

Professor Dr. Alexander Solovev
Founding Director
NanoTRIZ Innovation Institute
4101 Brisbane, Queensland
Australia



LOCATION	EMAIL	WEB	PHONE
Brisbane, Australia	director@nanotriz.com	www.nanotriz.com	+61 494 042 578
ORCID: 0000-0001-5918-3102 LANGUAGES: English: excellent Russian: native German: intermediate			
WORK RIGHTS & CITIZENSHIP: Permanent Resident: Australia (Subclass 858; Global Talent) Citizenship: Germany			

ACADEMIC PROFILE

Internationally recognised materials scientist and interdisciplinary research leader with more than two decades of research spanning strain-engineered thin films and nanomembranes, functional and responsive micro- and nanomaterials, catalytic and magnetic micro/nanosystems, microfluidics, biomaterials, biosensing, electrochemical and clean-energy microsystems. Connects materials synthesis and processing with structure–property–function relationships through micro/nanofabrication, advanced characterisation, physical measurement and quantitative analysis. Long-term user of shared research infrastructure and cleanroom/nanofabrication environments in Germany, Canada, the United States and China, using optical/video microscopy, electron microscopy and scanning-probe methods to connect nanoscale structure, interfaces, defects and fabrication history with dynamic function. Prospective alignment spans functional materials, interfacial and physical chemistry, active matter, analytical microsystems and complementary biomedical, environmental and energy applications.

Former tenured Professor of Materials Science at Fudan University (Shanghai, P.R. China), with research experience spanning Harvard University, University of Toronto, Max Planck institute for Solid State and Materials Research, Max Planck Institute for Intelligent Systems, Technical University of Munich, Leibniz Institute for Solid State and Materials Research, Walter Schottky Institute and UQ's ARC Centre of Excellence for Quantum Biotechnology. Academic record: h-index 36; > 6,800 citations; 74 entries in the main publication and research-output list and 80+ scholarly records overall; six competitive and institutional PI awards; one granted patent and one published patent application; more than 30 invited presentations; seven academic years of course leadership; and completed PhD supervisions. Leadership experience includes independent research-programme development, multidisciplinary team coordination, external funding and resource stewardship, international partnerships, researcher development, research infrastructure, translation and academic service. Prior tenured professorial experience and sustained independent PI leadership provide a basis for senior faculty consideration.

36	6,800+	70+	30+
H-INDEX	CITATIONS	SCHOLARLY RECORDS	INVITED TALKS

FUNCTIONAL NANOMATERIALS, MICROFLUIDICS & MICRO/NANOSYSTEMS

- **Materials physics and structure-property relationships:** strain-engineered thin films and nanomembranes; residual stress, interfaces, defects and three-dimensional architectures; catalytic and magnetic micro/nanosystems; functional response linked to processing history and geometry.
 - **Advanced materials characterisation and physical methods:** 20+ years of optical/video microscopy of dynamic micro- and nanosystems; SEM, and scanning-probe experience; quantitative tracking, image analysis and cross-modality interpretation linking static nanoscale structure to in situ behaviour.
 - **Micro/nanofabrication and shared research environments:** Walter Schottky Institute / Technical University of Munich; Max Planck Institute for Solid State Research, Stuttgart; IFW Dresden; and Harvard nanoscale/shared-user facilities, with thin-film processing, patterned structures, catalytic and magnetic architectures and lab-on-chip integration.
- **Functional, responsive and bio-inspired materials:** active micro/nanosystems, hydrogels, microcapsules, microbubbles, soft interfaces, biosensing and biomedical microtechnologies connecting material composition, transport, actuation and measurable function.
 - **Catalysis, electrochemistry and energy materials:** catalytic interfaces, fuel-cell microsystems, CO₂-conversion research, hydrogen evolution and reaction-transport coupling, integrating surface chemistry, electrochemistry, multiphase transport and materials performance.
 - **Institute-level research leadership and quality:** multidisciplinary research programmes spanning materials science, engineering physics, physical chemistry, microfluidics, sensing, biomedical imaging and energy systems; international collaborations across seven countries; traceable records, reproducibility, uncertainty-aware interpretation and responsible AI-assisted R&D.

SELECTED SENIOR APPOINTMENTS

2025–present	Founding Director, NanoTRIZ Innovation Institute, Brisbane, Australia
2024	Visiting Academic, The University of Queensland, ARC Centre of Excellence in Quantum Biotechnology, Brisbane, Australia
2015–2024	Professor (tenured), Department of Materials Science, Fudan University, Shanghai, China
2017	Visiting Scholar, Harvard John A. Paulson School of Engineering and Applied Sciences, USA

ACADEMIC AND PROFESSIONAL APPOINTMENTS

Jan 2025–present	Founding Director, NanoTRIZ Innovation Institute, Brisbane, Queensland, Australia Founded an independent Brisbane-based research, innovation and mentoring initiative. Leads international research mentoring and structured research-enrichment programs, including a remote Junior Research Scholar Program that has attracted more than 350 expressions of interest; develops AI-assisted R&D workflows for reproducibility, systematic problem-solving and translation.
Nov–Dec 2024	Visiting Academic, University of Queensland, ARC Centre of Excellence in Quantum Biotechnology, Australia One-month visiting appointment hosted by Professor Warwick Bowen; engaged with UQ's interdisciplinary research environment and Brisbane academic network.
Sep 2015–Feb 2024	Professor (tenured), Fudan University, Department of Materials Science, Shanghai, P. R. China Led PI-funded research and academic programs spanning strain-engineered nanomembranes, functional and active materials, microfluidics, microrobotics, biomaterials, sensing and clean-energy systems; secured six PI awards, led corresponding-author publications, designed and coordinated curriculum, and supervised doctoral, master's, undergraduate and postdoctoral researchers. Appointment concluded upon permanent relocation to Australia.
Apr–Jul 2017	Visiting Scholar, Harvard University, John A. Paulson School of Engineering and Applied Sciences, USA Hosted by Professor David A. Weitz; conducted collaborative research in microfluidics and droplet and hydrogel microcapsule engineering, with subsequent outputs on dynamic microcapsules and lab-on-chip systems.
Mar–Aug 2015	Postdoctoral Fellow, University of Toronto, Department of Chemistry, Canada Worked in Professor Geoffrey Ozin's group within the Solar Fuels Cluster on photoelectrochemical cell assembly and materials integration for solar-driven CO ₂ -to-fuel conversion.
Aug 2013–Dec 2014	Postdoctoral Fellow, Max Planck Institute for Intelligent Systems, Germany Conducted research in Professor Peer Fischer's group on catalytic micro-/nanorobotics, including propulsion, magnetic guidance, quantitative characterisation and externally controlled motion.
Aug 2011–Aug 2013	Postdoctoral Fellow, Technical University of Munich, Germany Investigated functionalised electrode surfaces in Professor Katharina Krischer's group using scanning tunnelling microscopy and electrochemical methods, with emphasis on interfacial catalysis and enhanced electrochemical CO ₂ conversion.
Feb 2007–Jun 2011	PhD Candidate, Leibniz Institute for Solid State and Materials Research (IFW Dresden) Developed strain-engineered rolled-up nanomembranes, catalytic microtubular engines and microfluidic transport systems in Professor Oliver G. Schmidt's group for controlled propulsion, pumping and energy-conversion applications.

EDUCATION

2012	PhD in Physical Chemistry, magna cum laude, Chemnitz University of Technology, Germany Doctoral research in integrative nanoscience conducted at the Leibniz Institute for Solid State and Materials Research (IFW Dresden) and the Max Planck Institute for Solid State Research, Stuttgart; strain-engineered nanomembranes and catalytic micro-/nanomachines with direct relevance to microfluidics, sensing and biomedical microrobotics. Supervisor: Prof. Oliver G. Schmidt
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2003–2006	Master of Science in Engineering Physics, Technical University of Munich, Germany Walter Schottky Institute; interdisciplinary training in engineering physics, semiconductor and nanoscale device science, measurement and quantitative analysis. Supervisors: Prof. G. Abstreiter and Prof. M. Tornow
2004	Exchange Study in Chemistry Princeton University and Columbia University in the City of New York, USA Conducted research on STM characterisation of organic-molecule self-assembly on electrode surfaces in Prof. George Flynn's group at Columbia University, and organophosphonate-based biofunctionalisation of silicon surfaces for silicon-on-insulator biosensor development in Prof. Jeffrey Schwartz's group at Princeton University
2003	Diploma in Mechanical Engineering and Materials Science, Kyrgyz-Russian Slavic University, Kyrgyzstan Diploma research on the effects of powder-milling parameters and particle-size distribution on the processing and properties of ceramic materials. Supervisor: Prof. Yakov I. Rudaev.

COMPETITIVE AND INSTITUTIONAL RESEARCH FUNDING

Funding leadership summary. Secured six competitive and institutional awards as PI and co-PI. Awards span national, municipal, talent-program and university schemes. The USD equivalents below are indicative; the original-currency amounts define the funding record. Additional participation in international consortia is reported separately; consortium figures denote total project awards rather than funds personally held or controlled.

Grants and Awards as Principal Investigator

Period	Sponsor / project	Role / funding
2022–2023	National Natural Science Foundation of China, RFIS-II <i>High-Performance Membraneless Hydrogen Peroxide Fuel Cells with Three-Dimensional Electrodes</i>	PI: RMB 800,000 (approx. USD 110,000)
2019–2021	National Natural Science Foundation of China, International Scholar Grant <i>Bio-Inspired Multifunctional Hydrogel Nano-/Micromotors for Water Purification</i>	PI: RMB 600,000 (approx. USD 83,000)
2015–2018	Central Government of the People's Republic of China, Young Talent Program for International Scientists, Start-Up Grant	PI: RMB 2,000,000 (approx. USD 275,000)
2015–2016	Fudan University Start-Up Grant	PI: RMB 1,000,000 (approx. USD 138,000)
2017–2018	Shanghai Municipal Education Commission, Shanghai "Dawn Program" <i>Self-Powered Micro-Engine, Rotor, and Pump for Clean Energy Conversion</i>	PI: RMB 250,000 (approx. USD 35,000)
2021	Fudan University "Zero to One" Program <i>Energy Conversion Based on Colloidal Motors in Non-Equilibrium Conditions</i>	PI: RMB 100,000 (approx. USD 14,000)

Collaborative, International, and Mobility Grants

Period	Sponsor / project	Role / funding
2019 call	BRICS STI Framework Programme, China, India and Russia Bioactive Ultrasound-Driven Microbubbles for Theranostics.	Research contributor Total consortium award: RMB 1,600,000 (approximately USD 220,000).

Period	Sponsor / project	Role / funding
2009–2011	Volkswagen Foundation, Germany; Grant I/84 072 <i>Rolled-Up Integrative Bioanalytic Microsystem for Single-Cell and Biological Applications</i>	Research contributor Total project award: EUR 6,300,000 (approximately USD 6,800,000).
2011–2013	German Federal Ministry of Education and Research (BMBF) <i>iC4 Cluster: Integrated Carbon Dioxide Capture, Conversion and Cycling</i>	Research contributor Total cluster award: EUR 5,000,000 (approximately USD 5,400,000).
2005	DFG Germany / Princeton University <i>A Novel Method of Biofunctionalization of Silicon Surfaces by Organophosphonates for Electrical Detection of DNA Hybridization</i>	Participant; research travel grant
2004	Columbia University in the City of New York <i>Scanning Tunneling Microscopy of Self-Assembled Monolayers of Molecules at the Solid–Liquid Interface</i>	Visiting student grant

RESEARCH PROGRAMME, LEADERSHIP AND TEAM DEVELOPMENT

Research programme established through six PI awards, 22 publication records identifying a corresponding-author role, one granted patent and one published patent application, six completed PhD supervisions or co-supervisions, seven academic years of course leadership, and research partnerships spanning Australia, P. R. China, Germany, the United States, Canada, India and Russia. The programme was materials- and infrastructure-intensive, integrating synthesis and thin-film processing, micro/nanofabrication, microscopy, quantitative imaging, microfluidics, electrochemistry, materials characterisation and modelling across internal and external facilities. This record provides a foundation for scientific strategy, team leadership, resource stewardship and research-group coordination in an interdisciplinary materials-science and chemistry environment, with transferable links to microfluidic analysis, biomedical technologies, environmental catalysis and energy materials.

Funding, financial and project stewardship. Obtained and administered six PI awards spanning hydrogel micro-/nanomotors for water purification, active materials, microfluidic energy conversion, colloidal motors and three-dimensional-electrode fuel cells. Responsibilities included project concepts, work plans, resource allocation, collaboration, sponsor/institutional reporting, publication pathways and delivery against funded objectives.

Multidisciplinary coordination. Directed project-based teams connecting materials science, physical chemistry, engineering physics, microfluidics, sensing, imaging, device development and external technical expertise, with collaborators across seven countries and participation in BRICS, Volkswagen Foundation and BMBF-supported research activity. This work required coordination across specialist facilities and scientific interfaces rather than within a single instrument or discipline.

Researcher development. Supervised or co-supervised six completed PhD researchers and mentored master's, undergraduate and postdoctoral researchers. Documented trainee outcomes include graduate distinctions, government scholarships, innovation awards, international mobility and progression to professorial and senior technology-industry roles.

Publication and translation leadership. The publication list contains 22 entries identifying my corresponding-author role across advanced materials, active matter, microfluidics, hydrogels, microrobotics, fuel-cell microsystems and biomedical technologies. Translation outputs comprise a granted patent for real-time micromotor imaging, tracking and control and a published patent application for surfactant-enhanced membraneless hydrogen peroxide fuel cells.

Institute and research-infrastructure leadership perspective. As a PI, research-group leader, Founding Director and intensive user of shared scientific facilities, I have worked at the intersection of multidisciplinary scientific demand, specialist technical expertise, training and safety, data quality, access constraints, research continuity, reproducibility and investment priorities. This experience provides a practical foundation for strategic leadership of a complex collaborative research environment while recognising the distinct professional expertise of scientific group leaders, facility scientists, engineers, technical staff and administrators.

Senior faculty relevance. My leadership approach links scientific strategy, people, infrastructure, funding and external collaboration through multi-year priorities and transparent responsibility. It emphasises independent project ownership, development of early-career and technical staff, evidence-based equipment decisions and funding portfolios that reinforce shared questions. This experience would support the development of an independent research group in functional materials and micro/nanosystems, with collaboration across complementary methods and a sustained emphasis on scientific quality, training and resource stewardship.

INDUSTRY, INSTITUTIONAL AND INTERNATIONAL COLLABORATION

Industry and translation profile. Research has repeatedly connected materials mechanisms with engineering constraints including reproducibility, manufacturability, reliability, safety, cost, intellectual property and partner-defined performance. Patents, clean-energy and electrochemical systems, micro/nanofabrication, commercialisation activity and international institutional partnerships provide evidence of applying engineering knowledge beyond purely academic demonstration.

- Developed and led research programs linking functional materials, nanomembranes, microfluidics, biomedical imaging, microbubbles and theranostics, biosensing, microrobotics, environmental remediation and clean-energy microsystems.
- Built an intellectual-property portfolio comprising one granted patent in real-time micromotor imaging, tracking and control and one published patent application for surfactant-enhanced membraneless hydrogen peroxide fuel cells.
- Participated in nanotechnology commercialisation and innovation-bridge activity through the Jiangsu–Ontario Nanotech Innovation Center and Suzhou Industrial Park.
- Played a coordinating role in establishing the Fudan–Skoltech Memorandum of Understanding for institutional collaboration in science and technology.
- Built cross-border research collaborations involving Australia, China, Germany, the United States, Canada, India and Russia, including BRICS-linked research activity.
- Worked across shared scientific infrastructure in Germany and the United States and coordinated research dependent on complementary fabrication, microscopy, fluidic, electrochemical and analytical capabilities across institutions.
- Founded NanoTRIZ Innovation Institute as a distributed research and innovation platform integrating structured problem formulation, evidence assessment, responsible AI-assisted workflows and translation-oriented research mentoring; its Junior Research Scholar Program has attracted more than 350 expressions of interest.

TEACHING AND ACADEMIC PROGRAM LEADERSHIP

2025–present	Founder and Program Lead, NanoTRIZ Research Scholar Program (Remote), NanoTRIZ Innovation Institute, Australia Designed and leads an international research-enrichment model integrating project mentoring, responsible AI-assisted workflows, literature analysis, research communication, TRIZ-based problem formulation and translational innovation training. The Junior Research Scholar Program has generated more than 350 expressions of interest internationally.
2016–2023	Curriculum Development and Teaching Leadership, Fudan University Developed interdisciplinary content under the university’s “Double First-Class” framework, connecting microfluidics, nanotechnology, functional materials, device fabrication, biomedical applications and research translation across taught and project-based learning.
2016–2023	Microfluidics and Lab-on-a-Chip, Fudan University Designed, coordinated and delivered a semester course over seven academic years. Content covered transport at the microscale, droplet and capsule technologies, microfabrication, diagnostics, pharmaceutical and biomedical applications and environmental analysis, supported by design projects, technical presentations and research-literature evaluation.
2016, 2018	Materials in Life, Fudan University Four-week international intensive on biomaterials, smart materials, nanotechnology, and sustainable technologies for health, energy, and environmental applications.

2012	Self-Organization in Physical Science: Patterns, Chaos, and Rhythms, Technical University of Munich Seminar on nonlinear dynamics, self-organization, fractals, chaos, pattern formation, and rhythmic processes.
2009–2011	Nanomachines: Self-Propelled Catalytic Nanomotors, IFW Dresden Laboratory instruction in catalytic tubular nanomotor design, fabrication, characterisation, and applications.
2000–2003	Physics and Mathematics, private tutoring Individual instruction for students preparing for advanced study in science and engineering.
Approach	Contemporary, Inclusive and Research-Integrity-Focused Teaching Practice Uses active and flipped learning, design projects, literature mapping, staged technical presentations, peer critique, transparent rubrics and structured feedback. Responsible AI use is framed through verification, disclosure, source checking and research-integrity expectations.

Proposed teaching contribution. Building on seven academic years of course leadership at Fudan, I would contribute research-led modules in materials science, physical chemistry, micro/nanotechnology, microfluidics and lab-on-chip systems. Advanced topics could connect functional nanomembranes, biomedical microrobotics, sensing, ultrasound-related research, catalytic interfaces and electrochemical microsystems with experimental design and reproducible analysis. Bachelor's, master's and doctoral contributions would be aligned with the host school's curriculum and agreed language requirements. English-language teaching and interdisciplinary co-supervision would provide an initial basis for contribution, with course responsibilities and additional language arrangements developed in consultation with the host school.

RESEARCH TRAINING, MENTORING, AND SUPERVISION

Supervised or co-supervised six completed PhD researchers and mentored master's, undergraduate and postdoctoral researchers in microfluidics, biomedical microtechnologies, catalytic micromotors, nanomembranes, hydrogel micro-/nanomotors, microbubbles and bioinspired microstructures. Supervisory practice combines project scoping, experimental design, research integrity, publication strategy, staged feedback and career development. Documented outcomes include Fudan graduate awards, national scholarships, international mobility, professorial appointments, progression to leading universities and senior technology-industry roles.

Selected Graduate Supervisees

Hong Zhu - PhD, 2022

Thesis: Novel Hydrogel Materials and Their Motility Characteristics for Miniaturized Robots

Selected distinctions: Most Energetic Award, 2nd "Si Ji Qing" Youth Forum (2021); Outstanding Graduate Student (2021); Shanghai MindMotion Scholarship (2021); Top Graduate Student Scholarship (2017, 2020); Silver Award, 12th "Challenge Cup" College Students Business Plan Competition (2020); Chinese Government Scholarship for Visiting PhD Study (2020); First Prize, 6th "Pan-Sea Cup" College Students Innovation Competition (2020).

Jinrun Liu - PhD, 2022

Thesis: Microfluidic-Based Fabrication of Microstructures and Applications in Transformable Microrobots

Selected distinctions: First-Class Scholarship (2018); Second-Class Scholarship (2020).

Hong Chen - Master's, 2021

Thesis: Study on Microfluidic Fabrication of Structural-Colored Microbubbles and Their Coloration Mechanism

Selected distinctions: First-Class Scholarship (2018); Second-Class Scholarship (2020).

Xiaojie Shi - Master's, 2021

Thesis: A Strain-Engineered Helical Structure as a Self-Adaptive Magnetic Microswimmer

Selected distinctions: Outstanding Graduate Student, Fudan University; Excellent Member of the Communist Youth League; Excellent Student, Fudan University.

Summayah Naeem - PhD, 2021

Thesis: Mechanism and Optimization of Catalytic Micromotors Made of Inorganic Nanomembranes

Selected distinctions: Chinese Government Scholarship for Graduate Study.

Selected Former Postdoctoral Researchers and Trainee Outcomes

- Dr Vladimir Bolanos, Senior Engineer, Infineon Technologies, Germany
- Dr Jawayria Mujtaba, Associate Professor, Anhui Normal University, China
- Walther Shen: continued academic trajectory at Northwestern University, USA
- Wei Chenyun: continued academic trajectory at Cornell University, USA

HONOURS, FELLOWSHIPS, AND DISTINCTIONS

2024	Australian Global Talent Program, Permanent Residency (Subclass 858), Government of Australia
2021	Graduate Student Supervisor “Best 10 Groups” Award, Fudan University, China
2018	Emerging Leader Award, IOP Publishing / Institute of Physics, UK
2016	Shanghai “Dawn Program” Award, Shanghai Municipal Government, China
2015	P. R. China Talent Program for International Scientists, Award for High-Level Foreign Experts
2015	Feodor Lynen Research Fellowship (not taken due to professorship offer at Fudan University), Alexander von Humboldt Foundation, Germany
2012	STIBET–DAAD Prize for International Scholars, Technical University of Munich, Germany
2011	Guinness World Record: World’s Smallest Man-Made Jet Engine, Guinness World Records, 2012 Edition
2010	DECHEMA Honourable Mention, Society for Chemical Engineering and Biotechnology, Germany
2009	DSM Science & Technology Award Finalist, DSM, Zürich, Switzerland
2001	First Place, National Students’ Olympiad in Theoretical Mechanics, Kyrgyzstan

PATENTS

1. Xu, J.; Fan, S.; Liu, X.; Zheng, X.; Ark, Y.; Solovev, A. A.; Yang, H.; He, Y. Real-Time Imaging and Tracking Methods for Micromotors, and Device and Control Method for Micromotors. China Patent No. CN113397591B; Application No. 202110665439.6; Certificate No. 5616219. Granted 2022.
2. Solovev, A. A.; Mei, Y.; Huang, G.; Xu, K.; Zhu, F.; Chen, G. Method for Improving Performance of Membrane-Free Hydrogen Peroxide Fuel Cell by Using Surfactant. China Patent Application No. CN117438627A. Filed 2023; published 2024.

EDITORIAL LEADERSHIP AND PEER REVIEW

2025–present	Founder and Editor-in-Chief, SciViD, Publisher of Video Science Developing video-science publishing platform. Leads editorial strategy, author guidance, peer-review framework, platform structure, editorial-board development and international outreach, with emphasis on experimental transparency, reproducibility and visual scientific communication.
2020–2021	Guest Editor, Micromachines (MDPI) Special Issue: “Dream Nanomachines”.

Peer-Review Service

Reviewer for leading international journals including *Advanced Materials*, *Advanced Functional Materials*, *ACS Nano*, *Nano Letters*, *Small*, *Nanoscale*, *Angew. Chemie*, *Journal of the American Chemical Society*, *Progress in Materials Science*, *Materials Today*, *Accounts of Materials Research*, *ACS Applied Materials & Interfaces*, *ACS Catalysis*, *Langmuir*, *Applied Physics Letters*, *Lab on a Chip*, *Soft Matter*, *Sensors and Actuators B: Chemical*, *Scientific Reports*, *Micromachines* and other *Journals*. Review activity has focused on originality, methodological rigour, experimental reproducibility, mechanistic interpretation, and interdisciplinary significance.

SELECTED INVITED TALKS, SEMINARS, AND CONFERENCES

Selected record from more than 30 invited presentations, seminars, and conference contributions.

Year	Venue / role	Presentation
2026	Keynote speaker – Porous Materials Workshop 2026, Chiang Mai University, Thailand	Strain-Engineered Thin Films: Nanomembranes and Nanomachines
2024	Invited seminar - University of Melbourne, Australia	Breaking Down Barriers Among Disciplines: From Nanotech Records to Global Academic Networks
2023	Invited speaker; Plenary Session Chair - IEEE MARSS, Abu Dhabi, UAE	High-Performance Hydrogen Peroxide Fuel Cells
2022	Invited speaker - International Conference on Frontier Materials, Zhuhai, China	Perspectives on Chemical Machines, Robots and Computers
2020	Invited talk - Technion – Israel Institute of Technology	Man-Made Nanomachines: Discovery and Applications
2019	Co-organiser - Fudan University, China	Celebration of 10 Years Nanorockets Research
2019	Invited talk - Hefei University, China	Man-Made Nano- and Micromachines
2019	Invited speaker - The University of Hong Kong	Man-Made Micro- and Nanomachines
2019	Invited speaker - The Chinese University of Hong Kong	Nanoparticle-Shelled Microbubbles
2019	Invited speaker - 2nd International Conference on Nanomotors, Harbin, China	Catalytic Nanomotors: Man-Made Nanomachines
2018	Invited speaker - 7th China Soft Matter Day, Chengdu, China	Nanoparticle-Shelled Bubbles and Hydrogel Microcapsules for Dynamic Materials
2018	Invited speaker - Soochow University, China	Man-Made Nanomachines: History and Applications
2017	Invited speaker - 1st International Conference of Nanomachines, Wuhan, China	The Smallest Man-Made Nanomotor
2016	Invited speaker - Conference of Higher Education, Shaanxi Province, China	How Do Chinese Universities Become Leading Without Losing Their National Characteristics?
2016	Invited speaker - Micro- and Nanomotors Workshop, Shenzhen, China	Biocompatible Microengines for Bio-Applications
2015	Invited speaker - ChiNANO Conference, Suzhou, China	Self-Propelled Nanojets for Cargo Delivery
2015	Invited talk - AVS International Shanghai Conference, China	Man-Made Micro- and Nanomachines
2015	Invited seminar - University of Toronto, Canada	The Reversed Fuel Cell: Converting Carbon Dioxide into Fuels
2014	Invited talk - Max Planck Institute for Intelligent Systems, Stuttgart, Germany	Nanomotors for Interdisciplinary Research
2014	Invited talk - Skolkovo Institute of Science and Technology, Russia	Shapeable Nanomembranes: Concepts and Perspectives of a 3D Nanoworld

Year	Venue / role	Presentation
2013	Invited talk - Massachusetts Institute of Technology, USA	The Smallest Man-Made Jet Engine
2011	Invited seminar - Ludwig Maximilian University of Munich, Germany	Catalytic Nanojet Engines in Applications for Nanotechnology
2011	Invited talk - Max Planck Institute of Biochemistry, Martinsried, Germany	Synthetic Catalytic Nanomachines
2011	Invited talk - Technical University of Munich, Germany	Catalytic Microjet Engines
2008	Invited / award presentation - DSM Science and Technology Awards, Switzerland	Self-Assembled Microjet Engines
2004	Invited talk - Columbia University, USA	Biofunctionalized Thin-Film SOI Transistors for DNA Biosensing Applications

INSTITUTIONAL, GOVERNMENTAL, AND PUBLIC ENGAGEMENT

2025	Submitted a proposal for a Brisbane microfluidics innovation hub; received formal acknowledgement from the Lord Mayor of Brisbane and referral to Brisbane Economic Development Agency for further engagement
2023	Invited expert commentator on Chinese national television on clean-energy innovation and CO ₂ conversion.
2021	Coordinating role in establishing the Fudan–Skoltech Memorandum of Understanding for science and technology cooperation.
2021	Faculty mentor/adviser, Fudan University Top Ten “Three-Good” Graduate Student Team (Materials Science “Mina” doctoral team).
2019	Strategic academic-cooperation discussion with Prof. Cai Jingmin, Party Secretary of Hefei University, China.
2018	Participant in an official Shanghai briefing on international development, foreign-expert engagement, and science and technology cooperation.
2016	Invited scientific delegate attending a meeting with Premier Li Keqiang at the Great Hall of the People, Beijing.
2016	Formal acknowledgement from the State Administration of Foreign Experts Affairs of P. R. China for contribution to international expert exchange and Silk Road-related academic engagement.
2016	Invited foreign expert at a meeting with the Mayor of Shanghai.
2016–2018	Nanotechnology-commercialisation engagement with the Jiangsu–Ontario Nanotech Innovation Center / Suzhou Industrial Park.
2013	Invited visit to the Massachusetts Institute of Technology through the MIT–Skoltech Initiative; technical presentation and discussions on research, education, and innovation.

ACADEMIC LEADERSHIP AND PROFESSIONAL SERVICE

2026–2027	Chair, Innovation, Academic–Industry & Partnerships Council, PorScience, Porous Materials for Advanced Applications Summit Series International platform; strategic/advisory leadership in innovation, academic–industry translation, international partnerships, program development, and related organizational initiatives.
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PROFESSIONAL MEMBERSHIPS AND LEARNED SOCIETIES

- Sigma Xi, The Scientific Research Honor Society: Full Member, 2026–present
- Harvard Club of Australia: Full Member, 2026–present

SELECTED MEDIA AND SCIENTIFIC RECOGNITION

- Guinness World Record recognition for a 600 nm, 1 pg micro-/nanojet described as the world's smallest man-made jet engine.
- IFW Dresden / idw press release, "Guinness-Rekord: Kleinster Düsenantrieb der Welt."
- Nanowerk News, Scinexx, Pro-Physik, and Spektrum der Wissenschaft coverage of the Guinness-certified micro-/nanojet.
- MIT / The Tech public lecture listing: "The Smallest Man-Made Jet Engine (Guinness World Record)."
- Nanowerk Spotlight features on catalytic microstriders and tubular catalytic microbots.
- RSC Nanoscale Blog coverage of self-propelled micro-/nanosystems and rolled-up magnetic microdrillers.
- Additional coverage in Zeit Wissen, Welt.de, Bild, derStandard.at, and educational science media.

PUBLICATIONS AND SCHOLARLY OUTPUTS

Selected Contributions: Functional Nanomaterials, Micro/Nanosystems and Microfluidics

Representative outputs trace a sustained materials-physics and materials-science trajectory from strain-engineered thin films, nanomembranes and three-dimensional micro-/nanoarchitectures to functional and responsive materials, catalytic and magnetic active systems, energy-conversion microsystems, microfluidics, biomaterials, sensing, imaging and biomedical microrobotics. This portfolio offers complementary entry points into materials synthesis and interfaces, responsive and active matter, analytical technologies, biomedical systems, environmental conversion and electrochemical energy. The following thematic summaries describe the established scientific record and the complementary expertise that would support the proposed research programme.

Advanced materials characterisation and structure-function analysis. More than two decades of optical/video microscopy, quantitative tracking and real-time analysis of active micro-/nanosystems in fluids, complemented by SEM, TEM, STM and other characterisation methods. This work links static structure, interfaces and fabrication with propulsion, rotation, field response, transport, collective behaviour and functional performance.

Strain-engineered nanomembranes and functional microstructures. Foundational work established rolled-up nanomembranes, catalytic microtubes, microstriders and self-propelled micro-/nanojets as controllable three-dimensional materials architectures for active devices, transport, pumping and microscale energy conversion (Small, 2009; Advanced Materials, 2010; Angewandte Chemie International Edition, 2011; ACS Nano, 2012).

Energy-conversion materials and microsystems. PI-led research connected catalytic interfaces, three-dimensional electrodes, hydrogen-peroxide fuel cells, valveless micropumps, hydrogen evolution and solar-fuels materials with microscale energy conversion and clean-energy applications (Advanced Materials Technologies, 2024; ACS Applied Nano Materials, 2021; University of Toronto Solar Fuels Cluster, 2015).

Multimodal biomedical imaging. Co-authored work on polymer-shell perfluoropentane nanodroplets for ultrasound, magnetic-resonance and optoacoustic imaging (Laser & Photonics Reviews 17, 2300137, 2023; DOI: 10.1002/lpor.202300137).

AI-enabled ultrasound localisation. Contributed to generative-adversarial-network acceleration of super-resolution ultrasound localisation microscopy (Acta Physica Sinica 71, 224301, 2022; DOI: 10.7498/aps.71.20220954).

Integrated biomedical microsystems. Corresponding author of the Advanced Materials review unifying micromotors, microfluidics and nanozymes as Micro-Bio-Chemo-Mechanical Systems for biomedical applications (33, 2007465, 2021; DOI: 10.1002/adma.202007465).

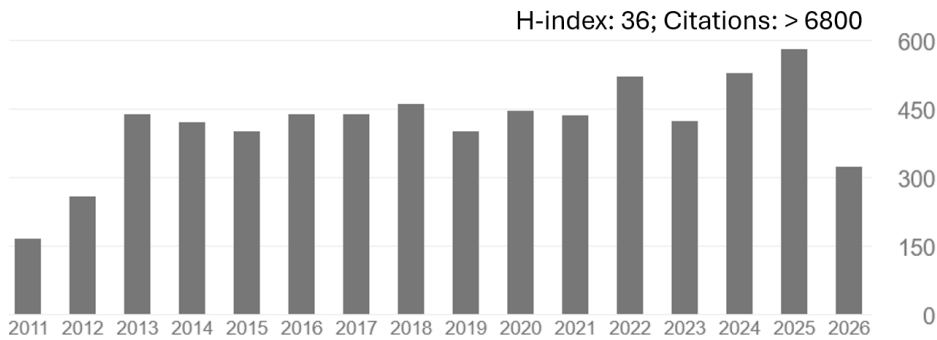
Theranostic microbubbles. Contributed to air-filled and albumin-based microbubbles functionalised for multimodal imaging and photodynamic applications (Micromachines; Nanomaterials; Colloids and Surfaces B: Biointerfaces, 2021–2024).

Hydrogel micromotors and soft microswimmers. Research and reviews, including corresponding-author contributions, addressed material capabilities, motility, biomedical requirements and operation in constrained microenvironments (Research, 2020; ChemNanoMat and Applied Materials Today, 2021; Current Opinion in Colloid & Interface Science, 2022).

Biomedical microrobotics. Foundational contributions include magnetic microdrillers for minimally invasive surgery (Nanoscale, 2013), self-propelled nanotools (ACS Nano, 2012), and catalytic microbots for cell manipulation and transport in microfluidic channels (Chemical Communications and JACS, 2011).

Biosensing and analytical platforms. Recent outputs span electrochemical cancer-biomarker detection, wireless sensor materials, DNA biosensing, molecular chemosensors and microfluidic analysis, connecting advanced materials with practical sensing architectures.

Imaging, tracking and control IP. Co-inventor of a granted patent covering real-time imaging, tracking and control of micromotors, providing a translation pathway from active materials to instrumented biomedical systems.



Articles, Reviews, Book Chapters, Conference Papers and Research Reports

Entries are grouped by type and listed in reverse chronological order. The candidate's name is in bold; * marks the corresponding author(s) and # marks equal contribution.

Summary

Category	Number
A. Peer-reviewed journal articles	67
B. Books and book chapters	2 book chapters; 1 monograph under contract
C. Conference papers and abstracts	4 proceedings papers; 1 conference abstract
D. Patents	2 (1 granted, 1 published application)
E. Other publications	11 (doctoral thesis, journal covers, research reports and highlights)

Citation metrics (Google Scholar, August 2026): h-index 36, i10-index 57, more than 6,700 citations.

A. Peer-reviewed journal articles

A1. V. Virender, I. M. Garazade, G. Khamiyeva, K. Seyidova, I. Guliyeva, A. Singh, ..., **A. A. Solovev**, ... Covalently linked porous structures: COFs and POPs for advanced emulsion separation and purification. *Advanced Sustainable Systems* 10(9), e70644 (2026). DOI: 10.1002/adsu.70644

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B. Books and book chapters

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- B2. J. Parikh, K. Bhatt, K. Modi, J. Sangwan, **A. A. Solovev**, B. Mohan. Data analysis in bioanalysis for interpretation of experimental data. In: *Bioanalytical Techniques: Principles and Applications*, pp. 575–604. Wiley (2025). DOI: 10.1002/9781394314133.ch20
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C. Conference papers and abstracts

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D. Patents

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- D2. K. Xu, S. Yan, J. Liu, X. Guo, **A. A. Solovev**, Y. Mei, D. Ta, G. Huang, W. Wang. Micro-nano motor real-time imaging and tracking method and device and micro-nano motor control method. Chinese patent CN113397591B, filed 16 June 2021, granted 29 November 2022. Assignee: Fudan University.

E. Other publications

- E1. F. Zhu, G. Chen, A. Kuzin, D. A. Gorin, B. Mohan, G. Huang, Y. Mei, **A. A. Solovev**. Author Spotlight: design and evaluation of Au-electroplated carbon fiber cloth electrodes for hydrogen peroxide fuel cells. *Journal of Visualized Experiments*, Author Spotlight (2023).
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- E3. **A. A. Solovev**. Catalytic tubular micro-jet engines. Doctoral thesis, Chemnitz University of Technology (2012).
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ACADEMIC REFEREES

Prof. David A. Weitz

Harvard University, USA

+1 617-496-2159 | weitz@seas.harvard.edu**Prof. Jeffrey Schwartz**

Princeton University, USA

+1 609-258-3926 | jschwartz@princeton.edu**Prof. Igor S. Aronson**Huck Chair Professor of Biomedical Engineering, Chemistry
and Mathematics, Pennsylvania State University, USA+1 814-867-6260 | isa12@psu.edu**Prof. Valeri Tolstoy**

St. Petersburg State University, Russia

+7 812-428-4104 | v.tolstoy@spu.ru**Prof. Krishna Kanti Dey**

Indian Institute of Technology Gandhinagar, India

+91 99093 26142 | k.dey@iitgn.ac.in**Prof. David H. Gracias**

Johns Hopkins University, USA

+1 410-516-8150 | dgracias@jhu.edu

SELECTED JOURNAL COVERS AND MEDIA HIGHLIGHTS

Selected journal covers, scientific features, book imagery and public recognition illustrating the visibility, interdisciplinary reach and communication impact of the research portfolio.



ACADEMIC SERVICE & LEADERSHIP STATEMENT

Building research platforms, international partnerships, mentoring pathways and scientific communities

1. Executive Service Profile

Service leadership throughout my academic career has centred on building scientific capacity rather than only participating in existing structures. Across research and teaching appointments, international collaborations and independent initiatives, I have created or helped develop partnerships, research-training pathways, courses, conferences, editorial platforms and innovation programmes that connect scientists, students, institutions and external stakeholders.

The unifying theme is platform building across disciplinary and national boundaries. My service has linked materials science, nanotechnology, microfluidics, micro-/nanorobotics, energy research and scientific communication with graduate education, research evaluation, science diplomacy and translation. I have worked in or with academic environments in Germany, China, Russia, Canada, the United States and Australia, and have repeatedly operated at interfaces where scientific goals require coordination across institutions, cultures and technical disciplines.

My service record combines established university contributions with newer independent initiatives. At Fudan University, I developed courses, supervised researchers, coordinated international collaboration and contributed to research and institutional activities. I have reviewed grants and manuscripts, chaired scientific meetings, and participated in government-facing and public-science activities. More recently, I founded NanoTRIZ Innovation Institute and related research-enrichment activities in Australia, and established SciViD as a video-based scientific publishing initiative. These activities extend a long-standing interest in research reproducibility, mentoring, scientific communication and the conversion of advanced ideas into structured research and innovation pathways.

I regard service as most valuable when it produces durable capability: a partnership that generates projects, a course that develops independent scientific judgement, a mentoring system that helps researchers progress, an editorial process that improves evidence standards, or an innovation platform that gives technically strong ideas a path toward validation. This statement therefore emphasises outcomes, structures and responsibilities rather than titles alone.

Service profile at a glance

International academic collaboration	Partnership development and research engagement across Europe, China, North America and Australia; coordinating role in the Fudan Memorandum of Understanding
Education and mentorship	Course design in microfluidics and materials; supervision and mentoring from undergraduate to postdoctoral level; trainee awards and progression to leading universities, industry and professorial appointments.
Professional service	Grant and proposal review for international programmes; peer review for more than 50 journals; conference and workshop leadership; more than 30 invited presentations.
Platform building	Founder of NanoTRIZ Innovation Institute and NanoTRIZ educational initiatives; Founder and Editor-in-Chief of SciViD.
Science-policy and public engagement	Government-facing expert activities in China; public science communication; industry and innovation advising; regional innovation engagement in Australia.

2. Academic Leadership and International Partnerships

2.1 International collaboration and institution building

A substantial part of my academic service has involved building bridges between research-intensive universities, emerging innovation institutions and government-facing science initiatives. I have contributed to international academic cooperation across Europe, China, Russia, the United States, Canada and Australia, with an emphasis on collaborations that connect complementary scientific capability rather than producing only nominal institutional links.

I initiated and supported cross-border engagement through the MIT-Skoltech initiative (2012), including invitations, technical presentations and discussions at Massachusetts Institute of Technology on research, education and innovation. At Fudan University, I later played a coordinating role in establishing the Fudan-Skoltech Memorandum of Understanding, aligning strengths in materials science and nanotechnology with Skoltech’s technological-innovation agenda and helping create a framework for multiple joint activities. These experiences developed my practical understanding of how international collaborations move from individual contacts to institutional mechanisms, and of the importance of clear scientific ownership, administrative follow-through and mutually useful objectives.

I have also contributed scientific perspectives to policy-facing and foreign-expert activities in China, including official Shanghai briefings, engagement with China’s State Administration of Foreign Experts Affairs, and science-diplomacy activities involving the German Consulate. In Australia, I have pursued a related institution-building trajectory through NanoTRIZ Innovation Institute and a proposal for a Brisbane microfluidics and droplet-technology innovation hub, which received formal acknowledgment from the Lord Mayor of Brisbane and referral to Brisbane Economic Development Agency in 2025. These activities reflect a continuing interest in creating interfaces between advanced science, research training and regional innovation.

2.2 Research evaluation, funding and academic responsibility

I have served the international research community through grant review, proposal assessment and peer evaluation. My reviewing experience includes European research foundations, the DAAD programme, the BRICS STI Framework Program and the National Natural Science Foundation of China. In these roles, I have evaluated scientific originality, methodological credibility, feasibility, international complementarity and the relationship between proposed resources and measurable research objectives.

My funding experience also informs this service perspective. As Principal Investigator, I received six competitive and institutional awards, including support from the National Natural Science Foundation of China, the Young Talent Program for International Scientists start-up programme, Fudan University, the Shanghai Dawn Program and the Fudan Zero to One Program. I additionally contributed to larger collaborative projects supported through the BRICS STI Framework Program, Volkswagen Foundation, German Federal Ministry of Education and Research and international mobility schemes. This experience has required project definition, resource planning, reporting, coordination of collaborators and adjustment of research scope when evidence or practical constraints changed.

I approach research evaluation as a scientific responsibility rather than an administrative exercise. Strong proposals and manuscripts should make the causal logic visible: what is known, what remains uncertain, which measurement can discriminate among explanations, what controls are required, and what conclusion would no longer be justified if the result changes. This same principle informs my mentoring, editorial work and development of AI-assisted research workflows.

3. Education, Mentorship and Researcher Development

3.1 Curriculum development and pedagogical innovation

At Fudan University, I contributed to curriculum development and advanced teaching within materials science and interdisciplinary engineering. From 2016 to 2023 I designed and taught the semester-long Microfluidics and Lab-on-a-Chip course, covering microfluidic fundamentals, lab-on-chip systems, nanomaterial-enabled devices, droplet and capsule technologies, microfabrication, diagnostics, pharmaceutical applications and environmental analysis. I also designed and taught Materials in Life in Fudan's International Summer Session in 2016 and 2018, introducing students to biomaterials, smart materials, nanotechnology and sustainable technologies for health, energy and environmental applications.

During the COVID-19 transition, I contributed to Fudan University's rapid shift to online education by developing digital course content and sharing approaches to effective online teaching. Earlier teaching experience included Self-Organization in Physical Science at the Technical University of Munich and nanomachine laboratory training at IFW Dresden. Across these settings, my aim has been to connect conceptual foundations to experimental reasoning: students should be able to move from a scientific question to a defensible design, identify controls, interpret conflicting evidence and communicate uncertainty rather than simply reproduce established protocols.

Through NanoTRIZ, I have extended this approach into project-based research enrichment. The Scholar and Junior Scholar model combines literature analysis, AI-assisted workflows, problem formulation, computational or experimental planning, research communication and expert review. More than 350 expressions of interest have been received. The programme is deliberately structured so that access to guidance or infrastructure does not imply authorship or predetermined outcomes; the emphasis is on documented contribution, research integrity and development of independent scientific judgement.

3.2 Mentorship and trainee development

Student and researcher development has been one of the most sustained components of my academic service. At Fudan University, I supervised and mentored undergraduate, master's, doctoral and postdoctoral researchers across nanotechnology, microfluidics, catalytic micromotors, nanomembranes, hydrogel micro-/nanomotors, bio-inspired microstructures and device-oriented materials science. My mentoring approach combines increasing scientific ownership with explicit expectations for experimental controls, data quality, authorship and communication.

Trainees received multiple university, government and innovation awards, including the Shanghai MindMotion Scholarship, Outstanding Graduate Student recognition, Top Graduate Student Scholarship, Chinese Government Scholarship, Challenge Cup Silver Award and Pan-Sea Cup First Prize. Representative work included Hong Zhu's doctoral research on hydrogel materials and miniature robots; Jinrun Liu's research on microfluidic fabrication and transformable microrobots; Hong Chen's work on structurally coloured microbubbles; Xiaojie Shi's strain-engineered magnetic microswimmers; and Summayah Naeem's studies of catalytic micromotors made from inorganic nanomembranes.

Former trainees and postdoctoral researchers progressed to leading universities and industrial research environments in the United States, Europe and China; one former team member, Dr Jawayria Mujtaba, is now an associate professor at Anhui Normal University. In 2021, my mentoring service was recognised by Fudan University through the Top Ten Three Best Postgraduate Supervision Group award. I regard these outcomes as more meaningful than the number of people formally supervised: the objective is to help researchers become capable of framing problems, defending methods and eventually making scientific decisions independently.

4. Field Building, Editorial Leadership and Professional Service

4.1 Conferences, workshops and scientific community building

I have contributed to field-building through the organisation and leadership of international conferences, workshops and interdisciplinary scientific meetings in microfluidics, nanotechnology, nanomachines, microrobotics, materials science and

translational innovation. These activities have provided forums where experimentalists, theorists, engineers and application-focused researchers can identify shared problems and form collaborations around methods rather than disciplinary labels.

- Founding Chair, International Conference on Advances in Microfluidics (AIM 2026/2027), Brisbane: developed as a meeting connecting academia, industry and government across bioengineering, diagnostics, medicine, AgriTech, food, energy, devices and nanotechnology.
- Conference Chair, MARSS 2023 - IEEE International Conference on Manipulation, Automation, and Robotics at Small Scales, Abu Dhabi: chaired plenary activity, organised interdisciplinary panels and curated keynote sessions.
- Workshop Co-Organizer, 10 Years Celebration of Nanorockets, Fudan University: helped convene international researchers around a decade of progress in catalytic nanomotors and nanoscale propulsion.

I have delivered more than thirty invited presentations at universities, research institutes and international conferences, including MIT, University of Toronto, Max Planck Institute, University of Hong Kong, Chinese University of Hong Kong, LMU Munich, Columbia University, Technion, University of Melbourne and major meetings in nanomotors, soft matter, frontier materials and small-scale robotics. I treat invited speaking primarily as a mechanism for scientific exchange and network formation rather than as a standalone visibility metric.

4.2 Editorial leadership and peer review

My professional service includes extensive peer review across nanotechnology, materials science, microfluidics, chemistry, microrobotics, applied physics and bioengineering. I have reviewed for more than fifty international journals, including Nature Nanotechnology, Nature Communications, Advanced Materials, Advanced Functional Materials, ACS Nano, Nano Letters, Small, Nanoscale, Angewandte Chemie International Edition, Journal of the American Chemical Society, Progress in Materials Science, Materials Today, Accounts of Materials Research, ACS Catalysis, Lab on a Chip and Soft Matter. My reviewing focuses on scientific originality, methodological rigour, reproducibility, mechanistic interpretation and whether the evidence supports the scope of the claims.

I am the Founder and Editor-in-Chief of SciViD, a peer-reviewed platform for video-based scientific articles with DOI registration. Through SciViD I oversee editorial strategy, peer-review standards, author guidance, platform development and international outreach. Its purpose is to make experimental methods and dynamic observations more transparent, particularly in research areas where a static manuscript can omit critical procedural information. I also served as Guest Editor for Micromachines (2020-2021) for the special issue Dream Nanomachines and was invited in 2024 to serve as Guest Editor for the Springer Nature journal Applied Science, with an interdisciplinary scope covering advanced micro- and nanodevices, functional materials, sensors and fluidic systems.

5. Independent Platform Building and Innovation Ecosystems

A major recent extension of my service is the development of independent platforms that combine research mentoring, scientific validation, publishing and innovation training. NanoTRIZ Innovation Institute was established as an Australian platform for advanced research mentoring, project-based scientific development and translational innovation pathways. Its purpose is to connect fundamental research, systematic invention, evidence-based validation and, where appropriate, future institutional or industry partnerships.

NanoTRIZ educational programmes provide structured training in scientific problem solving, nanotechnology, microfluidics, AI-assisted research, intellectual property awareness and research communication. The model is intended to help students and early-career researchers move from an initial question to documented research outputs while keeping scientific responsibility with human researchers. The associated affiliate network is a mentoring and collaboration structure rather than a substitute for university employment, accredited degrees or formal doctoral supervision.

SciViD addresses a related challenge from the publishing side by emphasising visualised methods, dynamic experiments and transparent communication. In parallel, SciOS is being developed as a research-workflow concept in which scientific claims, evidence, assumptions, computational steps and validation decisions can be traced explicitly. These initiatives are different in function but share a common service objective: to make high-level research more reproducible, auditable and accessible without lowering evidential standards.

This platform-building work is deliberately interdisciplinary. It draws on my experience in materials science, microfluidics, micro/nanomachines, sensing, energy systems and scientific communication, while creating structures through which specialists can contribute without forcing every project into a single laboratory or disciplinary identity. The longer-term objective is to build research-training and innovation ecosystems that can operate across institutions and countries while preserving clear scientific governance.

6. Science-Policy, Public and Industry Engagement

6.1 Government-facing and science-diplomacy service

I have participated in government-facing science activities and discussions related to research collaboration, innovation strategy, talent development and the role of international experts in scientific development. In 2016 I was invited as a scientific delegate to the Great Hall of the People in Beijing for a meeting with Premier Li Keqiang and received formal acknowledgment from China's State Administration of Foreign Experts Affairs, signed by Vice Minister Zhang Jianguo, in connection with international expert exchange. I also participated in official Shanghai activities involving foreign experts and science and technology cooperation. In 2019 I held strategic discussions with Prof. Cai Jingmin, Party Secretary of Hefei University, concerning academic cooperation and institutional development.

From 2016 to 2018, I participated in international nanotechnology commercialisation engagement through the Jiangsu-Ontario Nanotech Innovation Center and Suzhou Industrial Park. In Australia, the 2025 acknowledgment of my proposed Brisbane microfluidics and droplet-technology innovation hub by the Lord Mayor and its referral to Brisbane Economic Development Agency provided a further opportunity to connect research capability with regional innovation discussions. I view such activities as useful when they are anchored in concrete scientific capabilities and realistic institutional mechanisms rather than general advocacy.

6.2 Public science communication and industry engagement

I have contributed to public understanding of nanotechnology, microfluidics and scientific innovation through writing, lectures, demonstrations, documentaries and media engagement. I authored popular-science articles for NanoWerk and other audiences, and my work has been featured by international media including ORF television, Zeit Wissen, PM and Bild. Public demonstrations in Germany reached live audiences of more than 1,000 participants. In 2023 I appeared as an invited expert commentator in a Chinese national television segment on clean-energy innovation and CO₂ conversion.

My industry-facing service has included work as Academic Advisor to C4X on CO₂ capture and conversion concepts, participation in nanotechnology commercialisation activities and engagement at the Suzhou Expo and Conference on Nanotechnology Development. Through NanoTRIZ, I continue to develop innovation-advisory pathways that connect systematic invention, scientific validation, intellectual-property awareness and translational development. The principle is the same as in my research: translation should follow evidence, and the appropriate outcome may be a scientific result, a method, a prototype, a patent concept, an industry collaboration or a decision not to proceed.

7. Selected Evidence of Service Impact

Service dimension	Selected evidence	Result / significance
International partnerships	MIT-Skoltech engagement; coordinating role in Fudan-Skoltech MoU	Created institutional mechanisms for research, education and innovation collaboration.
Researcher development	Graduate and postdoctoral mentoring; Fudan supervision-group recognition	Trainee awards, international progression and later professorial appointments.
Professional standards	Grant review; >50 journals; editorial roles	Contribution to research evaluation, peer review and reproducibility standards.
Scientific community building	AIM founder/chair; MARSS conference chair; nanorockets workshop	Cross-disciplinary forums spanning microfluidics, nanotechnology and small-scale robotics.
Independent platforms	NanoTRIZ; SciViD; AI-assisted research-workflow development	New pathways for research mentoring, scientific communication and structured validation.

8. Service Philosophy and Future Contribution

The common principle underlying my service is the creation of bridges that remain scientifically useful after the initial interaction: between disciplines, countries, universities and industry, research and education, scientific discovery and public understanding, and early-stage ideas and validated outcomes. I therefore prefer service activities with explicit mechanisms, responsibilities and evidence of follow-through.

My approach to leadership is distributed rather than excessively centralised. Strong programmes depend on scientists, engineers, technicians, students, editors and administrators having real ownership of their expertise within a coherent framework. Clear expectations for authorship, research integrity, calibration, uncertainty, data stewardship and decision-making are not separate from ambitious science; they make ambitious collaboration sustainable.

Going forward, I intend to contribute as both a researcher and a builder of research ecosystems: developing international collaborations around non-substitutable expertise; mentoring researchers toward independent scientific judgement; improving the transparency of experimental communication; and creating research-training and innovation pathways that connect rigorous science with responsible translation. The objective is long-term scientific, educational and institutional value rather than service activity for its own sake.

Operating principles in practice

Scientific ownership	Responsibility remains with the researcher closest to the evidence; collaboration should increase capability without obscuring contribution or accountability.
Traceable evidence	Claims should remain connected to methods, controls, calibration, uncertainty and the records needed to understand how a conclusion was reached.
Development through responsibility	Mentoring should progressively transfer problem framing, method selection, interpretation and communication to the researcher rather than create permanent dependence.
Collaboration by scientific dependency	Partnerships are strongest when each participant contributes expertise or infrastructure that is genuinely required by the question and cannot be replaced by nominal networking.
Translation after validation	Public, policy and industry engagement should follow the maturity of the evidence; a decision to narrow, redesign or stop can be as valuable as a prototype or commercial outcome.

These principles connect my service activity to the same standards that guide my research: explicit questions, transparent evidence, distributed expertise, reproducibility and decisions proportionate to what the data can support.

RESEARCH STATEMENT

Functional Micro/Nanosystems, Active Matter, Micro/Nanofluidics, Imaging for New Materials, Bio- and Energy Applications
Research achievements, scientific vision and three- to five-year development plan

Scientific vision

Scientific premise. My research develops functional materials, micro/nanosystems and quantitative experimental platforms in which geometry, built-in strain, curvature, interfacial organisation, confinement, acoustic response and nonequilibrium energy flow are treated as programmable variables alongside chemical composition. The central objective is to establish predictive links between materials architecture, interfaces, transport and measurable function, and to convert these relationships into experimental systems capable of measuring, perturbing and controlling physical, chemical and biological processes at the micro- and nanoscale. The programme therefore links micro/nanofabrication to instrument function through active micro/nanoscale probes, micro/nanofluidic sample handling, imaging-visible soft compartments, molecular sensing, quantitative microscopy and real-time feedback. Optical and video microscopy, ultrasound and multimodal imaging, electron microscopy, scanning-probe methods, electrochemical analysis, modelling and validated AI-assisted tracking are used not as separate techniques but as coupled measurement layers for resolving structure-property-function relationships and testing whether a signal is reproducible, specific and mechanistically defensible.

Distinctive research position. The programme builds on more than two decades of work spanning strain-engineered nanomembranes, catalytic and magnetic micro/nanorobotics, microfluidics, hydrogel capsules, microbubbles and phase-change nanodroplets, biosensing, liquid-interface electronics, catalytic microreactors and compact electrochemical systems. It is organised around six connected research platforms: strain-engineered three-dimensional micro/nanodevices; active micro/nanoscale probes and information-guided systems; micro/nanofluidics, programmable soft matter and multimodal imaging; biosensing and liquid-interface bioelectronics; responsive compartments and programmable microenvironments; and electrochemical microsystems for sensing and energy conversion. Laboratory automation and AI-assisted analysis connect imaging, state estimation and actuation in closed loop. Electron and scanning-probe microscopy remain important for structural and interfacial measurement. Single-molecule and force-spectroscopy questions are scientifically adjacent and are approached through collaboration with specialists rather than presented as established core expertise. Biomedical, environmental and energy applications are treated as distinct validation domains linked by common questions of transport, interfaces, reproducibility and quantitative function.

Common research logic. Each programme begins with a bounded hypothesis, measurable variables and explicit controls. Planar, passive, non-functional, compositionally matched or sham-actuated reference systems are used where appropriate to isolate mechanism; operating regimes, uncertainty, batch variation and failure modes are mapped; and models are retained only when they reproduce limiting cases and predict experiments not used for calibration. For biomedical directions, this logic is extended through a staged validation pathway: physical and chemical calibration first, then tissue-phantom or biomimetic testing, followed by cell or other biological validation only with the appropriate specialist collaborators, ethics and safety framework. AI-assisted image analysis, tracking or decision support may be used where it improves measurement or experimental design, but algorithmic outputs must remain traceable to primary data and independently checked. Applications follow from validated design rules rather than substituting for them; negative, ambiguous and non-reproducible outcomes are retained because they define the operating envelope of the technology.

Scientific architecture and unifying objective. Across the programme, micro/nanofluidics provides controlled transport and programmable experimental environments; optical and high-speed microscopy, ultrasound-compatible materials and quantitative tracking provide dynamic readout; active micro/nanosystems provide local perturbation and mobile-probe functions; biosensors and bioelectronics provide molecular transduction; electron and scanning-probe microscopy connect nanoscale structure and interfaces to device performance; and real-time feedback provides a route from passive observation to adaptive experimentation. The unifying objective is not to accumulate disconnected devices, but to establish quantitatively validated design rules linking fabrication history, material state and interfacial physics to transport, signal generation, actuation and experimental decision. Biological, environmental and energy applications are pursued where the mechanism, controls and validation pathway can be defined explicitly.

INTEGRATED RESEARCH PROGRAMME

Integrated future research architecture

Discover	Design	Simulate	Fabricate	Measure	Validate	Translate	Communicate
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No.	Research platform	Fundamental focus	Representative research directions
1	Strain-engineered 3D micro/nanodevices for sensing and actuation	Curvature, topology, multilayer strain, interfaces	Curved/rolled microdevices; sensor/actuator geometries; microfluidic components; nanoscale structure-function mapping; interfaces to EM/SPM and optical measurement
2	Active micro/nanoscale probes & information-guided systems	Nonequilibrium energy, fluctuations, field-material coupling, feedback	Image-guided probes; magnetic control; microobject/cell-scale perturbation; quantitative biophysics; AI-assisted tracking and closed-loop experimentation
3	Micro/nanofluidics, programmable soft matter & multimodal imaging	Multiphase flow, interfaces, viscoelastic shells, acoustic response	Microbubbles/nanodroplets; droplet and single-cell workflows; quantitative microscopy; ultrasound/multimodal readout; high-throughput measurement platforms

No.	Research platform	Fundamental focus	Representative research directions
4	Biosensing, liquid-interface bioelectronics & molecular readout	Screening, drift, surface chemistry, thin-film interfaces	FET/electrochemical sensing; microfluidic diagnostics; real-time molecular monitoring; sensor calibration; integration with automated data acquisition
5	Responsive compartments & programmable microenvironments	Reaction-diffusion, permeable matrices, transport control	Hydrogel/capsule microenvironments; controlled biochemical assays; high-throughput screening concepts; coupling to liquid handling and imaging automation
6	Electrochemical microsystems, sensing & self-powered instrumentation	Catalyst selectivity, wetting, bubbles, multiphase transport	Electrochemical bioanalytics; low-power microfluidic devices; sensor/energy co-design; interfacial diagnostics and robust instrument operation

ESTABLISHED SCIENTIFIC FOUNDATION

Research achievements and translational platforms

01

ENABLING RESEARCH PLATFORM

Strain-Engineered 3D Micro/Nanodevices for Sensing and Actuation

Established contribution. In my early research, strain-engineered thin films were established as a practical route for transforming lithographically patterned planar multilayers into three-dimensional microtubes, helices, rolled nanomembranes and integrated lab-in-a-tube architectures [Mei et al., *Adv. Mater.*, 20, 4085–4090, 2008; Mei et al., *Chem. Soc. Rev.*, 40, 2109–2119, 2011; Wan et al., *J. Mater. Chem.*, 22, 12983–12987, 2012]. These experimental results and subsequent reviews describe how residual stress can be used as a programmable materials-design parameter through which conventional two-dimensional microfabrication could be converted into precisely defined three-dimensional functional systems [Gulina et al., *Prog. Nat. Sci.: Mater. Int.*, 30, 279–288, 2020; Solovev, “Nanomembrane Robotics,” in *Nanomembranes: Materials, Properties, and Applications*, 253–285, 2022]. Rolled architectures were subsequently used to demonstrate catalytic micropropulsion, magnetic guidance, and the transport and delivery of micro-objects, establishing a direct link among thin-film mechanics, interfacial chemistry and controlled microscale motion [Solovev et al., *Small*, 5, 1688–1692, 2009; Solovev et al., *Adv. Funct. Mater.*, 20, 2430–2435, 2010; Solovev et al., *Phys. Chem. Chem. Phys.*, 13, 10131–10135, 2011]. These principles were extended to light-controlled propulsion, collective active behaviour, cell manipulation and magnetically driven microdrilling [Solovev et al., *Angew. Chem. Int. Ed.*, 50, 10875–10878, 2011; Sánchez et al., *Chem. Commun.*, 47, 698–700, 2011; Solovev et al., *Nanoscale*, 5, 1284–1293, 2013; Xi et al., *Nanoscale*, 5, 1294–1297, 2013]. My collaborative publications and the wider literature illustrate extensions towards biointerfaces, optical resonators, curved semiconductor structures, sensor arrays, helical microswimmers and cylindrical optical waveguides in dense buffer-gas environments [Vogl et al., *Phys. Rev. A*, 83, 053403, 2011; Bolaños Quiñones et al., *Adv. Biosyst.*, 2, 1800230, 2018; Ning et al., *Micromachines*, 9, 75, 2018; Naeem et al., *RSC Adv.*, 10, 36526–36530, 2020; Shi et al., *ChemNanoMat*, 7, 607–612, 2021]. The broader significance of this work is represented by the establishment of geometry, curvature and strain as design variables that can be engineered alongside composition to generate functions unavailable in equivalent planar materials. This foundation is directly relevant to functional micro/nanosystems because rolled and helical architectures provide a route to three-dimensional devices with built-in magnetic, catalytic, optical or fluidic function. My subsequent work extended these principles to cell manipulation, microscale transport, magnetic navigation and microfluidic operation, establishing a bridge from thin-film mechanics to controllable functional microdevices. Rather than treating nanomembranes only as a materials-physics topic, the future programme uses them as an enabling fabrication technology for miniaturised actuators, sensor interfaces, microfluidic components and microrobotic structures whose geometry can be designed for a specific experimental task.

Fundamental question. The central question is how magnetic, optical, electronic, catalytic and transport behaviour is reorganised by residual stress, curvature, topology, multilayer sequence, thickness, confinement and interfacial adhesion relative to compositionally matched planar structures. Elastic and electromagnetic fields may be redistributed by curvature; demagnetising factors may be modified; carrier and exciton transport may be altered; catalytic accessibility may be changed; optical modes may be concentrated; and coupling between internal and external fluidic environments may be introduced [Vogl et al., *Phys. Rev. A*, 83, 053403, 2011; Wan et al., *J. Mater. Chem.*, 22, 12983–12987, 2012; Li et al., *Angew. Chem. Int. Ed.*, 57, 3772–3776, 2018; Ning et al., *Micromachines*, 9, 75, 2018]. These effects, however, may be confounded by surface chemistry, structural defects, strain relaxation, etching, delamination and release-induced damage. Genuine curvature- and strain-dependent function must therefore be isolated through compositionally matched planar controls, calibrated mechanical characterisation, independently fabricated batches and quantitatively predictive modelling [Bolaños Quiñones et al., *Adv. Biosyst.*, 2, 1800230, 2018; Gulina et al., *Prog. Nat. Sci.: Mater. Int.*, 30, 279–288, 2020]. For future deployment, an additional question is which of these geometry-dependent effects remain reliable in aqueous, protein-rich and cell-containing environments, where fouling, ionic screening, viscoelasticity and biological interfaces can alter the response. The relevant engineering objective is therefore not miniaturisation alone, but a reproducible mapping from fabrication history to physical response under the conditions in which sensing, actuation, transport or imaging would actually be performed.

Next-stage programme. Stress-thickness-curvature maps will first be established for independently fabricated semiconductor, metallic, dielectric and hybrid multilayers and compared with analytical and finite-element predictions. Reproducible operating regimes, instability thresholds and defect-sensitive failure modes will thereby be identified [Wan et al., *J. Mater. Chem.*, 22, 12983–12987, 2012; Gulina et al., *Prog. Nat. Sci.: Mater. Int.*, 30, 279–288, 2020]. Magnetic and magneto-elastic films will then be incorporated into rolled and helical structures so that curvature-dependent anisotropy, field-driven reconfiguration and mechanically coupled magnetic response can be quantified [Solovev et al., *Adv. Funct. Mater.*, 20, 2430–2435, 2010; Xi et al., *Nanoscale*, 5, 1294–1297, 2013; Shi et al., *ChemNanoMat*, 7, 607–612, 2021]. A biologically oriented branch will place selected structures in microfluidic environments representing confinement, flow and boundary conditions relevant to cell-scale transport. Functional coatings, catalytic interfaces and embedded electrical or wireless readout will be introduced only where a defined coupling mechanism can be tested [Mujtaba et al., *Adv. Mater.*, 33, 2007465,

2021; Mohan et al., Adv. Funct. Mater., 34, 2405231, 2024]. Biological interaction studies would proceed only after mechanical, magnetic and surface stability are established and would be undertaken with appropriate specialist collaborators.

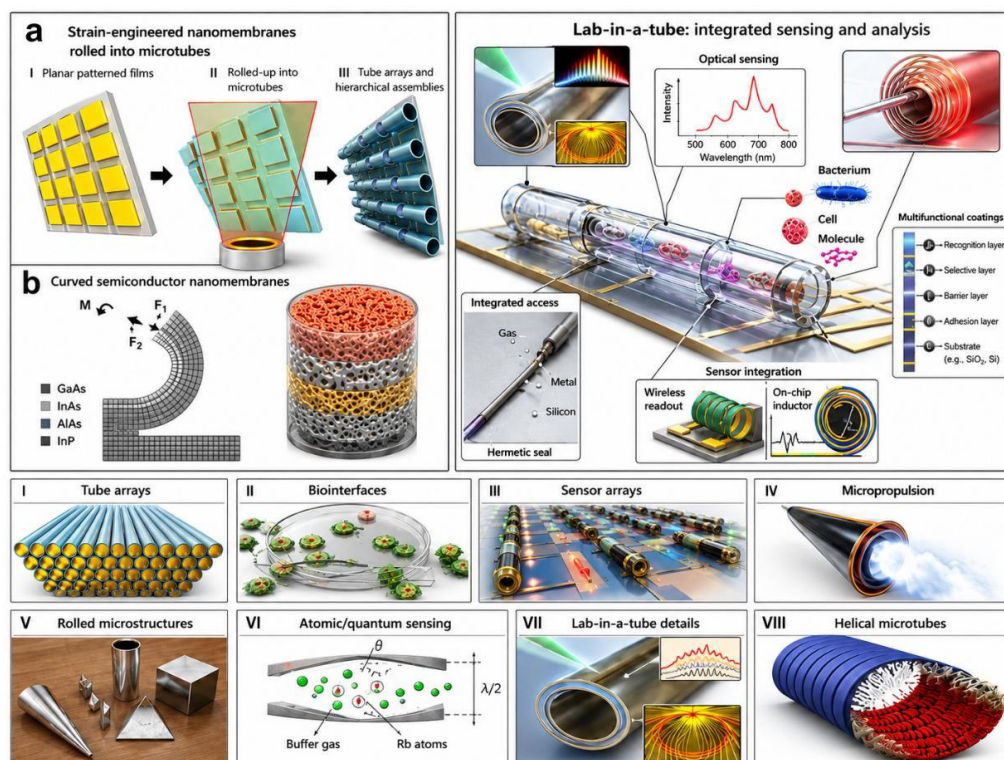


Figure 1. Geometry- and strain-programmed nanomembranes for three-dimensional micro/nanosystems. The composite brings together published examples and conceptual extensions of rolled multilayers, curved structures, lab-in-a-tube systems, biointerfaces, sensing, propulsion and optical cavities. In the future programme, these examples serve as an enabling fabrication library for microrobotic probes, micro/nanofluidic elements and sensor/actuator interfaces; the cited studies provide the evidence for individual examples and the composite does not imply that all functions have been demonstrated in one integrated device.

Expected scientific outcome and enabling technologies. Transferable stress-to-curvature and curvature-to-function relationships will be established so that fabrication parameters can be connected directly to measurable magnetic, optical, electronic, catalytic and transport performance. The principal engineering outcome will be a design framework for three-dimensional microrobotic probes, compact sensor geometries, micro/nanofluidic actuators and lab-in-a-tube or lab-on-chip components whose measurement limits are defined before biological use. These design rules can support magnetic navigation, local perturbation, on-chip manipulation, biosensing and image-visible microdevices. The same platform creates natural interfaces to advanced electron microscopy, scanning-probe microscopy, nanofabrication and optical-characterisation methods because curvature and interfaces can be correlated with independently measured structure and local function.

Established contribution. Within my research, catalytic micro-/nanomotors were established as experimentally controllable nonequilibrium systems in which chemical reactions, structural asymmetry, interfacial transport and external fields are converted into directed motion. Rolled-up catalytic microtubular jet engines were demonstrated in which propulsion was generated through the accumulation and expulsion of oxygen bubbles produced by hydrogen-peroxide decomposition, providing an early platform for autonomous microscale motion [Solovev et al., Small, 5, 1688–1692, 2009; Sánchez et al., Chem. Rec., 11, 367–370, 2011]. Magnetic layers were subsequently incorporated into tubular catalytic microbots, enabling remote steering, transport, assembly and delivery of micro-objects and thereby coupling catalytic energy conversion to programmable external control [Solovev et al., Adv. Funct. Mater., 20, 2430–2435, 2010]. Propulsion at air–liquid interfaces, light-regulated velocity, low-concentration micropumping, navigation in flowing microchannels, manipulation of multiple cells and collective motor behaviour were also demonstrated [Solovev et al., Adv. Mater., 22, 4340–4344, 2010; Solovev et al., Angew. Chem. Int. Ed., 50, 10875–10878, 2011; Solovev et al., Phys. Chem. Chem. Phys., 13, 10131–10135, 2011; Sánchez et al., J. Am. Chem. Soc., 2011; Sánchez et al., Chem. Commun., 47, 698–700, 2011; Solovev et al., Nanoscale, 5, 1284–1293, 2013]. Through later collaborative work, the materials basis of active matter was broadened to include catalytic–magnetic rolled assemblies, hydrogel micromotors, light-controlled TiO₂ plate motors, nanoparticle-shelled catalytic bubbles, strain-engineered helical microswimmers and magnetically propelled soft robots operating in confined channels [Zhu et al., J. Phys.: Condens. Matter, 31, 214004, 2019; Wang et al., RSC Adv., 9, 29433–29439, 2019; Naeem et al., RSC Adv., 10, 36526–36530, 2020; Adams et al., Adv. Mater. Interfaces, 7, 1901583, 2020; Shi et al., ChemNanoMat, 7, 607–612, 2021; Liu et al., Appl. Mater. Today, 25, 101237, 2021]. Recent collaborative work on magnetic bubble micromotors and dynamic self-assembly at liquid–gas interfaces was presented at the APS Global Physics Summit [Halpern et al., 19 March 2026, abstract MAR-S64.11]. This is a conference contribution; the abstract lists a planned journal submission, which is distinct from an accepted journal publication. Collectively, the experiments and reviews motivate the proposed investigation of active materials whose trajectories may encode information about chemical gradients, hydrodynamic flow, viscosity, confinement, boundaries, external fields and neighbouring objects [Mujtaba et al., Adv. Mater., 33, 2007465, 2021; Yan et al., Curr. Opin. Colloid

Interface Sci., 61, 101609, 2022; Chen et al., Next Nanotechnol., 2, 100019, 2023]. Several of these systems already intersect directly with biomedical microrobotics: magnetic microbots were used for transport and assembly of micro-objects; catalytic microbots were studied in flowing microfluidic channels and for manipulation of multiple cells; self-propelled nanotools and magnetic microdrillers established geometry-dependent motion and minimally invasive mechanical interaction; later soft microrobots and hydrogel micromotors extended the materials space toward compliant systems. In parallel, my collaborative work addressed ultrafast ultrasound imaging of micro/nanomotors in a phantom and real-time imaging/tracking approaches, creating a basis for connecting actuation with clinically relevant imaging modalities rather than relying only on optical microscopy.

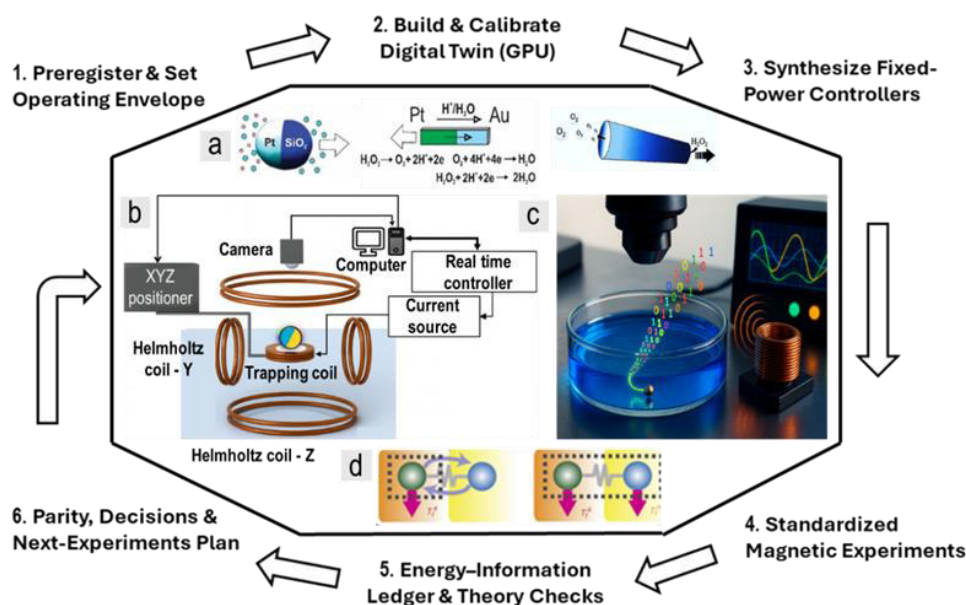


Figure 2. Active micro/nanorobotics and information-guided control. Published propulsion and magnetic-control concepts are combined with a proposed experiment-to-theory workflow involving real-time tracking, controlled fields, digital-twin/GPU modelling and active/passive comparison. The same architecture provides a controlled test bed for image-guided navigation, closed-loop steering and quantitative decision rules in microfluidic, complex-fluid or tissue-mimicking environments. The closed-loop, AI and computational elements illustrate the planned research architecture and are not presented as a completed, clinically validated system.

Fundamental question. The central question is when an active micro/nanorobot can be regarded as a controllable, information-bearing physical system rather than merely as a driven particle. For navigation or targeted interaction, environmental information must improve a measurable outcome relative to energy-matched open-loop actuation. The trade-offs among sensing accuracy, actuation strength, rotational diffusion, hydrodynamic disturbance, wall interactions, measurement uncertainty and feedback bandwidth determine whether closed-loop control adds genuine function. In biological or tissue-mimicking media, additional confounders include protein adsorption, non-Newtonian rheology, cellular obstacles, background motion and image-quality limitations. Operational criteria will therefore distinguish passive response, selective sensing, state estimation, feedback-dependent navigation and information-mediated work. This preserves the fundamental active-matter and stochastic-thermodynamics direction while providing a controlled, application-relevant test bed: can a microsystem use measured information to navigate, position, manipulate or report on a local environment more effectively than an otherwise equivalent open-loop system?

Next-stage programme. Catalytic, enzymatic, magnetic or hybrid active particles will be operated within microfluidically defined chemical, geometric and hydrodynamic landscapes that progressively move from simple channels to biomimetic confinement. Position, orientation, velocity, interaction with boundaries and task completion will be recorded by high-speed optical imaging and, where suitable, ultrasound-compatible tracking under real-time magnetic-field control. Passive-particle, noncatalytic, open-loop, closed-loop, time-shuffled and no-feedback conditions will be compared so that information-dependent performance can be distinguished from drift, convection, local heating or image-analysis error. AI-assisted segmentation and tracking may be used to improve temporal resolution, but the primary performance metrics will remain physically defined and auditable. Early benchmark tasks would include navigation to a defined target region, transport of model cargo, controlled contact with cell-sized objects and motion through constricted channels; cell or tissue studies would follow only with appropriate biological collaborators and safety controls. Mutual information, transfer entropy, first-passage time, entropy production and energy-per-task metrics will be evaluated only when they can be connected to calibrated observables and explicit system boundaries.

Expected scientific outcome and enabling technologies. The programme will establish experimentally validated operating maps linking propulsion, magnetic actuation, stochastic fluctuations, imaging quality, sensing accuracy, feedback bandwidth and energetic cost. The principal outcome is an active-probe platform in which navigation, local perturbation and information acquisition are evaluated quantitatively rather than described qualitatively. Enabling technologies may include image-guided microrobotic probes, active chemical or hydrodynamic sensors, microfluidic models of confined transport, trajectory-to-field reconstruction, adaptive control and automated experiments in which the next perturbation is selected from the measured system state. The fundamental active-matter direction remains important: micro/nanomachines will also serve as model systems for investigating how energy, information, interfacial physics and feedback couple in nonequilibrium matter. This dual role - measurement technology and physical model system - is central to the future research programme.

Established contribution. Within my research programme and collaborative work, microfluidically generated droplets, microbubbles, phase-change nanodroplets, hydrogel capsules and particle- or protein-stabilised interfaces were developed as programmable functional compartments. Dynamic pH-responsive hydrogel capsules were produced with controllable swelling and molecular release, while catalyst-containing hydrogel micromotors and photocatalytic microcapsules were established for active transport and pollutant removal [Werner et al., *Macromolecules*, 51, 5798–5805, 2018; Zhu et al., *J. Phys.: Condens. Matter*, 31, 214004, 2019; Liu et al., *Environ. Sci.: Nano*, 7, 656–664, 2020]. Nanoparticle-shelled catalytic bubbles, structurally coloured hydrogel microbubbles and protein-stabilised microbubbles were subsequently developed to connect interfacial assembly with propulsion, optical response and mechanical stability [Adams et al., *Adv. Mater. Interfaces*, 7, 1901583, 2020; Chen et al., *Adv. Opt. Mater.*, 9, 2100259, 2021; Barmin et al., *Colloids Surf. A*, 647, 129095, 2022; Dhara et al., *iScience*, 27, 109286, 2024]. Collaborative preclinical materials and imaging studies included gold-nanocage- and photosensitiser-functionalised microbubbles, albumin-based theranostic bubbles and multilayer polymer-shell perfluoropentane nanodroplets for ultrasound, magnetic-resonance and optoacoustic imaging [Barmin et al., *Nanomaterials*, 11, 415, 2021; Maksimova et al., *Micromachines*, 12, 1161, 2021; Barmin et al., *Colloids Surf. B*, 219, 112856, 2022; Maksimova et al., *Laser Photonics Rev.*, 17, 2300137, 2023]. Collectively, these systems established compartment and interface engineering as a common foundation for biomedical imaging, triggered release, environmental catalysis and adaptive soft materials. A distinctive feature of this direction is that my collaborative portfolio includes ultrasound-related systems at several levels: microbubble and nanodroplet materials for multimodal imaging, an ultrafast-ultrasound phantom study of micro/nanomotors, and participation in a BRICS STI project on bioactive ultrasound-driven microbubbles for theranostics. These activities connect microfluidic fabrication to acoustic function and provide a basis for designing particles or compartments whose composition, size and shell mechanics are selected for an imaging or delivery task rather than for morphology alone.

Fundamental question. The central question is how fabrication history, hydrodynamic breakup, interfacial assembly, shell composition, crosslink density and molecular state determine compartment size, viscoelasticity, permeability, gas retention, acoustic response, optical behaviour and structural failure. Flow-rate ratio, capillary number, viscosity ratio and channel geometry govern droplet and bubble formation, whereas particle packing, protein conformation, polymer-network structure and shell thickness regulate mechanical stability and molecular transport. For ultrasound and theranostic applications, these variables additionally determine resonance, vaporisation or cavitation thresholds, circulation-relevant stability, acoustic contrast and the possibility of triggered release. Small changes in protein nativity, fluorescent functionalisation or interfacial composition may produce large differences in shell lifetime and acoustic response even when the nominal formulation is similar [Barmin et al., *Colloids Surf. A*, 647, 129095, 2022; Dhara et al., *iScience*, 27, 2024]. The engineering challenge is therefore to replace empirical formulation with quantitative process-structure-acoustic-function relationships while explicitly separating size, loading and shell chemistry effects.

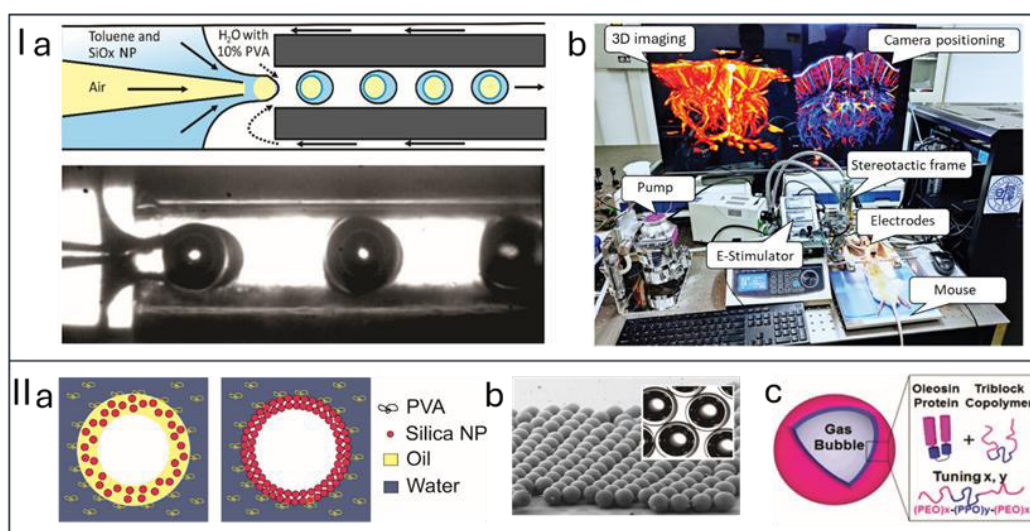


Figure 3. Microfluidic soft matter for micro/nanofluidic measurement, multimodal imaging and controlled transport. Examples from the cited collaborative studies illustrate flow-focused generation, particle-stabilised interfaces, capsule arrays, shell engineering and imaging approaches. In the future programme these principles are prioritised for microbubbles, nanodroplets, responsive capsules and other ultrasound-/imaging-visible systems, while environmental catalytic capsules remain a parallel application. The examples are distinct materials and experimental studies; the composite does not represent a single clinically validated platform.

Next-stage programme. Microfluidic operating maps will be established by varying flow-rate ratio, capillary number, viscosity ratio, channel geometry, interfacial composition and crosslinking conditions across independently fabricated batches. High-speed microscopy will quantify breakup regimes, size distributions, satellite droplets, coalescence and shell defects, while mechanical deformation, ultrasound excitation and optical measurements will be synchronised to determine shell elasticity, resonance, cavitation/vaporisation thresholds and structural failure [Yan et al., *IEEE International Ultrasonics Symposium*, 1-4, 2021; Chen et al., *Adv. Opt. Mater.*, 9, 2100259, 2021]. Permeability, release kinetics, gas retention and storage ageing will be measured using population-level statistics rather than selected representative particles. A staged validation route will progress from calibrated phantoms to cell-compatible or tissue-mimicking systems with relevant collaborators. Ultrasound and optoacoustic response, multimodal visibility, triggered release and material stability will be evaluated separately so that one strong modality does not conceal failure in another. The environmental-capsule branch will remain active as a parallel application of the same compartment-engineering principles, providing useful controls for catalyst retention, reuse and transport.

Expected scientific outcome and enabling technologies. Predictive fabrication-structure-function maps will be established for droplets, microbubbles, phase-change nanodroplets and adaptive capsules. Quantitative relationships will connect shell composition, mechanical

properties, permeability, acoustic response, optical behaviour, loading and failure probability, allowing reproducibility and stability to become explicit design variables. Enabling technologies may include calibrated ultrasound/optoacoustic contrast agents, imaging-visible compartments, droplet-based assays, artificial cell-like microenvironments and microfluidically manufactured standards for instrument calibration or method comparison. This platform creates a direct bridge between micro/nanofluidic fabrication and quantitative imaging, and can be combined with automated liquid handling or high-content microscopy when higher throughput is scientifically justified.

04

CORE MEASUREMENT PLATFORM

Biosensing, Liquid-Interface Bioelectronics & Molecular Readout

Established contribution. My early research included functionalised silicon-on-insulator thin-film resistors for biosensing applications, the subject of my master's thesis recorded in the Walter Schottky Institute annual report for 2005. This provides a foundation in semiconductor-based sensing and surface functionalisation. Later collaborative work broadened my perspective through analytical materials, biomarker detection and reviews of molecular ligands, porous frameworks, nanocomposites and wireless sensing [Kumar et al., *Microchem. J.*, 180, 107561, 2022; Mohan et al., *TrAC Trends Anal. Chem.*, 159, 116921, 2023; Mohan et al., *TrAC Trends Anal. Chem.*, 170, 117436, 2024; Mohan et al., *Adv. Funct. Mater.*, 34, 2405231, 2024; Mohan et al., *Vietnam J. Chem.*, 2025, DOI: 10.1002/vjch.202300399 and 10.1002/vjch.202300401]. The reviews contribute scientific synthesis and identification of research opportunities; they do not establish a new experimental SOI transistor platform. Building on this combination of early device experience and later analytical expertise, I propose to investigate liquid-interface transduction in which semiconductor geometry, surface chemistry and microfluidic delivery are studied as a coupled physical system. My more recent collaborative portfolio also includes electrochemical composite-nanomaterial approaches for cancer-biomarker detection and reviews of wireless and nanocomposite sensing architectures. Together with earlier silicon-on-insulator biosensor work, these activities create a continuous research line from surface functionalisation and semiconductor/liquid interfaces to microfluidic sample delivery, electrochemical transduction and portable analytical devices. The future sensing programme uses this foundation to focus not simply on sensitivity, but on specificity, drift, matrix effects, reproducibility and the ability to make a defensible decision from a small and potentially complex sample.

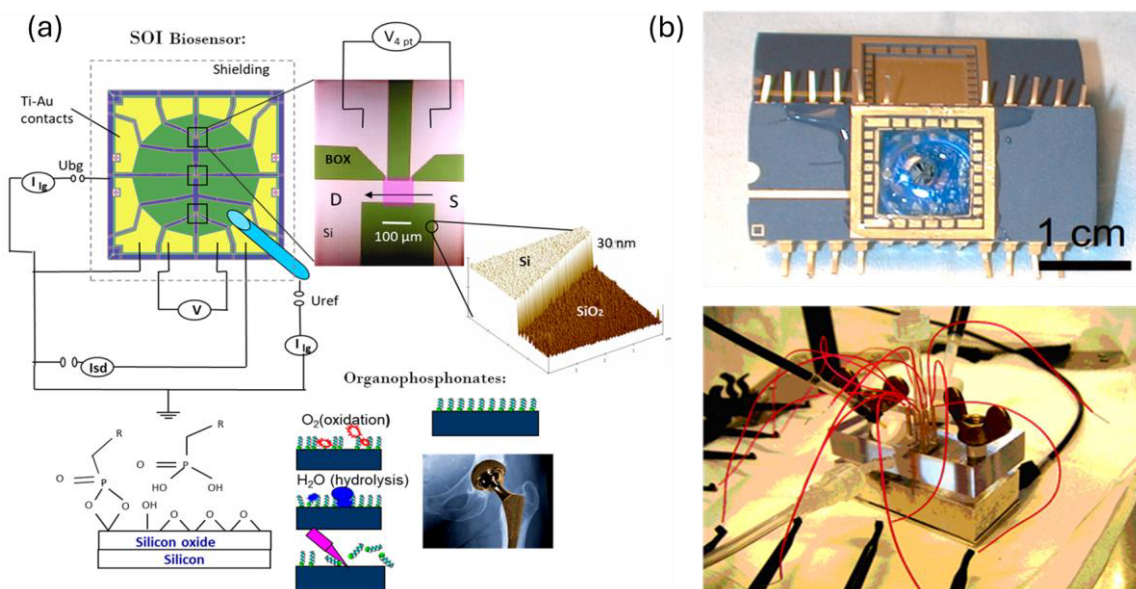


Figure 4. Thin-film bioelectronics, liquid-interface sensing and microfluidic precision diagnostics. The composite illustrates SOI device geometry, surface chemistry, sensor packaging and fluidic/electrical measurements. It provides context for the proposed programme in biomarker sensing, portable diagnostics and on-chip measurement; later review articles cited in the text contribute analytical perspective but do not establish all illustrated elements as a single experimentally demonstrated diagnostic platform.

Fundamental question. The central question is how reliable biomolecular transduction is governed by the combined effects of semiconductor or electrode geometry, interfacial charge density, electrolyte ionic strength, Debye screening, receptor packing, surface ageing, reference-electrode configuration, nonspecific adsorption and microfluidic delivery. Apparent sensitivity alone is insufficient because baseline drift, hysteresis, trapped gas bubbles, leakage current, pH variation, fouling and degradation of the recognition layer may generate signals comparable to those produced by specific molecular binding. Precision diagnostics adds another requirement: the system must distinguish biologically meaningful variation from device-to-device and run-to-run variation. The programme will therefore test when electrical, electrochemical or optical changes can be attributed quantitatively to a target interaction and when they should instead be treated as unresolved sample- or device-dependent effects.

Next-stage programme. Self-referenced and multiplexed sensor arrays will be developed with target-specific, nonspecific-control and calibration channels exposed to the same microfluidic environment. Field-effect, electrochemical, impedance and, where useful, optical or fluorescence readouts will be compared so that true binding events can be distinguished from changes in ionic strength, pH, flow or surface state. Performance will be quantified through signal change together with baseline drift, low-frequency noise, response and recovery kinetics, selectivity, inter-device variability and operational lifetime. Organophosphonate monolayers and alternative attachment chemistries will be compared under controlled aqueous ageing, while receptor density, electrolyte composition and flow rate are varied independently. The biomedical application layer will prioritise molecular and cancer-biomarker assays already represented in my publication record, while remaining open to molecular targets selected with relevant life-science or clinical

collaborators. AI-assisted classification may be explored only after the physical sensor response, data provenance and independent test sets are established.

Expected scientific outcome and enabling technologies. The objective is a validated model connecting interfaces, electrostatic screening, sample transport, packaging and drift to stable sensor operation. Quantitative operating windows will be defined in which molecular binding or electrochemical reaction can be resolved above nonspecific adsorption, device noise and matrix variation. The resulting design rules are expected to enable multiplexed microfluidic diagnostics, biomarker detection, repeated molecular monitoring, portable bioanalytical devices and sensor modules that can be integrated with imaging or active-probe experiments. A second outcome will be methodological: diagnostic performance will be reported together with uncertainty, negative controls, calibration history and failure modes. This creates natural interfaces with biosensor, bioelectronics, lab-on-chip and nanophotonic measurement research while keeping the scientific contribution focused on physically validated transduction and system integration.

05

CROSS-CUTTING PLATFORM
Responsive Compartments & Programmable Microenvironments

Established contribution. Microfluidic compartment engineering was extended through collaborative research to catalyst immobilisation, pollutant transformation and responsive chemical processing. Photocatalytic nanoparticles were confined within permeable hydrogel microcapsules, allowing molecular exchange while retaining photocatalysts in permeable compartments, with recovery and repeated use motivating further evaluation [Liu et al., Environ. Sci.: Nano, 7, 656–664, 2020]. Dynamic pH-responsive hydrogel networks were established as a means of regulating swelling, permeability and molecular release [Werner et al., Macromolecules, 51, 5798–5805, 2018]. Experimental collaboration on TiO₂ nanosheets broadened the catalyst perspective. Complementary reviews of metal-decorated CeO₂ nanomaterials, metal-organic frameworks and hydrogen-bonded organic frameworks assessed the wider literature on photocatalysis, molecular capture and analytical monitoring [Edy et al., Prog. Nat. Sci.: Mater. Int., 26, 493–497, 2016; Madaan et al., Inorg. Chem. Commun., 146, 110099, 2022; Mohan et al., TrAC Trends Anal. Chem., 170, 117436, 2024; Virender et al., Top. Curr. Chem., 383, 3, 2025]. The experimental capsule studies establish a basis for recoverable microscale reactors, while the reviews help identify candidate materials and unresolved mechanisms for future investigation. Their integration into a common responsive reactor remains a proposed research direction. Although the original application focus of this work was environmental catalysis, the underlying platform is broader: permeable hydrogel compartments, controllable reaction-diffusion, retained particles and microfluidic residence times are also useful for constructing small-volume biochemical reaction environments. In the future programme, this direction is developed as a platform for responsive microenvironments, controlled reaction-diffusion and automated measurement workflows. Hydrogel or capsule systems can define local transport, exposure and reaction conditions for small-volume biochemical assays, while the same architecture can serve as a reproducible test object for microscopy, sensing or microfluidic control. Environmental catalysis remains an independent application branch that contributes transferable reaction-diffusion, retention and compartment-engineering insight.

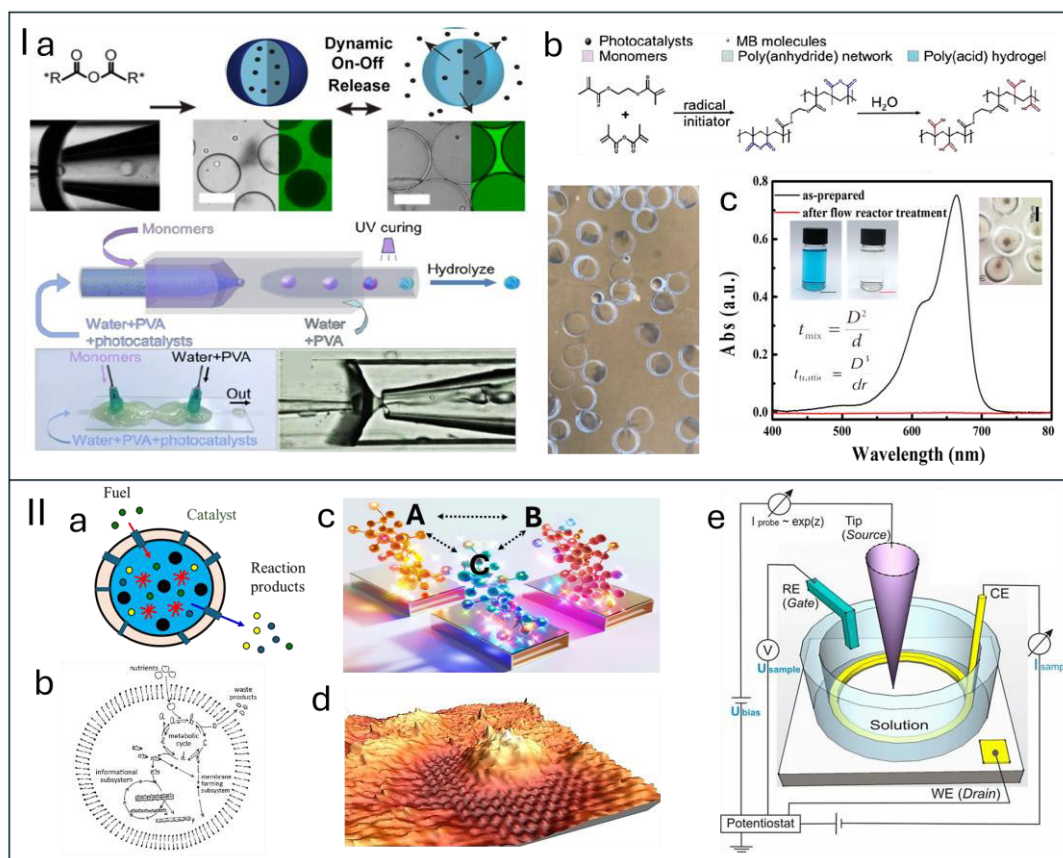


Figure 5. Responsive compartments and catalytic microreactors across biomedical and environmental applications. The composite brings together published and collaborative examples of capsule synthesis, responsive shells, mixing and diffusion, catalytic compartments and electrochemical monitoring. In the future programme, these principles would support both controlled biochemical/efficacy-safety assay environments and the continuing environmental-catalysis research line. Individual measurements refer to their original systems and conditions; they are not new comparative biomedical data.

Fundamental question. The central question is how reaction-diffusion behaviour is altered when catalysts, enzymes, porous frameworks, nanoparticles or other functional components are confined within a permeable and deformable matrix. Capsule diameter, shell thickness, porosity, crosslink density, surface charge, swelling and internal loading may improve retention and create favourable local reaction environments, but may also restrict molecular transport and generate internal concentration, oxygen or pH gradients. In environmental systems, apparent pollutant removal may additionally arise from adsorption or photolysis rather than catalytic conversion. In biomedical assay systems, an apparent change in cell or molecular response may likewise arise from transport limitation, adsorption, compartment chemistry or material toxicity rather than the intended mechanism. The programme will therefore determine how compartment architecture governs the balance among mass transfer, functional accessibility, reaction kinetics, leaching, local microenvironment and structural stability.

Next-stage programme. The platform will be developed through two linked experimental arms. In the environmental arm, encapsulated and freely dispersed catalysts will continue to be compared using catalyst-free, dark, adsorption-only, polymer-only and matched bulk-reactor controls; capsule size, shell thickness, catalyst loading, porosity, illumination intensity and residence time will be varied systematically. Quantitative mass balances, reaction-intermediate analysis, mineralisation measurements, catalyst-leaching assays and repeated-use cycles will be combined with calibrated optical or electrochemical readout. In the biomedical-assay arm, microfluidic compartments will be adapted to well-defined biochemical or drug-response assays in which transport, exposure time, adsorption and material background are independently controlled. Candidate responsive matrices or particle-loaded compartments would first be assessed for stability and nonspecific effects before any biological interpretation. Where biological interpretation is required, work would interface with appropriate life-science or clinical collaborators so that assay design reflects a meaningful biological question rather than purely engineering convenience.

Expected scientific outcome and enabling technologies. Quantitative relationships among compartment architecture, reaction-diffusion transport, functional-material retention, molecular exposure and dynamic permeability will be established. In the environmental branch these relationships will distinguish adsorption from genuine catalytic degradation and define operating windows for catalyst recovery and reuse. In the biomedical-assay branch they can support controlled microreactors for biochemical screening, drug-exposure studies, microenvironment engineering and high-throughput assay development, provided that biological readouts are validated by the appropriate specialists. Enabling technologies may therefore span reusable photocatalytic capsule beds, flow-through environmental microreactors, responsive water-treatment materials, microfluidic biochemical reactors, assay compartments and portable optical/electrochemical devices. Retaining both branches is scientifically useful because they share the same core problems - transport, retention, fouling, reaction kinetics and material stability - while imposing different validation requirements.

06

CROSS-CUTTING PLATFORM
Electrochemical Microsystems, Sensing & Self-Powered Instrumentation

Established contribution. Catalytic microtubes and hydrogen-peroxide-driven microsystems were established as compact platforms in which heterogeneous reaction, gas evolution and microscale transport are coupled [Solovev et al., *Small*, 5, 1688–1692, 2009; Solovev et al., *Phys. Chem. Chem. Phys.*, 13, 10131–10135, 2011]. This foundation was subsequently extended through experimental work on membraneless hydrogen-peroxide fuel cells and porous carbon-fibre electrodes, together with a collaborative review of peroxide fuel-cell materials and operating principles [Zhu et al., *JoVE*, e65920, 2023; Mujtaba et al., *Adv. Mater. Technol.*, 9, 2302052, 2024]. Experimental studies of Co₉S₈ nanoparticles, Pt-containing metal-organic-framework nanosheets and Pt microscrolls provide additional experience in catalyst synthesis and electrochemical evaluation. A collaborative review of atomic-layer deposition extends this perspective to energy materials. These studies motivate future comparisons of activity, charge transfer, accessible area and electrode stability [Mujtaba et al., *ACS Appl. Nano Mater.*, 4, 1776–1785, 2021; Zhao et al., *Electrochem. Energy Rev.*, 5, 31, 2022; Chen et al., *Sustain. Energy Fuels*, 7, 5120–5128, 2023; Tolstoy et al., *Chem. Commun.*, 60, 3182–3185, 2024]. Hydrogen-evolution electrocatalysts and peroxide-propelled Pt scrolls would require separate testing before their suitability as selective peroxide fuel-cell electrodes could be established. Within this research line, micropumping is treated as a secondary transport effect, whereas selective peroxide electrocatalysis and interfacial regulation remain principal mechanistic questions. A second axis of this energy-conversion programme is low-power and self-powered analytical instrumentation. My broader record in electrochemical sensing and biomarker detection provides a second bridge: the same principles of electrode architecture, surface chemistry, wetting, gas management and signal stability that determine fuel-cell performance also govern the reliability of many electrochemical biosensors. The research direction would therefore retain fundamental peroxide-fuel-cell and electrocatalysis studies while selectively integrating them with portable sensing, microfluidic instrumentation and bioelectronic device concepts where there is a clear systems-level advantage.

Fundamental question. The central question remains how useful electrochemical output, selectivity and operational stability are governed by the coupled effects of catalyst composition, electrode architecture, interfacial chemistry, wetting, gas evolution and mass transport. In membraneless peroxide fuel cells, mixed potentials, reactant crossover and parasitic decomposition must be suppressed through selective electrocatalysis rather than membrane separation. In electrochemical sensing, an analogous problem appears as interference, fouling, background current and transport-dependent signal distortion. Surfactants and surface modifiers may improve wetting and gas removal yet block active sites or alter the double layer. The common scientific problem is therefore to determine when an interfacial modification improves the intended electron-transfer pathway and when it merely changes transport or background response. This creates a coherent electrochemical research line spanning energy conversion and precision analytical microsystems without conflating their application requirements.

Next-stage programme. Selective anodic and cathodic electrocatalysts will continue to be synthesised and evaluated using matched electrode geometries and controlled electrolyte conditions. Catalyst composition, particle size, porosity, loading and support chemistry will be varied independently from surfactant identity, concentration, adsorption behaviour, contact angle and gas-evolution rate. Polarisation curves, power-density measurements, impedance spectroscopy, faradaic-efficiency analysis and product quantification will be synchronised with high-speed bubble imaging and post-operation surface characterisation. In parallel, selected electrode architectures will be tested as low-power or self-powered interfaces for microfluidic analytical modules, with sensing performance reported separately from energy-generation performance. Any claim of intrinsic catalytic or sensing improvement will require justified

active-area calibration, transport controls and appropriate interferent tests. This dual-track design preserves the fundamental energy-conversion work while creating a rigorous path toward portable precision-diagnostic devices.

Expected scientific outcome and enabling technologies. The programme will establish catalyst-structure-selectivity maps and interfacial wetting-performance relationships for peroxide fuel cells and related electrochemical systems. Operating windows will be defined in which selective electron-transfer pathways are preserved, parasitic decomposition or interference is minimised, gas removal remains stable and useful electrical or analytical output is maximised. The resulting design rules may enable compact membrane-free power sources, self-powered or low-power sensors and integrated microfluidic modules. Within the broader programme, this platform contributes interfacial measurement methods and sensor/energy co-design principles while preserving fundamental energy-conversion research as an independent scientific direction.

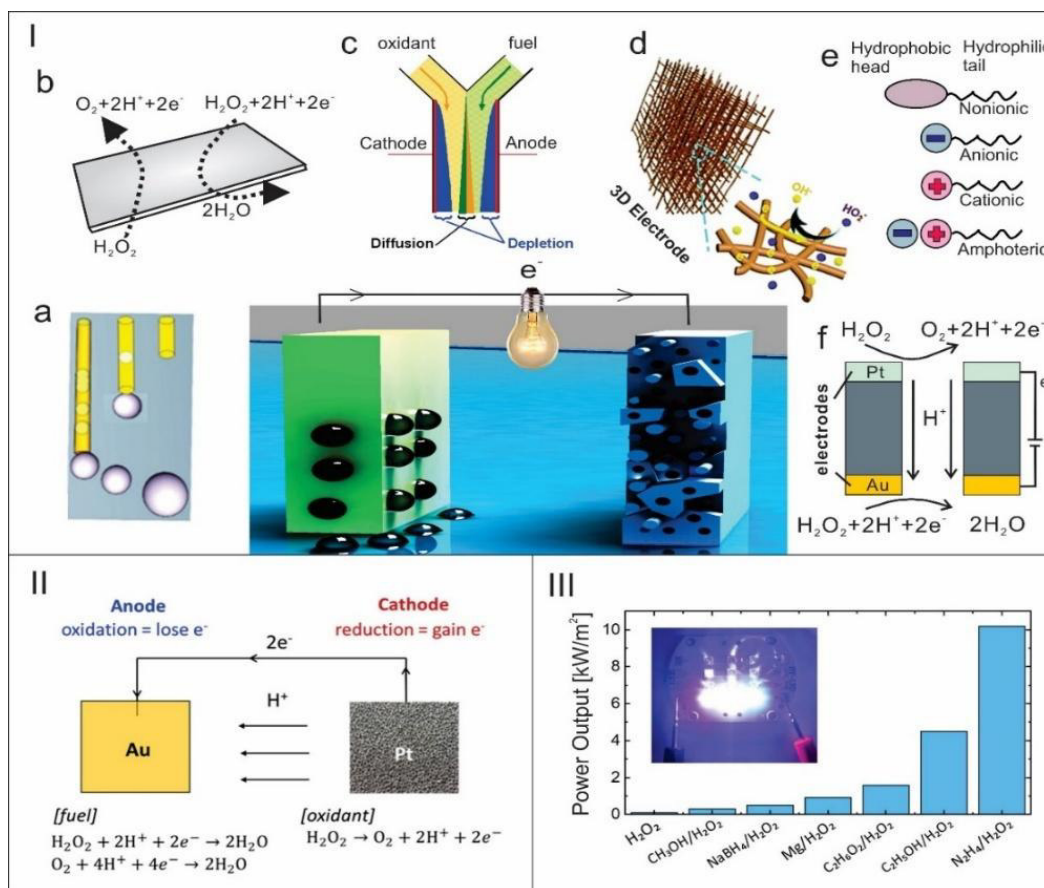


Figure 6. Membraneless hydrogen-peroxide fuel cells and electrochemical validation as a cross-cutting platform. The schematic shows a representative Ni-foam anode and Au-coated carbon-fibre cathode following Zhu et al. [JoVE, 200, e65920, 2023; DOI: 10.3791/65920]. Half-reactions are written in acidic notation to show electron balance; their depiction does not prescribe the electrolyte for every future experiment. The lower panel outlines a validation sequence that is retained for fundamental energy-conversion research and can inform the design of robust low-power analytical microsystems. No numerical performance data or cross-technology power comparison is plotted.

RESEARCH PROGRAMME INTEGRATION

Research integration, instrumentation and interdisciplinary development

Programme hierarchy and preserved scientific breadth. The research portfolio is organised around a clear hierarchy rather than six isolated topics. Micro/nanofluidics, quantitative imaging, active micro/nanoscale probes and biosensing/bioelectronics form the primary measurement-technology core. Strain-engineered nanomembranes provide an enabling fabrication layer; responsive compartments provide programmable reaction, assay and calibration environments; and electrochemical microsystems provide a complementary branch in sensing, interfacial transport and energy conversion. This structure creates a distinctive capability in active measurement and closed-loop experimentation while preserving strong fundamental directions in materials physics, active matter, soft microfluidics and electrochemistry. Initial priorities are selected according to scientific opportunity, available capabilities and the strength of the unresolved mechanism rather than by treating all platforms as equally mature.

Multimodal measurement, automation and AI as integrating axes. A central cross-platform objective is to connect fabrication and sample history to structure, interfacial chemistry, motion, acoustic response, molecular signal and final experimental decision. Optical and high-speed imaging can be combined, where scientifically appropriate, with ultrasound, optoacoustic imaging, electron microscopy, scanning-probe methods, electrochemical analysis and microfluidic control. AI-assisted segmentation, tracking, classification and state estimation are treated as measurement tools rather than independent sources of truth: training/test separation, primary-data retention, uncertainty, failure cases and comparison with conventional baselines are required. The next step is laboratory automation: when the system state can be estimated reliably, pumps, fields, stages or other actuators can be updated in real time so that experiments become adaptive while remaining auditable. This measurement-to-decision loop extends my prior tracking and control work into reproducible, state-aware experimentation.

Collaboration strategy. The programme is designed around specific scientific interfaces rather than nominal interdisciplinarity. Bioimaging collaborations can test new active or microfluidic probes against advanced microscopy; biophysics and active-matter collaborations can supply questions in which controlled perturbation and quantitative tracking reveal dynamics; micro/nanofluidic and single-cell collaborations can couple sample handling to active sensing or feedback; biosensor and bioelectronics collaborations can connect calibrated fluid delivery to closed-loop readout; and electron or scanning-probe microscopy can connect nanoscale structure to local function. Single-molecule tracking, force spectroscopy and specialised biological assays are treated as collaborative interfaces rather than claimed as established in-house expertise. Shared questions, explicit responsibilities, primary-data provenance and measurable outputs define each collaboration.

Initial research questions. Four early pilot families provide a practical route to integration. The first tests active magnetic or hybrid micro/nanoscale probes in microfluidic environments, comparing open-loop and feedback control for target localisation, model-cargo handling, boundary interaction and state-dependent measurement. The second connects microfluidically manufactured microbubbles or nanodroplets to calibrated optical, ultrasound or multimodal imaging, focusing on how shell composition, acoustic response, stability and image formation determine quantitative readout. The third develops self-referenced microfluidic biosensor arrays in which drift, matrix effects, calibration and automated acquisition are treated as primary design variables. The fourth integrates a microfluidic workstation with real-time imaging, tracking and programmable actuation so that a measured state triggers the next experimental action. Together these pilots establish a coherent path from device fabrication to measurement, state estimation and adaptive experimentation.

THREE- TO FIVE-YEAR DEVELOPMENT

Implementation, funding and measurable research milestones

Immediate-start capability. Initial pilots would be selected in micro/nanofluidics, active micro/nanoscale probes, imaging-visible soft compartments and biosensing after an equipment, expertise, biosafety and ethics assessment. Their core methods - optical microscopy, microfluidic fabrication, magnetic actuation, electrochemical measurement, quantitative image analysis and modelling - build directly on my previous work. Advanced microscopy, electron/scanning-probe characterisation, single-molecule methods and biological validation will be integrated through shared facilities and specialist collaborations rather than assumed as universal in-house capabilities. Strain-engineered nanomembrane fabrication and semiconductor processing will use suitable cleanroom or shared infrastructure and targeted partnerships. This staged approach links new investment to demonstrated scientific demand and allows early results to determine which measurement platforms merit expansion.

Funding, translation and external relevance. Third-party funding would be pursued around a focused portfolio of micro/nanofluidic instrumentation, quantitative bioimaging, active micro/nanoscale probes, biosensing/bioelectronics and automated experimental systems, with supporting work in functional materials and self-powered microsystems. Early proposals would be modular, with each project testing a defined measurement principle while sharing fabrication, imaging, microfluidic and computational capabilities across the programme. Translational collaboration would focus on technically consequential problems - measurement sensitivity, calibration, sensor drift, imaging resolution, probe stability, throughput, reproducibility, manufacturability and data quality - where physical understanding changes an experimental or device-development decision. Industry interaction would be pursued when a validated instrument or method has a clear scientific or biomedical use case; IP, licensing or startup activity would follow only after reproducibility and operating boundaries are established.

Proposal development and resource planning. My previous principal-investigator awards and experience developing externally funded programmes provide a foundation for competitive proposal development. For each initial project I would define the scientific gap, preliminary evidence, partner contributions, staff time, technical support, equipment access, biosafety/ethics requirements and recurring costs before selecting an appropriate funding route. Pilot results would support larger collaborative proposals and external partnerships. Resource decisions would be linked to the capacity to deliver and maintain the work: specialised equipment would be justified by a multi-project measurement need, not by a single speculative application. Where a capability already exists in a shared facility or collaborating laboratory, shared access would be preferred over unnecessary duplication.

People, leadership and research culture. The programme will be managed as an integrated research environment rather than a collection of device projects. Researchers will develop depth in a primary method while gaining enough cross-disciplinary literacy to understand how fabrication, interfaces, imaging, microfluidics, sensing, computation and biological validation connect. Project leaders should have genuine scientific ownership; technical expertise should be recognised as integral to performance; and recruitment should follow a multi-year roadmap that balances micro/nanofabrication, microfluidics, microscopy, biosensing, control and computation. Shared expectations will cover safety, sample traceability, calibration, uncertainty, data stewardship, authorship, research integrity and reporting of negative or ambiguous results. In a measurement laboratory, the ability to identify an instrument limitation early is a scientific success, not a failure to produce a positive result.

Experience developing distributed research initiatives. Through the development of NanoTRIZ Innovation Institute, I have worked on a model in which affiliated principal investigators and scientific mentors in different locations contribute complementary expertise to structured research projects. This experience is relevant to coordinating cross-disciplinary teams, defining project questions, documenting decisions and reviewing progress across institutional boundaries. My development of SciViD adds experience in method-centred scientific communication, while SciOS is a further digital initiative focused on traceable, AI-assisted research workflows. Any such approaches will be adapted to the applicable governance, data-security, ethics, intellectual-property and collaboration requirements of the research environment in which they are used. Their practical value would be to make complex instrument-development and computational workflows easier to audit, reproduce and communicate across engineering and life-science teams.

Phase	Strategic objective	Programme-level objectives	Representative outputs	Progression criteria
Years 1-2	Measurement baselines and	Establish reproducible baselines for active-probe actuation, micro/nanofluidic	Reference datasets; validated protocols; first	Independent repetition; quantified uncertainty and

	platform integration	fabrication, imaging-visible compartments and biosensing; map interfaces to shared laboratories and specialist facilities; establish closed-loop instrumentation testbeds.	collaborative projects; co-supervision pathways; early external proposals.	batch variation; core measurement systems operate reproducibly before biological complexity is added.
Years 2-3	Mechanisms and predictive measurement models	Resolve control, transport, imaging and sensor mechanisms; connect structure/interfaces to measured function; validate physical and data-assisted models against withheld data.	Active-probe operating maps; imaging/calibration maps; biosensor drift/selectivity datasets; automated-control benchmarks; major collaborative proposals; peer-reviewed outputs.	Alternative explanations excluded; models predict independent data; multimodal measurements converge; automation or AI adds measurable value over baseline analysis.
Years 3-4	Integrated instrumentation and biological testbeds	Combine micro/nanofluidics, imaging, biosensing and active probes where a defined measurement dependency exists; extend validated tools to cell-compatible or specialist biological studies.	Integrated demonstrators; collaborative biological datasets; shared instrumentation methods; international/industry projects; prototype IP where justified.	Collaborators reproduce principal measurements; biological interpretation is supported by defined instrument controls rather than device artefact.
Years 4-5	Prospective prediction and adaptive experimentation	Test design laws on unseen materials, geometries and samples; validate operating envelopes; consolidate programme themes in active measurement, micro/nanofluidics, multimodal imaging, sensing and laboratory automation.	Predictive design rules; externally validated datasets; adaptive experimental workflows; durable partnerships; major grants; reproducible instruments/licensing opportunities where justified.	Independent prediction within predefined uncertainty; failure boundaries documented; automated decisions outperform fixed protocols on defined tasks; translation supported by validated physical and biological evidence.

SCIENTIFIC RIGOUR AND IMPACT

Validation, translation and success criteria

Experimental rigour. Each project will define its system boundary, mechanistic hypothesis, critical variables, primary readouts, control conditions and failure criteria before claims are advanced. Measurement uncertainty, batch variation, instrumental drift, negative results and competing explanations will be retained in the analysis. For microscopy-intensive work, quality assurance will include instrument checks, acquisition metadata, representative sampling, separation of raw and processed data, documented image-processing operations and uncertainty in segmentation, localisation or tracking. For micro/nanofluidics and biosensors, channel geometry, flow, surface condition, calibration history and sample matrix will be documented. For AI-assisted analysis and laboratory automation, training/test separation, software/versioning, latency, baseline comparison and failure cases will be explicit. Models will be required to respect physical constraints and, where possible, predict datasets not used for fitting.

Milestones and decisions under uncertainty. Each pilot will have an initial reference measurement, an independent repeat, an agreed uncertainty budget and a decision point before wider integration. Failure to reproduce a functional effect will trigger investigation of preparation, measurement, transport, actuation or analysis conditions rather than immediate escalation to a more complex biological model. If a proposed coupling is too weak, unstable or sample-dependent, the result can still inform a materials or mechanism study and determine whether to redesign, narrow or stop that branch. Active-probe tasks will be compared against open-loop or passive controls; imaging readouts will be separated from morphology and concentration effects; biosensor signals will be evaluated against drift, nonspecific adsorption and interferents; and automated workflows will be benchmarked against fixed protocols. Shared records will retain unsuccessful conditions, code versions and calibration history so later teams can reconstruct how a conclusion was reached.

Responsible evaluation of measurement and biomedical claims. New tools will first be assessed as instruments and laboratory systems, with biological interpretation pursued through appropriate specialist collaboration. Microrobotic navigation in a channel or phantom will not be described as therapeutic delivery until relevant biological and safety evidence exists. Ultrasound contrast or triggered behaviour will be distinguished from demonstrated biological benefit. Biosensor performance will report sample conditions, controls, limits of detection or discrimination, drift and reproducibility rather than a single best-case response. Claims about improved microscopy, tracking or automation will be benchmarked against established methods using predefined metrics. This framework keeps the central question explicit: what can the instrument measure or control reliably, and what biological conclusion is justified by that measurement?

Translation and external validation. Translation will proceed only after mechanism, reproducibility and operating boundaries are sufficiently established for the intended use. Candidate technologies may progress through calibrated benchtop systems, reference samples, cell-compatible models, specialist biological validation, prototype integration, IP assessment and external testing, with the sequence adapted to the technology. Microfluidic and sensor systems should be designed with manufacturability, sample handling, user workflow and data interpretation in mind; imaging-visible materials should be evaluated for stability and concentration-dependent behaviour; active-probe systems require explicit control, tracking and retrieval or degradation considerations; and automated instruments require robust fail-safe states. Industry or clinical partners should enter when their constraints can meaningfully change design decisions.

Measures of success. Success will be assessed through a balanced portfolio: scientific quality and impact; predictive design laws; independently validated datasets; reproducible micro/nanofluidic, imaging, active-probe and sensing platforms; instruments that enable measurements not previously practical; competitive third-party funding; development and retention of excellent researchers; co-supervision and cross-laboratory collaboration; shared methods and infrastructure; biological relevance where appropriately validated; industry partnerships; defensible intellectual property where justified; and international collaboration. No single publication, funding, device-performance or commercial metric should dominate programme strategy. The strongest evidence of programme-level value will be measurement capabilities that other groups can use and extend, rather than one-off prototypes dependent on a single researcher.

CLOSING SCIENTIFIC POSITION

An integrated research programme built around functional materials, micro/nanosystems, interfaces, measurement, imaging and feedback

Future scientific position. The programme addresses a common set of questions across diverse systems: how geometry and strain reorganise micro/nanoscale function; how interfaces convert chemical, magnetic, acoustic or electrical inputs into measurable responses; how soft confinement changes transport and reaction; how active matter couples energy, information and feedback; how imaging-visible compartments can be fabricated reproducibly; and how molecular interactions can be transduced reliably in complex liquids. The primary objective is to create experimentally validated systems that measure, perturb and control micro- and nanoscale processes through micro/nanofluidics, quantitative imaging, active micro/nanoscale probes, biosensing/bioelectronics, responsive compartments, electrochemical microsystems and closed-loop instrumentation. The intended outcome is not a collection of incremental devices, but a set of predictive frameworks, validated operating maps and experimentally testable design laws that connect materials and physical mechanisms to new measurement and control capabilities. By integrating my background in micro/nanofabrication, microscopy, active matter, microfluidics, sensing and quantitative validation, the programme defines a distinctive interface among engineering physics, functional materials, active matter and quantitative measurement, with biomedical, environmental and energy applications pursued where the physical mechanism and validation pathway are well defined.