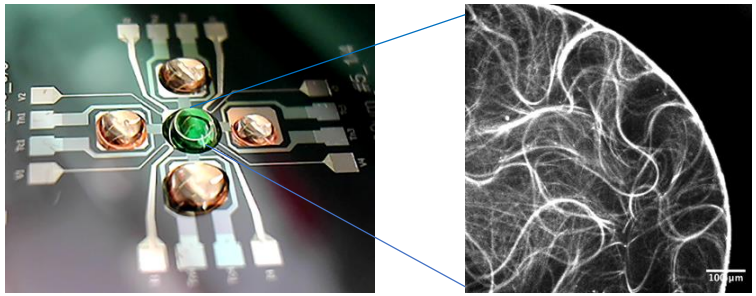
UC San Diego
JACOBS SCHOOL OF ENGINEERING

Department of NanoEngineering
NanoEngineering • Chemical Engineering

Micromachined Pico-calorimetric Sensor for Biological Systems



Jinhye Bae

Department of NanoEngineering
University of California San Diego

The 16th U.S.-Korea Forum on Nanotechnology
University of California San Diego
September 24, 2019

(Email: j3bae@ucsd.edu)

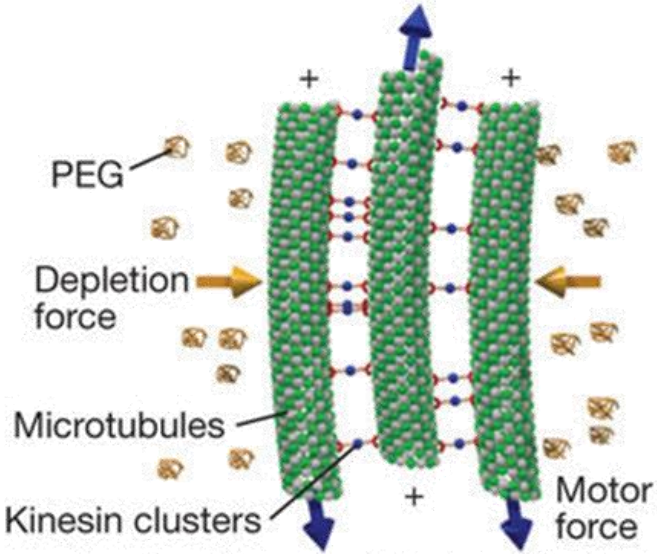
Active matter

Self-collective objects that transduce energy into mechanical work to drive their motion

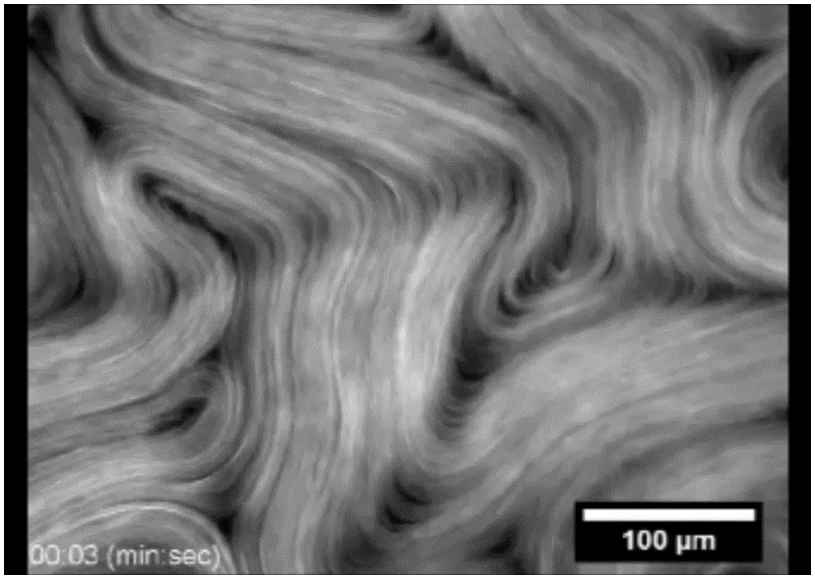
https://www.youtube.com/watch?v=bb9ZTbYGRdc

Microtubule-based active matter

Non-equilibrium, but steady state system



T. Sanchez et al., Nature **491**, 431-434 (2012)



→ Challenge is developing theory for non-equilibrium self-organized hierarchical systems for active matter

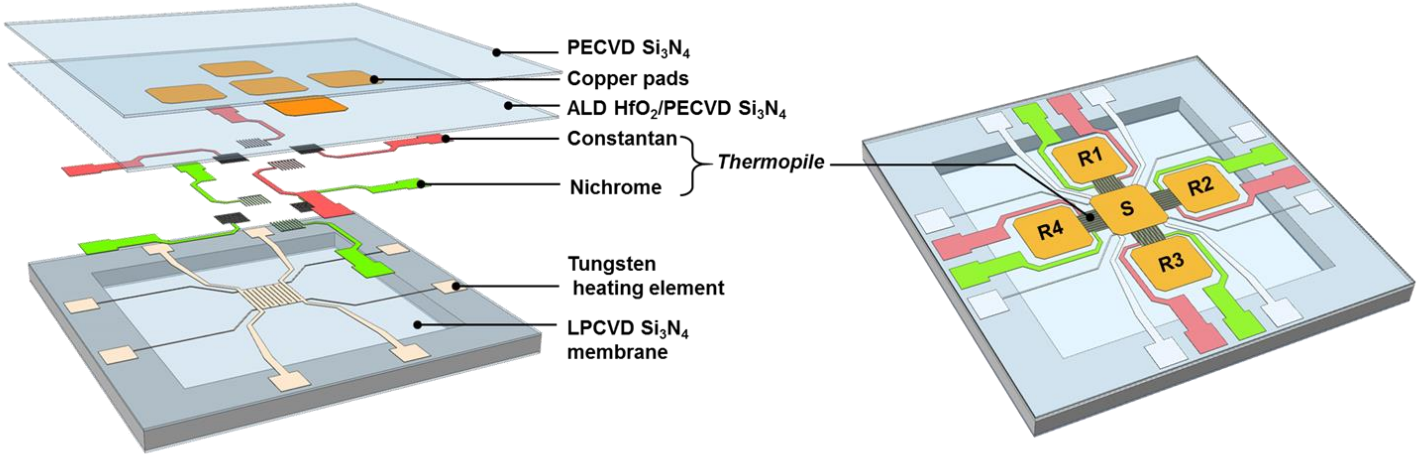
Why calorimeters as biosensors?

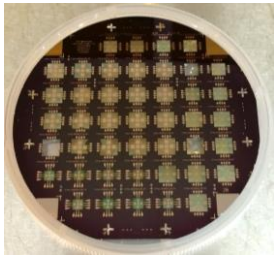
- **Small sample volume (~nL)**
- **High-throughput capability**
- **Label-free biosensors**
- **Real-time measurement**
- **Simple sample preparation**

- ***Limitation:* *low sensitivity***

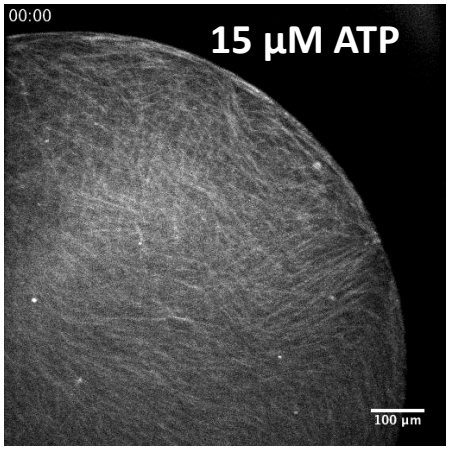
(the average metabolic rate of a single mammalian cell is ~ 60 pW)

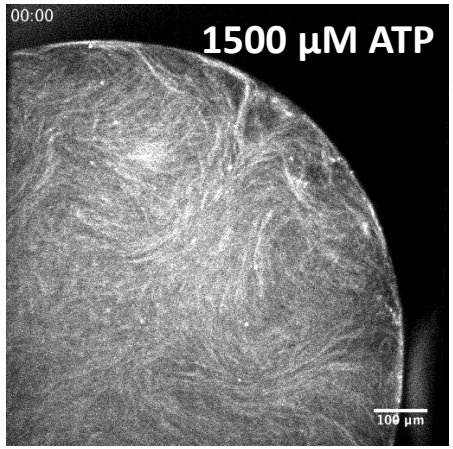
Thermopile-based calorimetric sensors

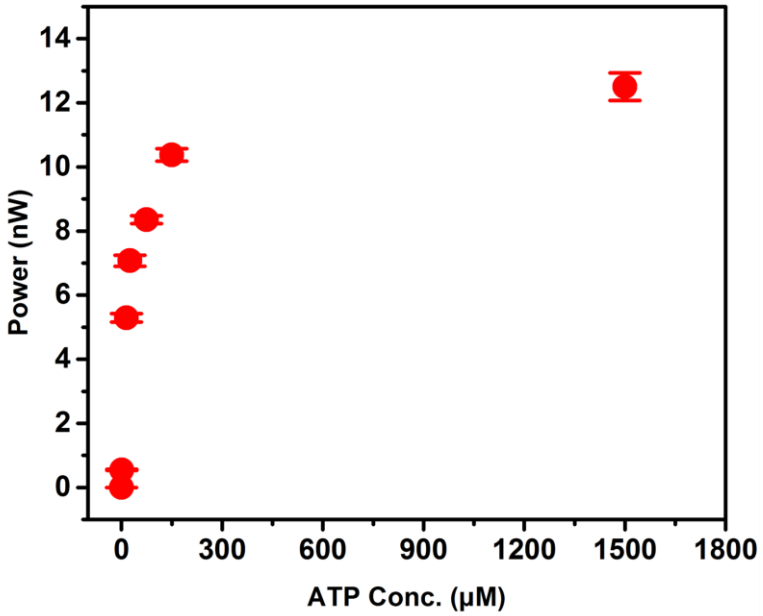




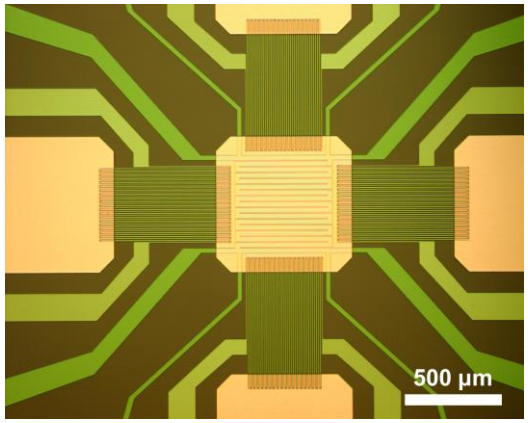
Non-equilibrium thermodynamics of active matter



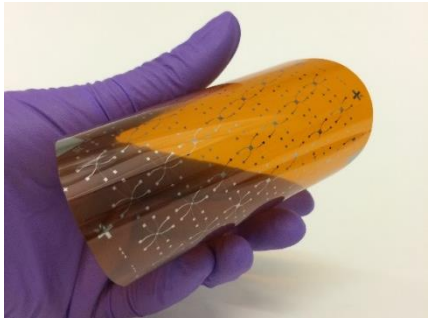




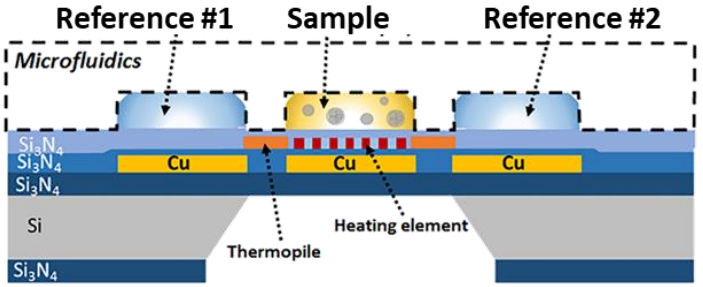
Future direction



Micromachined calorimetric sensor



Flexible sensor array



Integration of microfluidics

Acknowledgements

- *Collaborators: Prof. Joost Vlassak, Prof. Daniel Needleman, Dr. Peter J. Foster* (Harvard)
  Prof. Zvonimir Dogic, Bezia Lemma (UCSB)

- Materials Research Science and Engineering Center at Harvard University (Award No. DMR-1420570)
- Center for Nanoscale Systems at Harvard University (Award No. ECS-0335765)