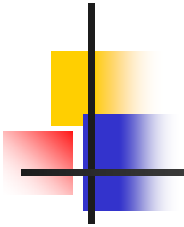
3.155J/6.152J Lecture 22: Take Home Exam Discussion

Prof. Martin A. Schmidt

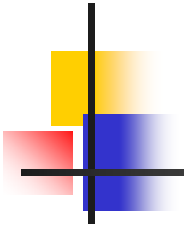
Massachusetts Institute of Technology

12/5/2005



Outline

- Review of Schedule
- The Knowles Microphone



Schedule

- Week of 12/5
  - Monday – Take Home Discussion
  - Wednesday – Prof. Joel Voldman – Biological and Medical Applications of Micro/Nano Fab
    - Fluids Lab Due
    - Course Evaluation
- Week of 12/12
  - Monday – Prof. Leslie Kolodziejski – Photonic Devices and Compound Semiconductors
  - Wednesday – Analog Devices Tour
    - Take Home Due

Take Home Design Challenge

- Design a process for fabrication of a microphone integrated with a depletion mode nMOSFET
- Utilize the Knowles microphone as our model device
  - U.S. Patent 6,847,090
    - ‘Silicon Capacitive Microphone’ - Loeppert

Microphone Cross-Section

Figure removed for copyright reasons.

Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

Microphone Cross-Section

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Microphone Cross-Section

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Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

How are the electrical connections made?

Starting Materials

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Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

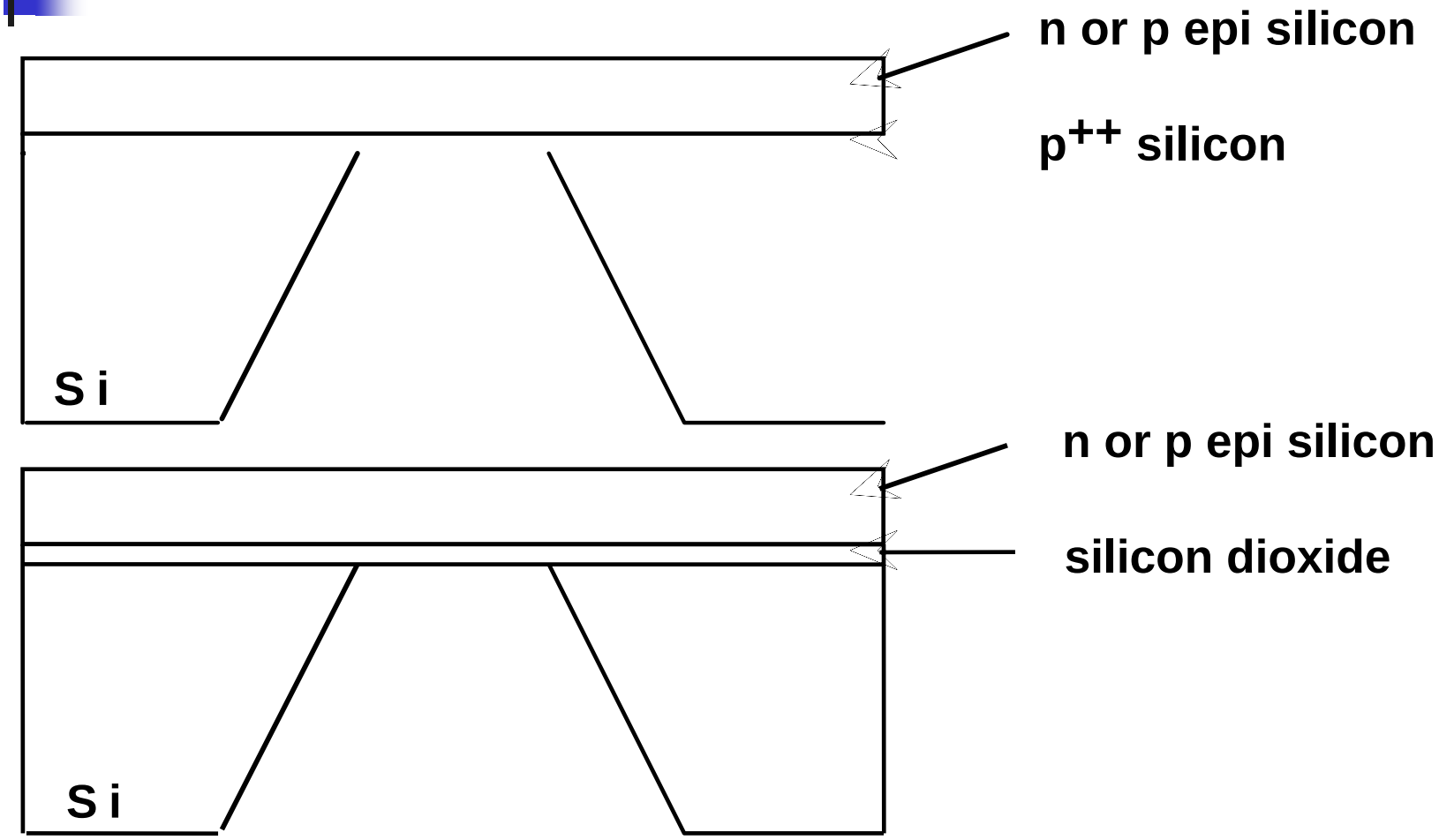
- Membrane (1)
  - Stress-compensated boron-doped etch stop
  - Lightly doped silicon with buried etch stop
    - Boron-doped silicon or oxide
- Backplane (2)
  - Boron-doped silicon

Boron Etch Stop

Figure removed for copyright reasons.

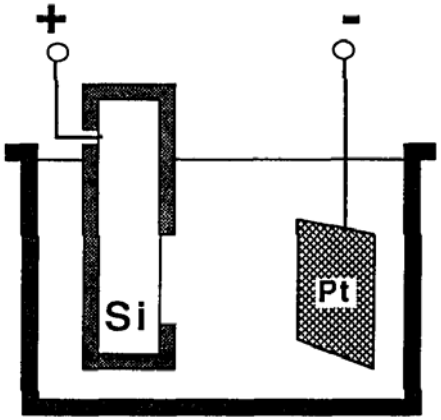
Figure found in H. Seidel, L. Csepregi, A.Hueberger, and H. Baungärtel. *The Journal of the Electrochemical Society* 137 (1990): 3612-3626.

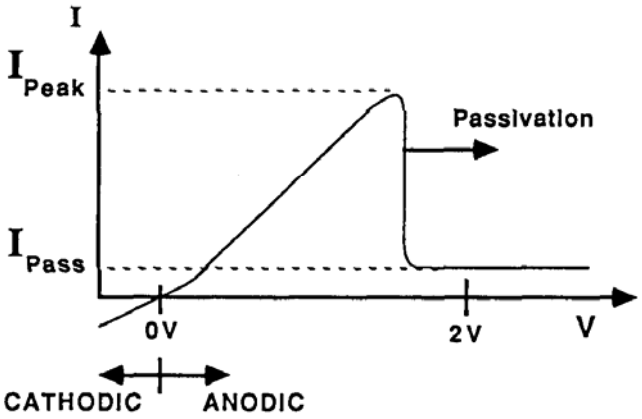
Buried Etch Stops

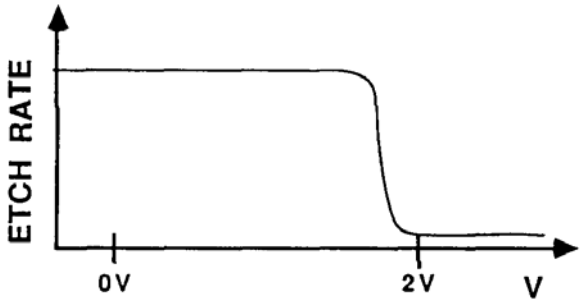


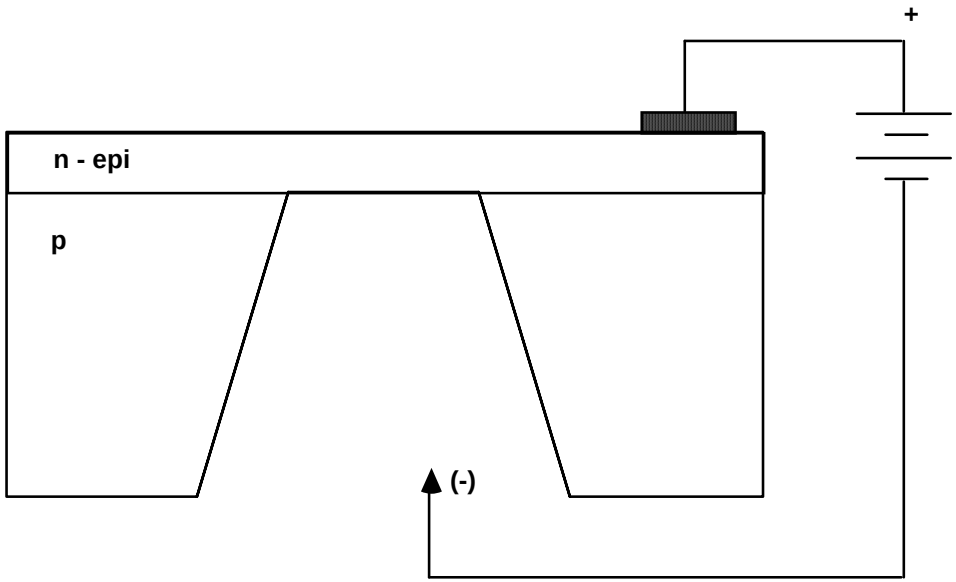
Masking material: silicon dioxide or silicon nitride

Electrochemical Etch-stop









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Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

- Pattern insulating layer (oxide)
- Etch trenches

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Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

- Silicon Fusion Bonding
  - Clean (RCA) both wafers
  - Contact
    - Reduced atmosphere ambient
  - Anneal 1000C, 1hour

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Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

- Substrate Etch
  - Masking material
  - Boron etch stop ($N > 10^{20}$ cm^{-3})
  - Alternatives
    - SOI, Electrochemical

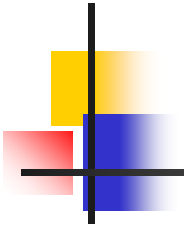
Figure removed for copyright reasons.

Loeppert "Silicon Capacitive Microphone." U.S. Patent 6,847,090.

- Trench Etch

Integration with nMOS

- Isolation
  - Can utilize oxide isolation
- Move cavity etch to end of process
  - Requires a means to protect the wafer frontside
- Interconnect
  - Need to connect FET to capacitor plate, and provide metal covered connections to other plates of capacitor
- Process ‘ease’
  - Some steps hard (e.g. handling a wafer with holes)



Next steps

- Complete Take Home Problem Statement will be handed out / posted on Wednesday
- Solution due on Wednesday