Semiconductor Processing

A series of background movies that cover the state of the art and history of semiconductor device integration technologies
From sand to silicon

- Silicon is formed by heating silicon dioxide into large crystals by crystal pulling (Czochralski technique)
- This silicon is then cut into wafers and used for its semiconductor applications
- Transistors or Diodes can be made from this semiconductor by using lithography and doping
• From Sand to Silicon -
  http://www.youtube.com/watch?v=Q5paWn7bFg4
Czochralski Process

• Silicon Crystal Growth

http://www.youtube.com/watch?v=cYj_vqcyl78
Lithography: Enabling Technology for Miniaturization – Printing small things

• Photolithography is based on light exposure of a photosensitive coating (called photoresist)
• The size of structures is limited by the wavelength of light (UV is preferred over red)
• Contact Lithography is the simplest method where a chromium mask is pushed against a coated wafer
• Projection lithography uses a “camera” system that reduces the original mask (reticle) size down to the feature size by a factor of 5:1 or 10:1
Photolithography: Enabling the Miniaturization of the past

- Photolithography -
  http://www.youtube.com/watch?v=9x3Lh1ZfggM
Si IC fabrication in the 1980-1990s

• The Fabrication of Integrated Circuits
  http://www.youtube.com/watch?v=35jWSQXku74
Modern Cleanrooms (2011)

- Semiconductor Technology at TSMC
  http://www.youtube.com/watch?v=4Q_n4vdyZzc
AMD processing: Introduction of Cu

• From Sand to Chip
  http://www.youtube.com/watch?v=GQmtITMdas
Si IC fabrication at 22nm: A 3-D process with deposition and polishing

• http://www.youtube.com/watch?v=d9SWNLZvA8g
Modern Fabrication Lines

• TSMC is one of the major silicon fabrication lines located in Taiwan
• All automated clean-rooms cost up to 4 Billion Dollars to build
• Feature Sizes down to 22nm are now fabricated over 12 inch wafers
• Next generation: 450mm wafers with EUV lithography
2011 Intel Fab Line (AZ): $4B
When UV light isn’t good enough

• As the device and structure sizes are reduced to enable even more integration, the wavelength of light limits us.
• Deep ultra-violet (UV) sources with wavelengths between 150 and 200nm using fluoride lasers have enabled us to make structures down to 30nm.
• Next generation devices need even smaller sizes and these can be made by even shorter wavelength UV light. Problem is, that glass and other optical elements absorb such short wavelengths.
• Therefore, new methods have been developed with reflective optics to enable EUV lithography.
• Originally, this work was done with synchrotron sources and required enormous equipment cost.
EUV lithography: The method of the future

- http://www.youtube.com/watch?v=XLNsYecX2Q
Concepts in EUV lithography

- http://www.youtube.com/watch?v=Ba9DD9PvUwA
EUV Lithography: From Synchrotrons to Compact Sources

- http://www.youtube.com/watch?v=8xJEs3a-1QU
Semiconductor Integration

- Fairchild pioneered the integrated circuit in the 1960s
- Gordon Moore postulated Moore’s law in 1965
- Intel formed out of this work and made the first microprocessors (1000 transistors in 1971)
Integrated Circuits

http://www.youtube.com/watch?v=z47Gv2cdFtA
How to add binary numbers

- [http://www.youtube.com/watch?v=VBD0T804q00](http://www.youtube.com/watch?v=VBD0T804q00)
Where is the Semiconductor Processing going next

- Structures below 10nm in 2015 (on SIA roadmap)
- Structures down to 3nm possible (in 2020s)
- Silicon exhibits new and exciting properties (wide bandgap, light emission etc.) below 8nm
- Contacts to small structures must be lowest possible resistance
- Doping no longer possible in smallest device volumes – need to use electrostatics instead
- Surfaces become dominant in determining device performance
- Strain and local geometry can be used to “tune” materials properties in device
- Combination between “top-down” lithography and “bottom-up” self-assembly will become enabling at the smallest scales
History of Computers: From Babbage to Apple

- [http://www.youtube.com/watch?v=VPDy2y4A jSo](http://www.youtube.com/watch?v=VPDy2y4A jSo)
New computer architectures?

• Is optics and opto-electronics finally ready to enable optical “computers”?
• New non-binary logic gates?
• Coherent and electron wave-interference devices will enable high-speed performance
• Multiple functions can be included in the same devices (controlled through gating)
• Physical device layer can be changed during computation
• Geometry and strain will define fundamentally new materials properties and devices functions
History of Computers

- http://www.youtube.com/watch?v=qundvme1Tik
History of Computers – part 2

• http://www.youtube.com/watch?v=wsirYCAocZk