

# Synthetic and Bio-hybrid Untethered Mobile Microrobots

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Untethered mobile microrobots have the unique capability of accessing to small spaces and scales directly. Due to their small size and micron-scale physics and dynamics, they could be agile and portable, and could be inexpensive and in large numbers if they are mass-produced. Mobile microrobots would have high impact applications in health-care, bioengineering, mobile sensor networks, desktop micromanufacturing, and inspection. In this presentation, synthetic and bio-hybrid mobile microrobots from few micrometers up to hundreds of micrometer overall sizes and various locomotion capabilities are presented. Going down to micron scale, one of the grand challenges for mobile microrobots is miniaturization limitation on on-board actuation, powering, sensing, processing, and communication components. Two alternative approaches are explored in this talk to solve the actuation and powering challenges. First, biological cells, e.g. bacteria, attached to the surface of a synthetic microrobot are used as on-board microactuators and microsensors using the chemical energy inside or outside the cell in physiological fluids. Bacteria-propelled microswimmers are steered using chemical and pH gradients in the environment and remote magnetic fields towards future targeted drug delivery and environmental remediation applications. As the second approach, external actuation of untethered magnetic microrobots using remote magnetic fields in enclosed spaces is demonstrated. New magnetic microrobot locomotion principles based on rotational stick-slip and rolling dynamics are proposed. Novel magnetic composite materials are used to address and control teams of microrobots. Such untethered microrobot teams are demonstrated to manipulate live cells and microgels with embedded cells for bioengineering applications, and to self-assemble into different patterns with remote magnetic control.

## Brief Bio:



Metin Sitti received the BSc and MSc degrees in electrical and electronics engineering from Bogazici University, Istanbul, Turkey, in 1992 and 1994, respectively, and the PhD degree in electrical engineering from the University of Tokyo, Tokyo, Japan, in 1999. He was a research scientist at UC Berkeley during 1999-2002. He is currently a director in Max-Planck Institute for Intelligent Systems and a professor in Department of Mechanical Engineering and Robotics Institute at Carnegie Mellon University. His research interests include small-scale physical intelligence, mobile microrobots, bio-inspired millirobots, smart and soft micro/nanomaterials, and programmable self-assembly. He is an IEEE Fellow. He received the SPIE Nanoengineering Pioneer Award in 2011 and NSF CAREER Award in 2005. He received the IEEE/ASME Best Mechatronics Paper Award in 2014, the Best Poster Award in the Adhesion Conference in 2014, the Best Paper Award in the IEEE/RSJ International Conference on Intelligent Robots and Systems in 2009 and 1998, the first prize in the World RoboCup Micro-Robotics Competition in 2012 and 2013, the Best Biomimetics Paper Award in the IEEE Robotics and Biomimetics Conference in 2004, and the Best Video Award in the IEEE Robotics and Automation Conference in 2002. He is the editor-in-chief of Journal of Micro-Bio Robotics.