical Collection 'complex interactions with droplets,'" *Exp. Fluids*, 63(5), 1-2 (2022)
 - 19) K. Park, J. Pyeon, S.H. Jeong, Y.-J. Yoon, and **H. Kim**, "Avalanche coalescence of liquid metal particles for uniform flexible and stretchable electrodes," *Adv. Mater. Interfaces* 9(35), 2201693 (2022)
 - 20) J. Ryu, G. Lee, W. Lee, J. Yoon, **N. Koo**, and **H. Kim**, "Volatile vapor knife of immersion lithography hood using solutal Marangoni effect," *J. Vac. Sci. Technol. B* 40(5) (2022) (Selected as Editor's Pick)
 - 21) J. Pyeon, S. M. Park, D. K. Yoon, and **H. Kim**, "Controlled nucleation in evaporative crystallization using confined-vapor driven solutal Marangoni effect," *Soft Matter* 21(18) 4067-4076 (2022) (Cover)
 - 22) J.-H. Jeong, K. Park, **H. Kim**, I. Park, J. Choi, and **S. S. Lee**, "Multiplexed electrospray of water in the cone jet mode using UV embossed pyramidal micro-nozzle film," *Microsystems & Nanoengineering* 8(110) (2022)
 - 23) G. Ryu, K. Park, and **H. Kim**, "Interfacial properties of liquid metal immersed in various liquids," *J Colloid Interf. Sci.* 621, 285-294 (2022)
 - 24) J. Lee, H. Kim, **H. Kim**, T. Lee, J.-H. Kim, A. Anderu, S. Kim, and **Y.-J. Yoon**, "Average accumulated normalized (A-AND) predicts ultimate tensile strength and elastic modulus of photopolymer printed by vat photopolymerization," *Addit. Manuf.* 55 102799 (2022)
 - 25) **H. Kim**, G. Lee, J. Song, and **S.-G. Kim**, "Real-time visualization of scent accumulation reveals the frequency of floral scent emissions," *Frontiers in Plant Science* 13 835305 (2022)
 - 26) J. Ryu, **H. S. Ko**, and **H. Kim**, "Vapor adsorption and Marangoni flows in evaporating drops," *Langmuir* 38, 7, 2185-2191 (2022) (Selected as a cover)
 - 27) J. Pyeon, K. M. Song, Y. Jung, and **H. Kim**, "Self-induced solutal Marangoni flows realize coffee-ring-less quantum dot microarrays with extensive geometric tunability and scalability," *Adv. Sci.* 2104519 (2022)

- 28) J. Y. Kim, M. Goncalves, N. Jung, **H. Kim** and **B. M. Woen**, "Evaporation and deposition of inclined colloidal droplets," *Sci. Rep.* 11(1), 1-9 (2021)
- 29) K. Park and **H. Kim**, "Crystal capillary origami capsule with self-assembled nanostructures," *Nanoscale* 13(35), 14656-14665 (2021) (Cover)
- 30) J. H. Lee, S. Kim, J. Kim, **H. Kim** and **H.-Y. Kim**, "From an elongated cavity to funnel by the impact of a drop train," *J. Fluid Mech.* 921, A8-1 (2021) (Highlighted in Focus on Fluids)
- 31) S.M. Park, W.-G. Kim, J. Kim, E.-J. Choi, **H. Kim**, J.-W. Oh, and **D. K. Yoon**, "Fabrication of chiral M13 bacteriophage film by evaporation induced self-assembly," *Small*, 2008097, 1-11 (2021)
- 32) S. H. Lim, S. Y. On, **H. Kim**, Y. H. Bang, and **S. S. Kim**, "Resin impregnation and interfacial adhesion behaviors in carbon fiber/epoxy composites: Effects of polymer slip and normalized surface free energy with respect to the sizing agents," *Composite Part A.* 146, 106424 (2021)
- 33) J. Kim, J. Ahn, and **H. Kim**, "Characterization of vortical structures in T-shaped branch depending on shear-thinning," *Phys. Fluids.* 33(3), 033107 (2021)
- 34) J. Pyeon and **H. Kim**, "Controlling uniform patterns by evaporation of multi-component liquid droplets in a confined geometry," *Soft Matter.* 17(13), 3578-3585 (2021) (Invited to be featured in the 2021 *Soft Matter Emerging Investigators* issue and backside cover)
- 35) J. Ryu, J. Kim, J. Park, and **H. Kim**, "Analysis of vapor-driven solutal Marangoni flows inside a sessile droplet," *Int. J. Heat Mass Transf.* 164, 120499 (2020)
- 36) Y. Lee, Y. Kim, and **H. Kim**, "Symmetry breaking of Worthington jets by gradients in liquid pool depth," *Phys. Fluids.* 32(11), 112104 (2020)
- 37) M. J. Han, J. Kim, B. Kim, S. M. Park, B. Kim, **H. Kim**, and **D. K. Yoon**, "Orientation control of semiconducting polymer using microchannel molds," *ACS Nano*, 14(10), 12951-12961 (2020)
- 38) **E. Um**, M. Kim, **H. Kim**, J. H. Kang, H. A. Stone, and **J. Jeong**, "Phase synchronized breakup of droplets from hydrodynamically coupled fluid interfaces," *Nat. Comm.* 11(1), 1-11 (2020)
- 39) Y. J. Kim, A. Kim, J. M. Kim, D. Lim, K. H. Chae, E. N. Cho, H. J. Han, K. U. Jeon, M. Kim, G. H. Lee, G. R. Lee, H. S. Ahn, H. S. Park, **H. Kim**, J. Y. Kim, and **Y. S. Jung**, "Highly efficient oxygen evolution reaction via facile bubble transport realized by three-dimensionally stack-printed catalysts," *Nat. Comm.* 11(1), 1-11 (2020)
- 40) **H. Kim**, N. Belmiloud, and P. W. Mertens, "Non-uniformly receding contact line breaks axisymmetric flow patterns," *Eur. Phys. J-Spec. Top.* 229(10), 1771-11784 (2020) [Invited paper]
- 41) Y. Jo, H. Kim, J. Lee, C. Lee, H. Hugonnet, Y. Park, X. Liu, Y.-T. Chang, **H. Kim**, and **P. Kim**, "Fluid-matrix interface triggers a heterogeneous activation of macrophages," *ACS Applied Bio Mater.* 3(7), 4294-4301 (2020)
- 42) J.-H. Jeong, H. Choi, K. Park, **H. Kim**, J. Choi, I. Park, and **S. S. Lee**, "Polymer micro-atomizer for water electrospray in the cone jet mode," *Polymer*, 141, 122405 (2020)
- 43) J. Park*, J. Ryu*, H.J. Sung, and **H. Kim**, "Control of solutal Marangoni-driven vortical flows and enhancement of mixing efficiency," *J Colloid Interface Sci.*, 561, 408-415 (2020)
- 44) Y.H. Gim, D.G. Son, **H. Kim**, and **H.S. Ko**, "Three-dimensional particle tracking velocimetry using shallow neural network for real-time analysis," *Exp. Fluids*, 61(2), 1-8 (2020)
- 45) Y.J. Cha, S.M. Park; **H. Kim**, and **D.K. Yoon**, "Microstructure arrays of DNA using topographic control," *Nat. Comm.* 10 (2019)
- 46) M. S. Abbasi, R. Song, S. M. Kim, **H. Kim**, and **J. Lee**, "Mono-emulsion droplet stretching under direct current electric field," *Soft Matter* 15, 2292 (2019) (Cover)
- 47) M.S. Abbasi, R. Song, **H. Kim**, and **J. Lee**, "Multimodal break-up of double emulsion droplet," *Soft Matter* 15, 2328 (2019)
- 48) S.Y. Lee, **H. Kim**, S.H. Kim, and **H.A. Stone**, "Uniform coating of self-assembled noniridescent colloidal nanostructures using the Marangoni effect and polymers," *Phys. Rev. Applied* 10(5), 054003 (2018)
- 49) **H. Kim** and H.A. Stone, "Direct measurement of selective evaporation of binary mixture droplets by dissolving materials," *J. Fluid Mech* 850(10), 769 (2018) (Highlighted in Focus on Fluids)

- 50) J. Park, G. Destgeer, **H. Kim**, Y. Cho, and H.J. Sung, "In-droplet micro particle washing and enrichment using surface acoustic wave-driven acoustic radiation force," *Lab Chip* **18**(19), 2936 (2018) (*Selected as a backside cover*)
- 51) P. Min, P. Kaneelil, **H. Kim**, and Y. Sun, "Contact line instability caused by air rim formation under nonsplashing droplets," *Langmuir* **34**(17), 4962 (2018)
- 52) A. K. Grosskopf, R. L. Truby, **H. Kim**, A. Perazzo, J. A. Lewis, and H. A. Stone, "Viscoplastic matrix materials for embedded 3D printing," *ACS Appl. Mater. Interfaces* **10**(27), 23353 (2018)
- 53) E. Turkoz, A. Perazzo, **H. Kim**, H.A. Stone, and C.B. Arnold, "Impulsively induced jets from viscoelastic films for high-resolution printing," *Phys. Rev. Lett.* **120** 074501 (2018).
- 54) N. Xue, S. Khodaparast, L. Zhu, J. Nunes, **H. Kim**, and H.A. Stone, "Laboratory layered latte," *Nat. Comm.* **8**(1), 1960 (2017)
- 55) **H. Kim**, K. Muller, O. Shardt, S. Afkhami and H.A. Stone, "Solutal-Marangoni flows of miscible liquids drive transport without surface contamination," *Nat. Phys.* **13**, 1105–1110 (2017)
- 56) D.-O. Kim, M. Pack, H. Hu, **H. Kim**, and Y. Sun, "Deposition of colloidal drops containing ellipsoidal particles: competition between capillary and hydrodynamic forces," *Langmuir* **32**(45), 11899 (2016)
- 57) J. Feng, M. Muradoglu, **H. Kim**, J. T. Ault, and H. A. Stone, "Dynamics of a bubble bouncing at a liquid-liquid-gas interface," *J. Fluid Mech.* **807**, 324 (2016)
- 58) P.D. Howell*, **H. Kim***, M.G. Popova, and H. A. Stone, "Rivulet flow over a flexible beam," *J. Fluid Mech.* **796**, 285 (2016)
- 59) **H. Kim**, F. Boulogne, E. Um, I. Jacobi, E. Button, and H. A. Stone, "Controlled uniform coating induced by the interplay of Marangoni flows and surface-adsorbed macromolecules," *Phys. Rev. Lett.* **116**, 124501 (2016) (*Selected as a cover and PRL Editors' Suggestion and highlighted in Physics, Nature Physics, The New York Times, and Chosun Ilbo*)
- 60) Y. L. Kong, F. Boulogne, **H. Kim**, J. Nunes, J. Feng, and H. A. Stone, "Deposition of quantum dots in a capillary tube," *Langmuir* **31**(45), 12560 (2015)
- 61) Z. Zheng, **H. Kim**, and H. A. Stone, "Control viscous fingering using time-dependent strategies," *Phys. Rev. Lett.* **115**, 174501 (2015)
- 62) **H. Kim**, J. Lee, T.-H. Kim, and H.-Y. Kim, "Spontaneous Marangoni mixing of miscible liquids at a liquid-liquid-air interface," *Langmuir* **31**(31), 8726 (2015)
- 63) **H. Kim**, Z. Zheng, and H. A. Stone, "Noncircular stable displacement patterns in a meshed porous layer," *Langmuir* **31**(20), 5684 (2015)
- 64) **H. Kim**, C. Poelma, G. Ooms, and J. Westerweel, "Experimental and theoretical study of dewetting corner flow," *J. Fluid Mech.* **762**, 393 (2015)
- 65) Y. L. Kong, I. Tamargo, **H. Kim**, T.-W. Koh, B. N. Johnson, M. K. Gupta, H.-A. Chin, D. A. Steingart, B. P. Rand, and M.C. McAlpine, "3D Printed quantum dots LED," *Nano Lett.* **14**(12), 7017 (2014) (*Highlighted in Nature Research Highlights, Nature News + Views*)
- 66) Y. Pang, **H. Kim**, Z. Liu, and H. A. Stone, "A soft microchannel decreases polydispersity of droplet generation," *Lab Chips* **14**, 4029 (2014)
- 67) P. H. Trinh, **H. Kim**, N. Hammoud, P. D. Howell, S. J. Chapman, and H. A. Stone, "Curvature suppresses the Rayleigh-Taylor instability," *Phys. Fluids* **16**(5), 051704 (2014)
- 68) **H. Kim**, J. Westerweel, and G. E. Elsinga, "Comparison of Tomo-PIV and 3D-PTV for microfluidic flows," *Meas. Sci. Technol.* **24**(2), 024007 (2012)
- 69) **H. Kim**, S. Große, G. E. Elsinga, and J. Westerweel, "Full 3D-3C velocity measurement inside a liquid immersion droplet," *Exp. Fluids* **51**(2), 395-405 (2011)
- 70) **H. Kim**, H. S. Kwak, and J. Westerweel, "Assessment of mixing applications on the EOF with thermal effects," *Colloid Surface A* **376**, 53 (2011)
- 71) H. S. Kwak, **H. Kim**, J. M. Hyun, and T.-H. Song, "Thermal control of electroosmotic flow in a microchannel

through temperature-dependent properties," *J. Colloid Interface Sci.* **335**, 123 (2009)

* Equivalent 1st co-authors and the underline represents the corresponding author.

Patents (Domestic)

- 1) Apparatus and method for washing and enrichment of microparticles encapsulated in microscale droplets using acoustic radiation force, Reg. No.: 10-2203572-0000, Date: 2021.01.11, South Korea
- 2) Mobile expansion type negative pressure ward module, Reg. No.: 10-2214043, Date: 2021-02-03, South Korea
- 3) Method for quantum dot coating using droplet evaporation in confined system, Reg. No.: 10-2585769, Date: 2021.09.27, South Korea
- 4) A negative pressure mask using a cyclone, Reg. No: 10-2337725-0000, Date: 2021-12-06, South Korea
- 5) A negative pressure mobile device using cyclone, Reg. No.: 10-2339302, Date: 2021-12-09, South Korea
- 6) Free-energy droplet mixing and flow control method, Reg. No.: 10-2342742-0000, Date: 2021-12-20, South Korea
- 7) Hybrid Positive-Negative Convertible Pressure Cyclone-type Personal Protection Equipment, Reg. No.: 10-2410336, Date: 2022.06.14, South Korea
- 8) Personal Protection Equipment using a Cyclone, Reg. No.: 10-2410336, Date: 2022.06.22
- 9) Soft pressure sensor and method for manufacturing the same, Appl. No.: 10-2022-0140989, Date: 2022.10.28, South Korea
- 10) Immersion photolithographic system, Appl. No.: 10-2022-0146388, Date: 2022.11.04, South Korea
- 11) A design for a negative pressure transfer device, Reg. No.: 30-1192008, Date: 2022.11.16, South Korea
- 12) Portable negative pressure pump module for negative pressure stretcher, Appl. No.: 10-2574808, Date: 2023.08.31
- 13) Anti-icing film using broadband plasmonic metasurfaces co-assembled with anisotropic gold nanorods and cellulose nanocrystals, Appl. No.: 10-2023-0146268, Date: 2023.10.30, South Korea
- 14) Manufacturing method of self-sintering liquid metal slurry ink and conductive pattern formed using liquid metal slurry, Appl. No.: 10-2023-0192276, Date: 2023.12.27, South Korea
- 15) Sealing device for medical chamber, Appl. No.: 10-2024-0025686, Date: 2024.02.22, South Korea
- 16) Portable apparatus for generating positive pressure and negative pressure, Appl. No.: 10-2024-0044121, Date: 2024.04.01, South Korea
- 17) Movable negative pressure chamber, Reg. No.: 10-2815522, Date: 2025.05.27, South Korea
- 18) Medical Negative Chamber, Reg. No.: 30-1262778, Date: 2024.05.29, South Korea
- 19) Apparatus and Method for Plasma Controlling Using Liquid Metal, Appl. No.:10-2024-0071946, Date: 2024.05.31, South Korea
- 20) Device for visualization of airflow and particle behavior in airtight equipment, Appl. No.: 10-2024-0072160, Date: 2024.06.03, South Korea
- 21) Method for generating of modular focus ring and focus ring using thereof, Appl. No.:10-2024-0074991, Date:2024.06.10, South Korea
- 22) Plasma control using meta-materials with tunable properties based on liquid metal, Appl. No.:10-2024-0111102, Date: 2024.08.20, South Korea
- 23) Method for manufacturing non-sintering liquid metal ink, Reg. No.: 10-2719657, Date: 2024.10.15, South Korea
- 24) Flexible plasma generator and method for manufacturing flexible plasma generator, Appl. No: 10-2024-0148262, Date: 2024.10.28, South Korea

Patents (Abroad)

- 1) Prefabricated Modular System for Building Positive and Negative Pressure Facilities, Appl. No.: 2021-096989, Date: 2021.06.10, Japan
- 2) Method for manufacturing non-sintering liquid metal ink, Reg. No.: PCT/KR2021/019827, Date: 2021.12.24, USA
- 3) Method for manufacturing non-sintering liquid metal ink, Appl. No.: 21876738.2, Date: 2022.04.13, EU
- 4) Apparatus and method for washing and enrichment of microparticles encapsulated in microscale droplets using acoustic radiation force, Reg. No.: 11369961, Date: 2022.06.28, USA
- 5) Method for coating a quantum dot using droplet evaporation in confined system, Pub. No.: US2022/0306933, Date: 2022.09.29, USA
- 6) Immersion lithographic system, Pub. No.: US2024/0152058, Date: 2024.05.09, USA
- 7) Anti-icing film using broadband plasmonic metasurface in which anisotropic gold nanorods and cellulose nanocrystal particles are co-assembled, Appl. No: 18/929.960, Date: 2024.10.29, USA
- 8) Medical Negative Pressure Chamber, Pub. No: US2025/0025360, Date: 2025.01.23, USA
- 9) Method for generating of modular focus ring and focus ring using thereof, Appl.No.: PCT/KR2025/00725 6, Date: 2025.05.28, PCT

Technology Transfer

- 1) Prefabricated Modular System for Building Positive and Negative Pressure Facilities, Shinsung E&G, KOR
- 2) Movable cyclone negative pressure pump, Woojung Bio, KOR
- 3) Portable negative pressure chamber, Biodech, KOR

Selected Invited Talks

- 1) Plenary Talk: The 6th International Conference on Experimental Fluid Mechanics, Canada, May 9-12, 2025
- 2) Keynote speech: The 35th International Symposium on Transport Phenomena, Korea, Sept. 21-25, 2025
- 3) Keynote speech: ASME JSME KSME Fluids Engineering Division, Japan, July 9-13, 2023
- 4) Invited talk: The 2nd International Conference on AI Sensors, Malaysia, July 30 - Aug. 4, 2025
- 5) Invited talk: The 3rd International Symposium on Sustainable Healthcare Innovation for Future Society, Thailand, Jan. 20-22, 2025
- 6) Invited talk: The 10th International Symposium on Sensor Science, Singapore, Aug. 1-4, 2024

Selected other press

- 1) Development of a Self-Heating Anti-Icing Coating Technology Activated by Sunlight, YTN Science (2024)
- 2) Quantum dot uniform patterning technology, Dong-A Science, KOR (2022)
- 3) Now, you can see the flower odor, ETNEWS, HelloDD, KOR (2022)
- 4) Salt! Self-assembled nanocapsule, Dong-A Science, KOR (2021)
- 5) 'Coffee-ring effect' for soft matter packing techniques, ETNEWS, KOR (2020)
- 6) Solutal Marangoni flows of miscible liquid drive transport without surface contamination, PhysOrg (2017)
- 7) "How warm milk generates latte layers," Nature (2017)
- 8) Klein, "How Layers in a Latte Form," The New York Times, USA (2017)
- 9) Lee, "Universe in a whisky glass," Chosun Ilbo, South Korea (2016)

- 10) Chang, "At the Bottom of a Whisky Glass, a Beautiful Experiment," The New York Times, USA (2016)
- 11) Verberck, "Fluid dynamics: Spirited away," Nature Physics 12, 291 (2016)
- 12) Schirber, "Synopsis: Whisky-Inspired Coatings," Physics (2016)
- 13) Lewis and Ahn, "Device fabrication: Three-dimensional printed electronics," Nature 518, 42–43 (2015)
- 14) Diodes printed in three dimensions, Nature 515, 468 (2014)
- 15) Chang "Art in a whisky glass, neatly explained," New York Times (2014)
- 16) Morone "Scotch ring art and science, treats from nut trash," Chem. Eng. News, 92 (51), 48 (2014)

Academic Activities

▷ Journal peer reviewer:

Nature Communications, Physical Review Letters, Journal of Fluid Mechanics, Proceedings of the National Academy of Sciences, ACS Nano, Nano Letters, Advanced Functional Materials, Advanced Materials Interfaces, Journal of Physical Chemistry, Journal of Colloid and Interface Science, etc.

▷ Journal editorial board member:

- Editorial advisory board member in Experiments in Fluids
- Associate Editor in Experiments in Fluids special issue (2021)
- Leading Guest Editor in Int. J. Multiphase Flow special issue (2025)

▷ Organization board member:

- 2025- Present: Korean Society of Manufacturing Process Engineering (KSMPE)
- 2022- Present: The Society of Micro and Nano Systems
- 2017- Present: Korean Society of Mechanical Engineering (KSME), Fluid Engineering
- 2017- Present: The Korean Society of Visualization

▷ Research grant proposal peer reviewer:

- Natural Sciences and Engineering Research Council of Canada
- Veni, NWO, the Netherlands

▷ Professional affiliations

- Member, European Society of Rheology
- Member, European Mechanics Society
- Member, American Physical Society: Division of Fluid Dynamics
- Member, American Physical Society: Soft Matter
- Member, American Society of Mechanical Engineers
- Member, Korea Society of Mechanical Engineers
- Member, The Korea Society of Visualization

▷ Service

- Local organizing committee
 - Asian Joint Workshop on Thermophysic sand Fluid Science 2026
 - The 35th International Symposium on Transport Phenomena (2025)
 - The 18th Asian Congress of Fluid Mechanics (2025)

- The 26th International Congress of Theoretical and Applied Mechanics (ICTAM) (2024)
- The 18th IEEE International Conference on Nano/Micro Engineered & Molecular Systems (2023)
- ASME - JSME - KSME Joint Fluids Engineering Conference 2023, Japan (2023)
- The 15th Asian Symposium on Visualization, Busan, KOR (2019)
- Discussion leader: Fluids in Disease Transmission and Contamination, Gordon Conference, USA (2022)
- International Scientific Committee of Asian Joint Workshop on Thermophysics and Fluid Science (2022)
- Organizing committee: KAIST e-Symposium on Emerging Technologies in Mechanical Engineering (2021)
- Co-track-organizer: ASME - JSME - KSME Joint Fluids Engineering Conference 2019, USA (2019)

▷ Awards

- 2024, Kasan Research Award, KSME
- 2024, Best Teaching Award, Mechanical Engineering, KAIST
- 2022, Technology Innovation Award, KAIST
- 2021, Fusion Research Award, KAIST
- 2021, Best Teaching Award, Mechanical Engineering, KAIST
- 2021, Songam Future Scholar for Excellent research, KAIST
- 2018, Young Engineering Award, The Korea Society of Visualization
- 2017, Best Paper Award, The Korea Society of Visualization
- 2017, Outstanding Reviewer Award 2016 for Measurement and Science Technology

▷ Selected student awards under supervision

- 2025, Junil Ryu, Best Thesis Award (PhD), KSME
- 2022, Jeongsu Pyeon, Gold prize, Samsung Display
- 2022, Jeongsu Pyeon, Best Thesis Award (Master), KSME
- 2021, Gihyun Song, Best Paper Award, The Korea Society of Visualization
- 2021, Jeongsu Pyeon, Best Paper Award, KSME
- 2021, Junil Ryu, Best Thesis Award (Master), KSME
- 2021, Ara Jo, Best Research Award from WISSET, KSME

Consulting Activities for Industry

- 2025, Advice for enhancing the long-lasting fragrance of fabric softeners, LG Healthy & Beautiful
- 2025, Advice for nano/micro particle cleaning, SK Hynix
- 2024, Advice for improvement of uniformity of PEM electrolysis electrodes, Hyundai NGV
- 2024, Advice for defrosting techniques for the interior of refrigerators, LG Electronics
- 2023, Advice for development of cosmetics to prevent eye irritation, COSMAX
- 2022, Advice for a method to quantify the human and cosmetic fragrance, LG Healthy & Beautiful
- 2022, Advice for development of active magnetic field control techniques, Samsung DS
- 2021, Advice for development of detecting a toxic gas in a factory, Samsung DS
- 2020, Advice for a method for uniform electrodes for an electric vehicle, LG Chemistry
- 2019, Advice for cleaning oxide layers of the steel plate, POSCO
- 2019, Open lecture for visualization of fluid and thermal flow, Hanon system
- 2017, Advice for optimization and advancement for the air purifier of LG Electronics
- 2018, Advice for efficiently removing oil and metal impurities from bulk solution, POSCO
- 2018, Advice for efficient removal of nanoparticles on bare wafers, Samsung

- 2018, Advice for precision plasma field control using liquid metal, Samsung
- 2017-2020, Advice for mobile healthcare device, BBB

Achievement of Research Grants

As a principal investigator in KAIST (since 2017), total research grant ~ KRW 9 B (~ USD 6.7 M). Small grants (\leq 100M KRW) are not listed below.

- 1) Aug. 2024 – July 2027, Laboratory for Programmable Electromagnetic Liquid-Metal Composites System for Plasma Active Control, Principal Investigator, National Research Foundation (NRF). (KRW 1500M)
- 2) June 2024 – Dec. 2025, KAIST Convergent Research Center for Next-Generation Semiconductor Packaging Technology, KAIST. (KRW 550M)
- 3) Aug. 2023 – Feb. 2024, Development of Coating/Drying Techniques for Improved Uniformity of PEM Water Electrolysis Electrode, Principal Investigator, Hyundai NGV. (KRW 127M)
- 4) Jan. 2022 – Dec. 2024, Development of active negative pressure pump for mobile clinical module, Collaborator, Principal Investigator, Ministry of Health and Welfare (MOHW). (KRW 1200M)
- 5) March 2021 – Feb. 2026, Development of Key Elements of New-generation of Stretchable Display based on Liquid Metal and Quantum Dots, Principal Investigator, National Research Foundation (NRF). (KRW 962M)
- 6) Jan. 2021 – Nov. 2021, Development of active negative pressure pump for mobile clinical module, Principal Investigator, KAIST. (KRW 251M)
- 7) Sept. 2020 – Aug. 2025, Samsung DS part strategical industrial project, Principal Investigator, Samsung. (KRW 350M)
- 8) Aug. 2020 – Dec. 2020, Development of active negative pressure pump for mobile clinical module, Principal Investigator, KAIST. (KRW 1500M)
- 9) April 2020 – Feb. 2021, Development of precision control system for highspeed fluid flow in next-generation, Samsung. (KRW 103M)
- 10) March 2019 – Feb. 2022, Development of real-time gas(odor) visualization mobile system, PREP research, Principal Investigator, KAIST. (KRW 230M)
- 11) July 2019 – Dec. 2021, Precision control of liquid metal for safe nuclear fusion reaction, Principal Investigator, NRF. (KRW 200M)
- 12) March 2018 – Feb. 2021, Energy-free mixing and particle separation and uniform coating using solutal Marangoni effects, Principal Investigator, NRF. (KRW 399M)
- 13) March 2017 – Dec. 2018, Study on physico-chemical hydrodynamics and interfacial instabilities of complex fluids, Principal Investigator, KAIST. (KRW 200M)

Graduate Student Supervision

Alumni/Theses Supervised

- 1) Yewan Lee, MS 2020 (Thesis: A liquid drop impact on a liquid pool with an inclined bottom substrate)
Current position: Korea Institute of Machinery and Materials
- 2) Jonghyeok Park, MS 2020 (Thesis: Flow control method using vapor-driven solutal marangoni effects for sessile droplet microfluidics)
Current position: Samsung Semiconductor Company
- 3) Junil Ryu, MS 2021 (Thesis: Study on the analysis of the vapor-driven solutal Marangoni flow pattern and the mechanism inside a sessile droplet)
Current position: PhD student at H. Kim's group in KAIST
- 4) Mekidelawit Grima, MS 2021 (Thesis: Effect of microchannel materials on the apparent viscosity of liquids)
Current position: PhD student at Physics in KAIST
- 5) Jeongsu Pyeon, MS 2021 (Thesis: Study on the evaporative flow and deposition pattern depending on a

- confined geometry and droplet shape) Current position: PhD student at H. Kim's group in KAIST
- 6) Heyjun Jeon, MS 2022 (Thesis: Theoretical Study on Rayleigh-Plateau Instability on a Solid Plate and Satellite Droplet Formation) Current position: PhD student at H. Kim's group in KAIST
 - 7) Biruk Tekla, MS 2022 (Thesis: Study on atomization morphology of expelled respiratory liquids) Current position: PhD student at Univ. Michigan Ann Arbor
 - 8) Muhammad Ijaz, MS 2022 (Thesis: Investigation of thermophysical properties of liquid metal emulsions) Current position: Start-up company and applying to US University
 - 9) Ara Jo, MS 2023 (Thesis: Retraction Dynamics of Droplet Impacting Face Mask) Current position: SK ON
 - 10) Kwangseok Park, PhD 2023 (Thesis: Interface controls using physicochemical changes at emulsions) Current position: Research Institute of Industrial Science & Technology
 - 11) Junkyu Kim, PhD 2023 (Thesis: Numerical investigation of complex fluid flow by non-linear viscosity and elasticity in microchannels) Current position: Research Institute of Industrial Science & Technology
 - 12) Minhyeok Kook, MS 2023 (Thesis: Experimental study on sessile droplet evaporation using laser interferometry) Current position: PhD student at H. Kim's group in KAIST
 - 13) Byungeun Jeon, MS 2025 (Thesis: Optimization of inkjet printing process for transparent self-heating plasmonic metasurfaces fabrication) Current position: PhD student at H. Kim's group in KAIST
 - 14) Junil Ryu, PhD 2025 (Thesis: Study on interfacial instabilities driven by interphase mass transfer of multi-component liquids and its applications) Current position: BK21 Postdoctoral position at KAIST
 - 15) Jeongsu Pyeon, PhD 2025 (Thesis: Controlling Dried Patterns of Nanomaterials Based on Soft Matter Hydrodynamics and Their Applications)

Current Graduate Students/Postdoc Advisee

- 1) Gihyun Song, PhD course (2021.09 – present)
- 2) Heyjun Jeon, PhD course (2022.03 – present)
- 3) Minhyeok Kook, PhD course (2023.03 – present)
- 4) Minwoo Choi, MS+PhD course (2023.03 – present)
- 5) Song Hyeon Chung, MS course (2024.03 – present)
- 6) Ilham Darni, MS course (2024.09 – present)
- 7) Yunhyeok Kook, MS course (2025. 03 – present)
- 8) Seunghyun Kim, MS course (2025. 03 – present)