MEMS Education Workshop Roundtable Discussion 2008

1. Is there MEMS education structure at a university that makes the most sense (*e.g.,*a MEMS department, major, or scattered classes within the university)? What are the pros and cons? Is there a direction where universities are heading?
    a. Challenges: mix fundamentals and specialization without overflowing. Especially if you include the reliability, packaging, statistics, etc. that industry wants.
    b. Be careful of the naming approach, so it doesn't seem like it would be too constraining as far as later job opportunities are concerned. So Advanced Technology or Micro Systems Technology is better than "MEMS".
    c. It's not universal, because it depends on level (bachelor's or graduate), what you want the people to know (generalists or specialists).
    d. Many different models appear to be successful, or potentially successful: ranging from a MEMS-focused department (such as Micro Systems Technology in Japan) to a less specialized multidisciplinary program (Advanced Technology) at Twente to a "choose from existing courses for a track" approach.
    e. What are the pros and cons?
    f. How soon you can implement it; how well you manage to fit in the relevant material.
    g. Is there a direction where universities are heading?
    h. Steady trend towards more explicitly MEMS departments and programs appearing, especially in Europe and in parts of Asia.
    i. The trend mimics that of bioengineering, in which the body of knowledge grew and grew until it could finally stand on its own as a department.

2. Are the cooperative agreement centers and infrastructure (*e.g.*, the nanotechnology alliance in the US) working to help benefit education in addition to research?

    Shared infrastructure areas

    a. Fab
        i. NNIN etc not for education
        ii. Pool resources to make test chips
        iii. Mechanics of buckling, snap-in structures via polyMUMPs etc
        iv. Need fast turnaround, predictable resources
    b. CAD tools
        i. Free for everyone (academics? Please?)
        ii. Train students to use that software
        iii. They continue using it in industry
        iv. Pool or subsidize across schools??
    c. IP
        i. If not CAD tools for free, can we share case studies for free
        ii. Models
        iii. Handouts/instructions
        iv. Libraries of useful components

d. Test
    i. Undergrads on SEMS? Other test equipment, LDVs, Wykos, dektak?
    ii. Ship parts to location, use virtual interface remotely, harder to break the tool!
    iii. Kris Pister has .gds file of lots of cool chips to test (pister lab website, sunil will send beth the file?!)
    iv. Virtual worlds….?!

3. How much hands-on experience is necessary to be considered proficient in MEMS at the B.S., M.S., and Ph.D. levels? Is there a method to evaluate it?
    a. What is hands on? Fab? Simulation? Design?
    b. Differences of BS/MS/PhD?
    c. BS follow cookbook usually, expose to problem solving
    d. MS should get more advanced technique(s): modeling, packaging, …
    e. PhD broadly knowledgeable, expertise in specific area of thesis, creative and critical thinkers
    f. Input from industry welcome for:
        i. Statistics –data sets and real problems
        ii. Modeling –case studies
    g. How to evaluate:
        i. Students evaluated by finals, homeworks
        ii. In industry—how are they doing?
        iii. How can we get this feedback?
        iv. Can take awhile to realize gaps…

4. How can a university build the necessary infrastructure to develop a strong MEMS education program, particularly with the need for interdisciplinary training of the faculty? How easy is it for faculty to cross-over departments (*e.g.*, MEMS Department to Mechanical or Electrical Engineering, and vice versa)?
    a. Important, potentially expensive
    b. How fund infrastructure for *education*, vs. just for research
    c. Interdisciplinary also key to biomedical, optics, etc but they don't require as much infrastructure
    d. What do we mean by infrastructure
        i. To get BS interested
        ii. To get research done
        iii. Both might need, not necessarily in same room:
        iv. Quick and dirty "kitchen" to try things
        v. Standard process for transfer to industry
        vi. What is goal of program—which "fab" do you let the students into?
    e. Interdisciplinary but needs basics too
        i. Physics, chemistry, etc
        ii. Organize on school level vs. dept level
        iii. Hands on is necessary to really appreciate the material
        iv. Support of the hands-on, the labs, the "stuff"

5. Where are the MEMS jobs? Which industries are hiring MEMS trained graduates?
    a. Complex, fragmented field and jobs are not necessarily listed as "MEMS"
    b. Government jobs- labs, military (often US only)
    c. Small companies, specific products, needs everyone to everything
    d. Big companies, looking for variety of people
    e. Range of job types have range of paths in school
        i. Very specific jobs crossing fields, e.g. biomedical--Need in depth training in 2 fields to contribute
        ii. Want breadth and lots of general knowledge--Package, test, proposals, IP across fields and change to new fields over time
        iii. Science and problem solving jobs, want folks with lots of creativity
    f. Do you want industrial job?
        i. Internships allow students and employers to test out a match
        ii. Some programs integrate this into the educational plan (MIT, others)
    g. Need for diversity
        i. Experimental hands-on experience AND modeling motivated by scientific questions
        ii. Communication skills, foundries provide an interesting challenge in translating design needs to practice
        iii. Cultural communication
        iv. Able to provide realistic assessments of how long and probability of success when starting a project
    h. Comments from Rob Candler, Bosch:
        i. Need for…
        ii. Circuit design
        iii. Systems integrator
        iv. Interns a good way to shop for skills

6. What mechanisms are available to include MEMS industry/companies in the definition of the MEMS education needs and curricula?
    a. Ground rules
        i. Boundary Conditions
        ii. Considered both curriculum and training
        iii. Included *recommendations*, *problems* and *open questions*
    b. Curriculum (R=Recommendation, P=Problem, ?=Open Question)
        i. R: Technicians critically needed (Bachelors or Associates Degrees)
        ii. R: Platform Education for Semiconductors & MEMS
        iii. ?: To what extent do MEMS companies hire Bachelors? fabrication/technician/testing?
        iv. R: Industry Group – Provide needs analysis as recommendation to Universities
        v. R: Surveys – already done, reach broader audience
        vi. Industry beyond MEMS Ed workshop

vii. Recent Graduates (e.g., what skills got you a job, what lack of skills held you back?)
viii. ?: How much MEMS specific education do we really need to include at the Bachelor level?
ix. R: Industry-taught courses for different flavor (often for faculty on sabbatical)

c. Training R=Recommendation, P=Problem, ?=Open Question)
    i. R: Funded research
    ii. R: Students work with industry devices for relevant experiences
    iii. P: IP, secrecy (especially for small companies)
    iv. R/?: Consider in-resident PhD students (European Model)

7. Is there a benefit for an international collaboration in MEMS education, *e.g.* joint MEMS Masters program, student exchange programs, etc.?
    a. YES
    b. Exchange programs?
    c. Why benefit students:
        i. Enjoy access to best knowledge, resources, experiences
        ii. Cross schools to get best course/experiences?
        iii. Experience MEMS specific cultures: who maintains equipment, who does fab, lab management
    d. Exchange professors?
        i. Teach a specific topic course at another university (not normally taught at that school)
        ii. Summer school, regular courses
        iii. Fewer issues with degrees, credits, certificates
        iv. “sabbatical” or other exchange network?