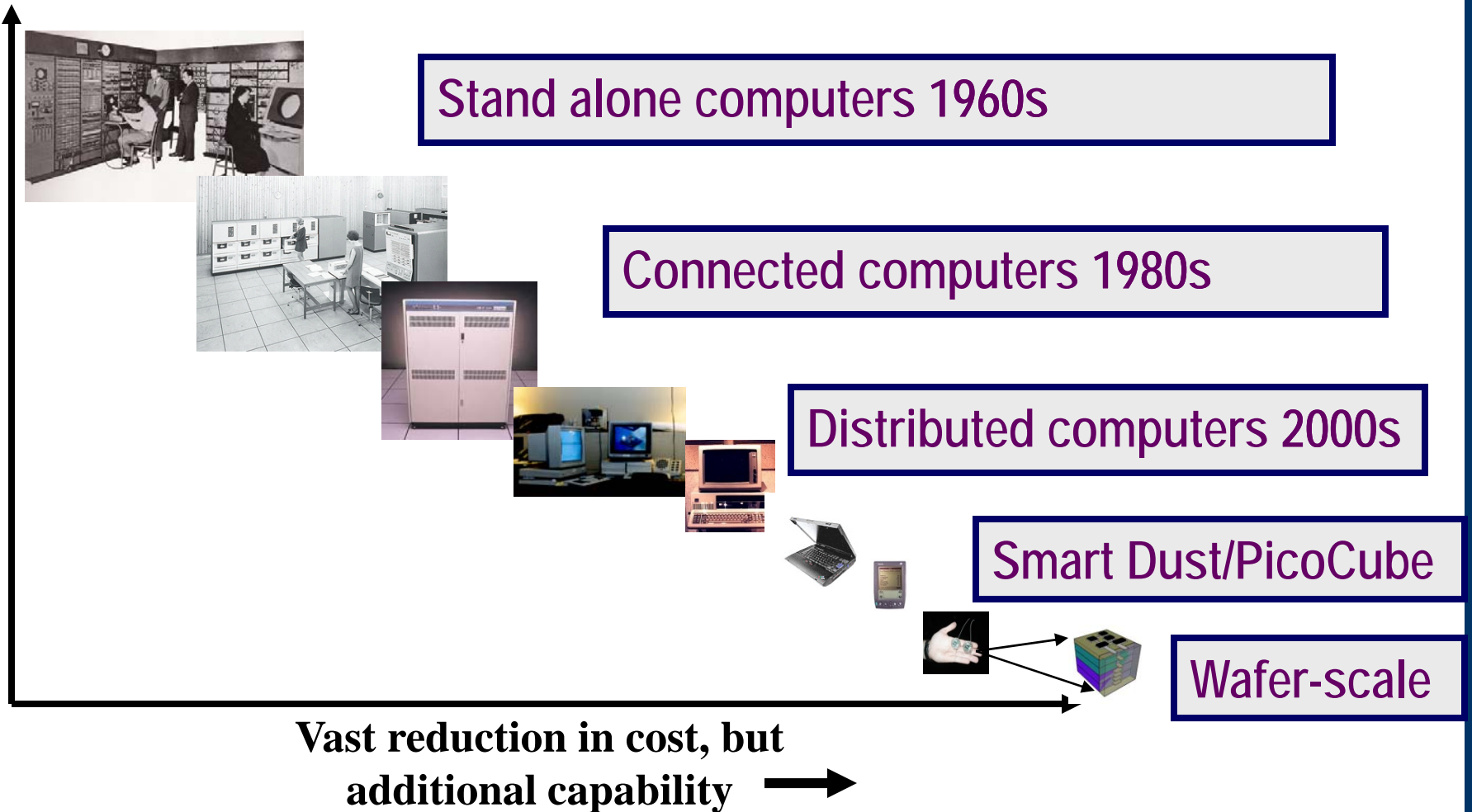




# Macro to Micro to CMOS Systems



Adapted from Various Sources:

E.g. G. Bell, R. Newton, J. Rabaey, D. Culler, K. Pister, P. Wright

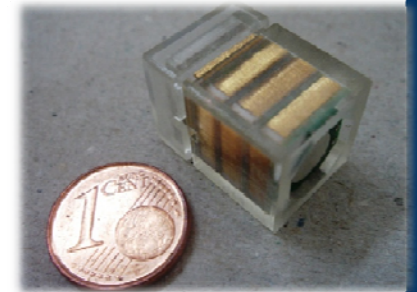


# Innovations in ULP Radios

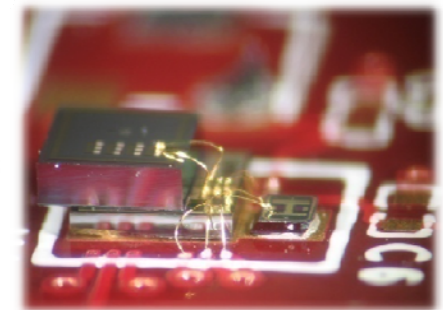
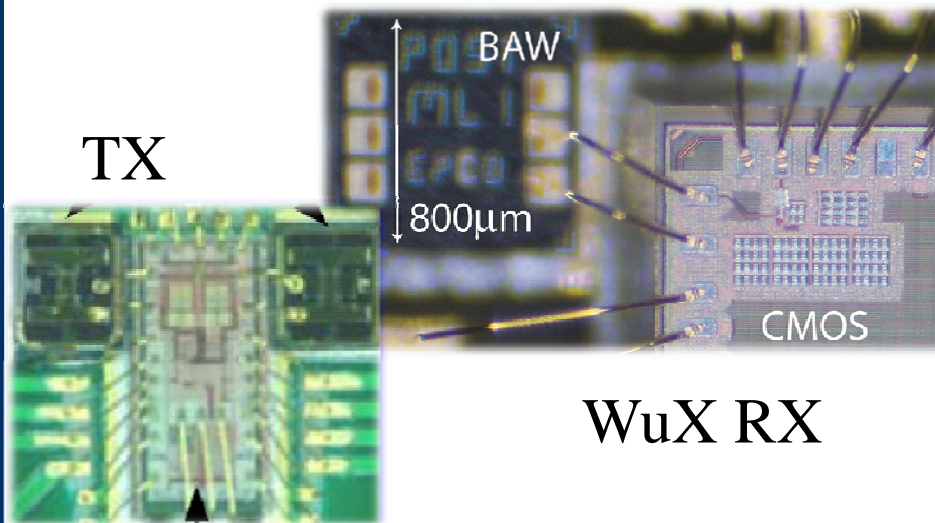
- ◎ MEMS-based ultra-low power receiver and highly efficient transmitter
- ◎ Low-voltage, low-power logic family
- ◎ Integrated, efficient energy conversion and innovative power management



FBAR MEMS Resonator  
(Avago Technologies)



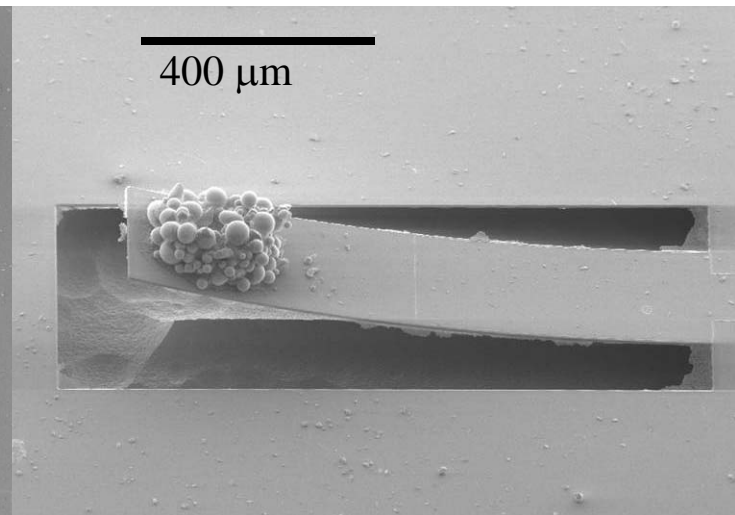
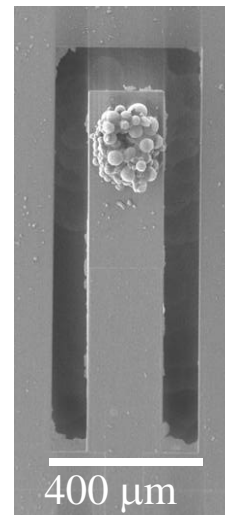
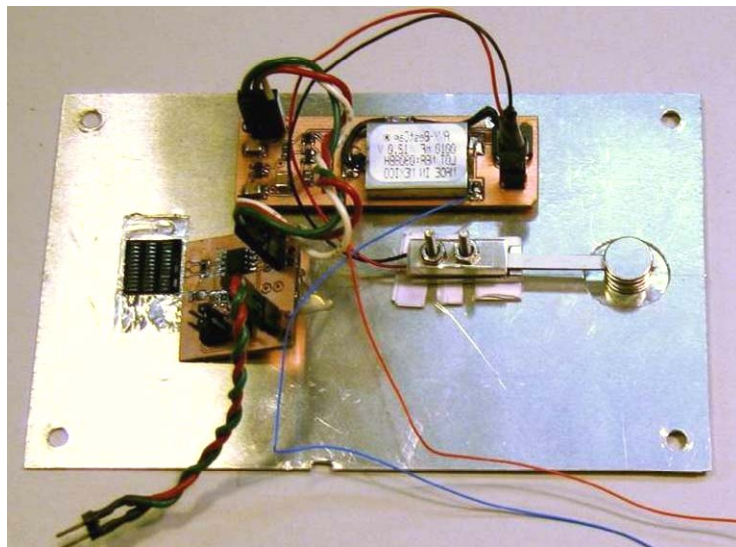
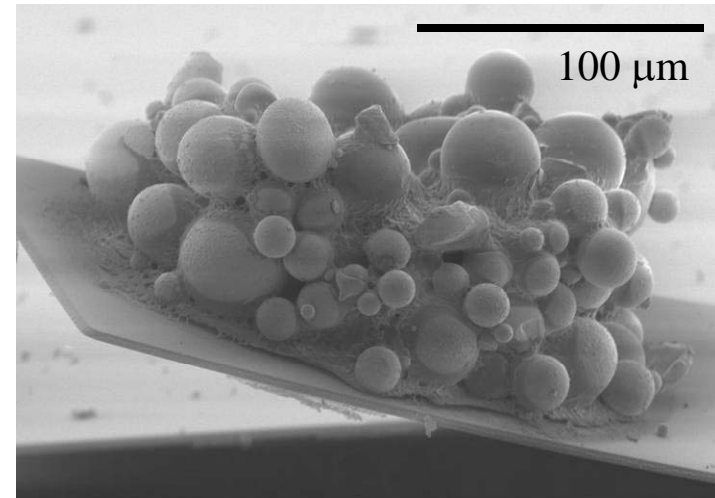
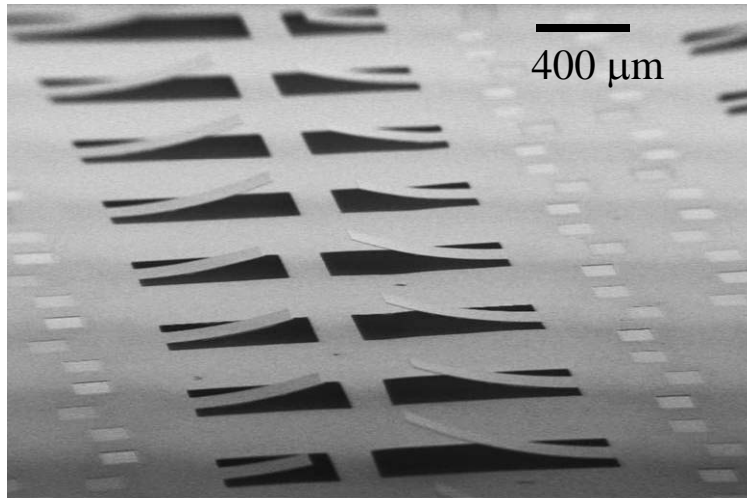
UCB PicoCube



UCB mm<sup>3</sup> radio



# Pictures of a prototype device



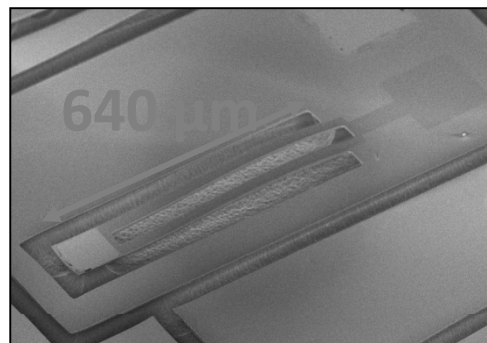
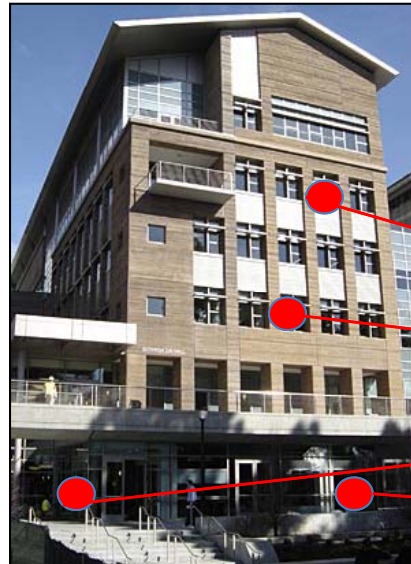
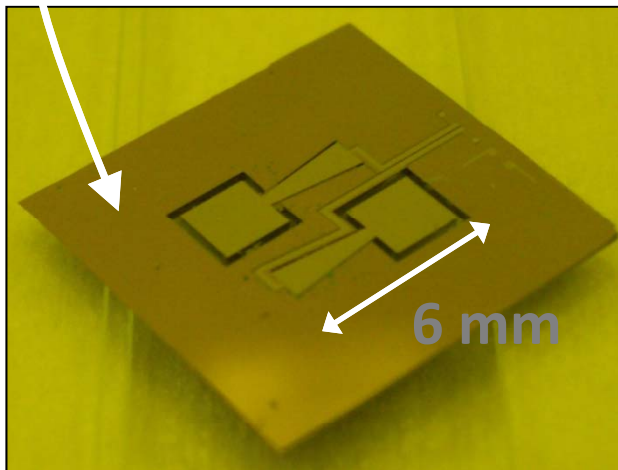
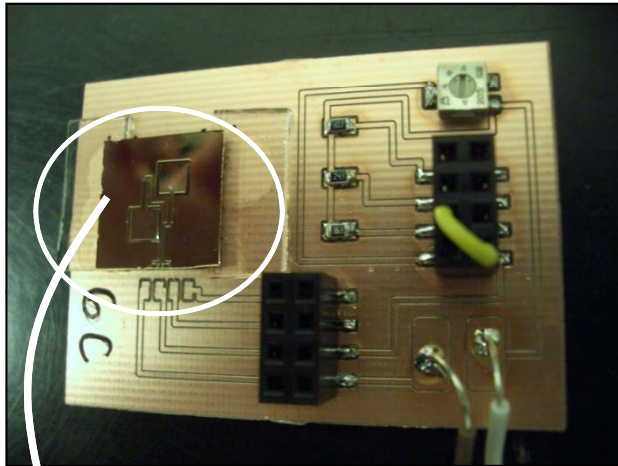
E.S. Leland, et al.

PowerMEMS 2009

3



# Vision: harvest energy from ambient vibrations in buildings to power wireless sensor networks



## Wireless sensor network applications:

- Energy/water efficiency monitoring:

- Lighting
- Appliances
- Onsite heat & power
- Thermal & electrical storage
- HVAC

- Building automation

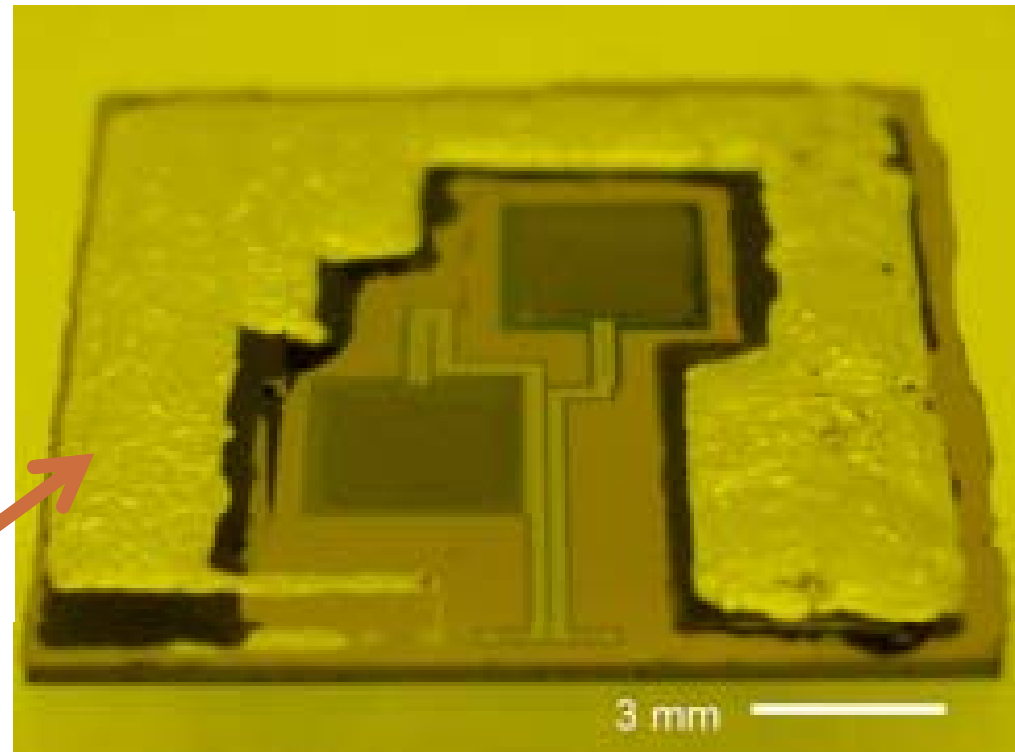
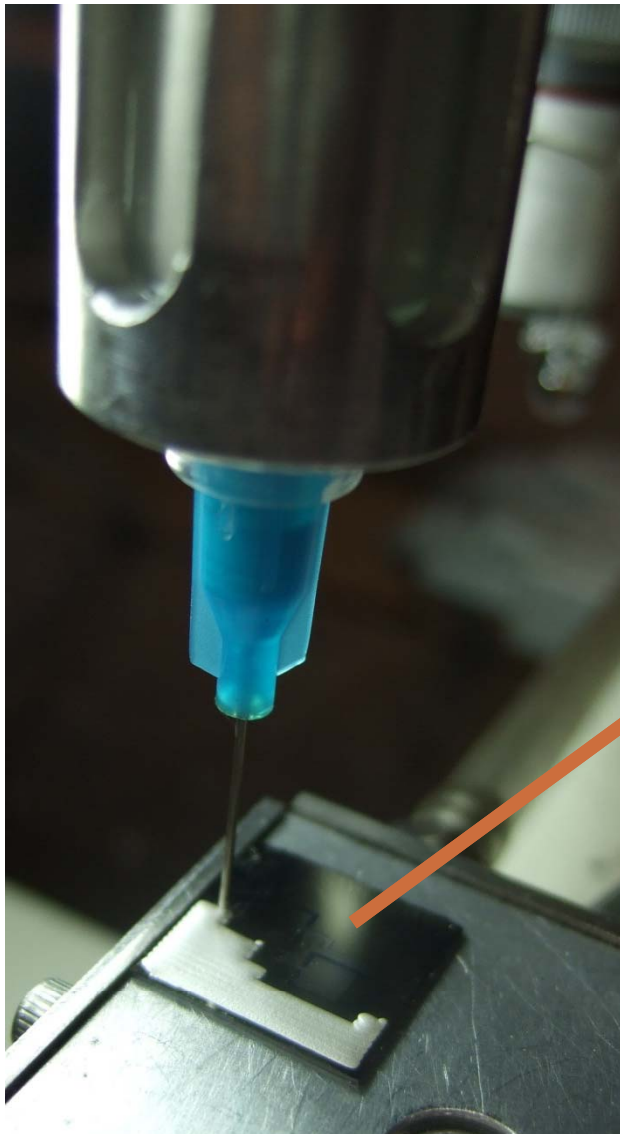
- Manufacturing process control

- Asset management

*Photos: Lindsay M Miller, PhD candidate, Mechanical Engineering, UC Berkeley.  
CITRIS building photo: Jules P. Feher, UC Berkeley Capital Projects*



# Integration of Micropower Components



*Integrated vibration harvesters  
surrounded by a printed  
capacitor*



# Wafer Scale Integration

## ★ Goal:

- ◆ Very Low Cost Self-powered Communicating Sensor technology
  - One CMOS wafer run for radios and power circuits
  - One wafer run for energy harvesting, storage and sensor