

Why Surface Science and Nanostructure Physics?

example 1: MOSFET and the high k-dielectrics

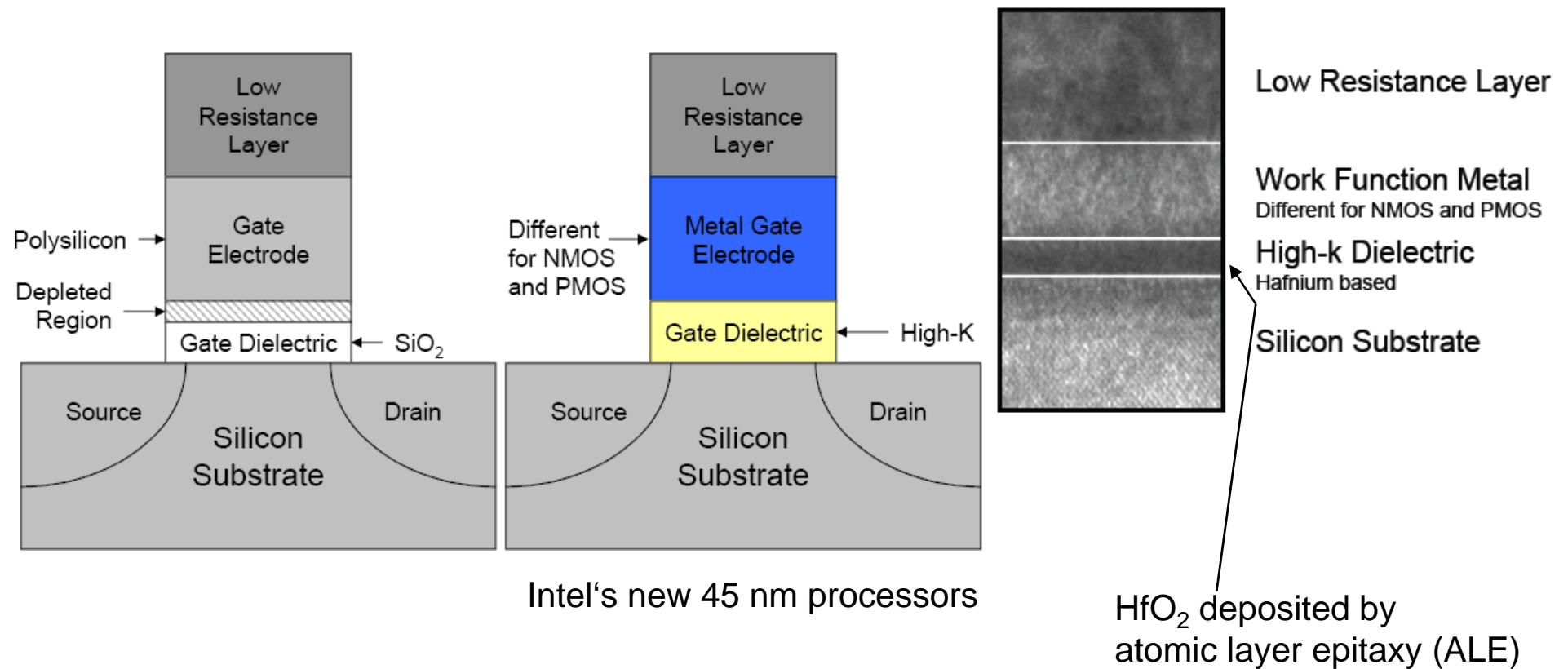


Fig.1

Example 2: the Car Exhaust Catalytic Converter

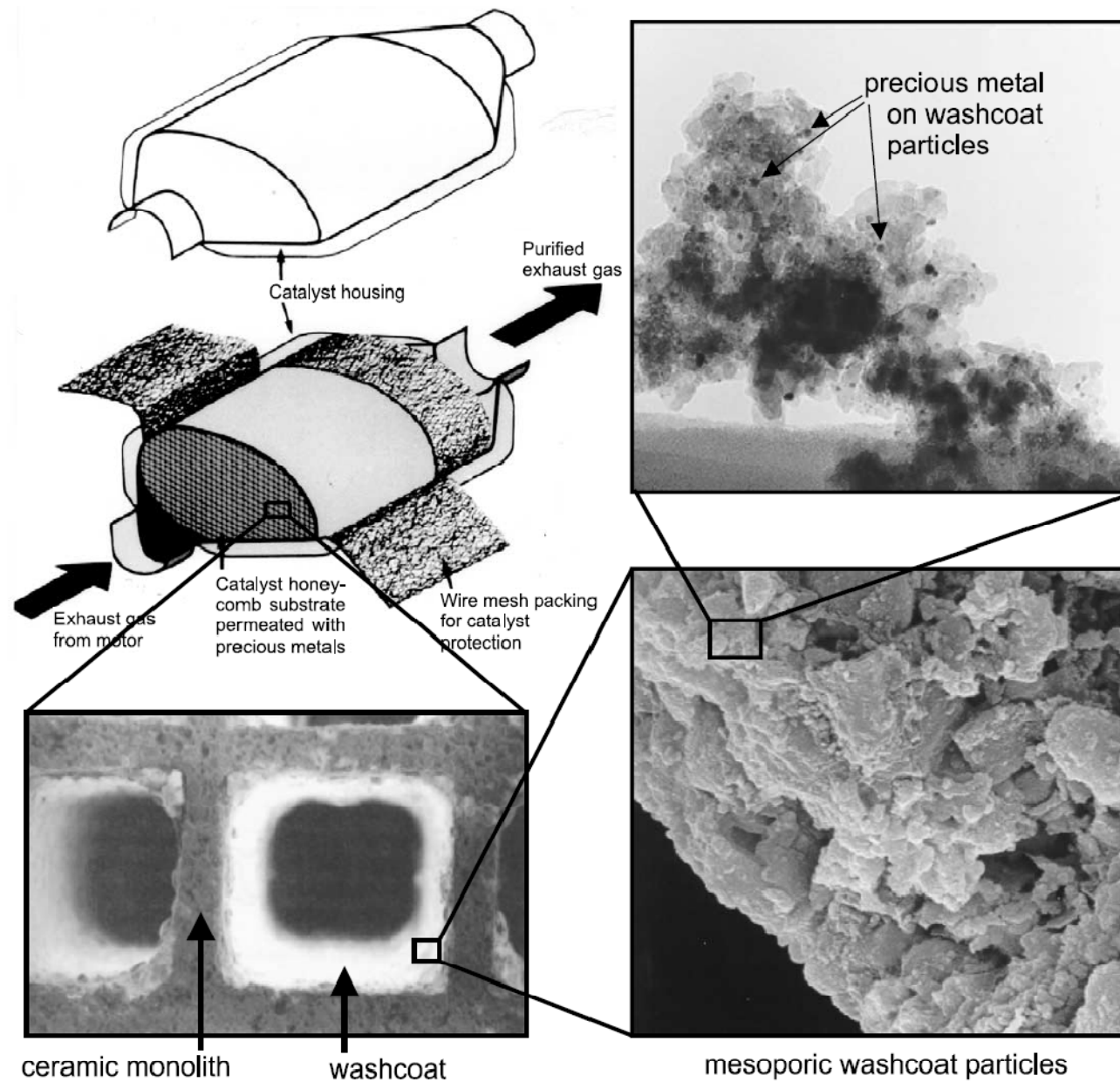
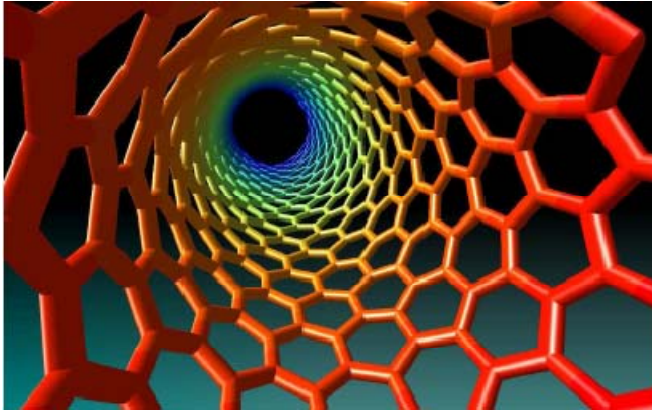


Fig.2

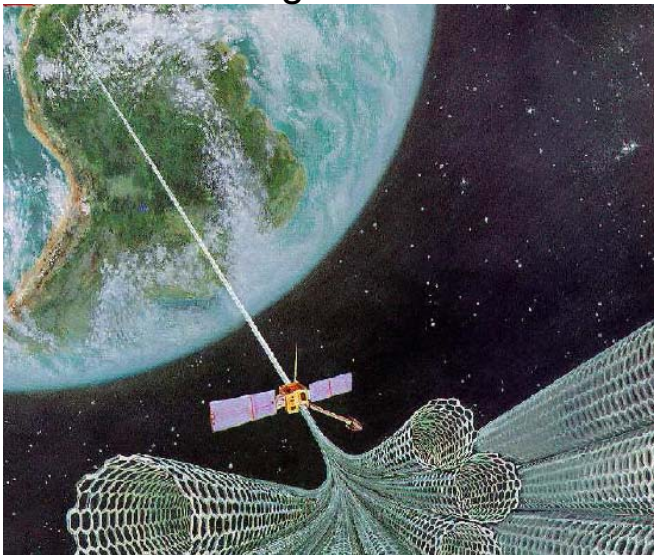
H.J. Freund,
Surf. Sci. 500, 271 (2002)

Example 3: Nanotubes

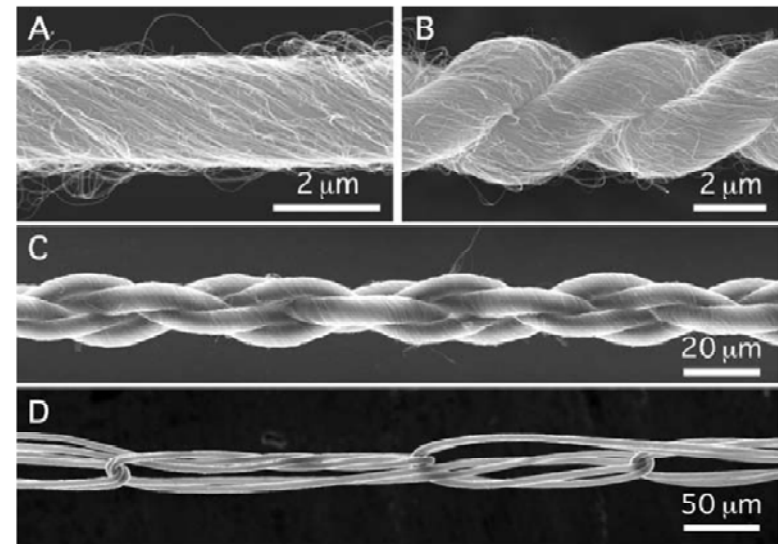
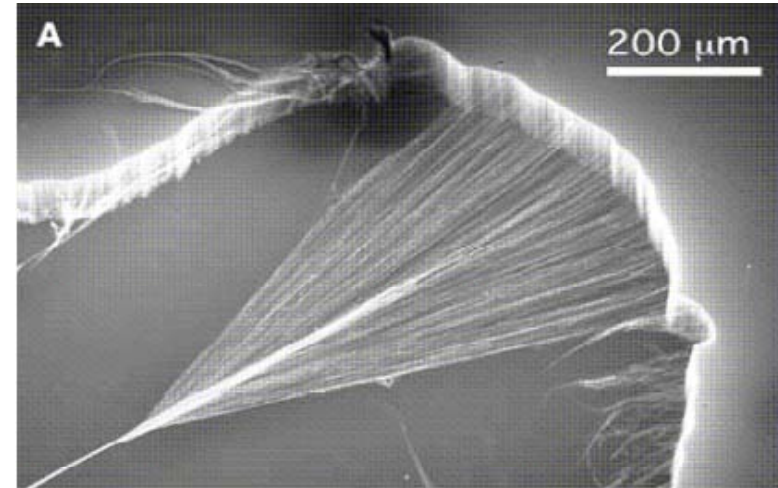
view into a carbon nanotube



vision of the space elevator realized through nanotubes



harvesting and spinning of nanotubes



M. Zhang et al., Science 306, 1358 (2004)

Fig.3

Lecture Plan „Physics of Surfaces and Nanostructures WS0910

1. Structure of Surfaces

- basic concepts of surface crystallography
- measuring surface structure
- reconstruction, examples
- domain walls and the Frenkel-Kontorova model
- surface defects and their measurement

2. Electronic Structure of Surfaces

- work function and its measurement
- jellium model
- surface states
- quantization effects in confined geometries
- measuring surface electronic structure

3. Adsorption, Desorption, and Catalysis

- physisorption and chemisorption
- measuring surface composition and binding
- rates of surface chemical reactions and the transition state
- charge transfer and binding mechanisms
- concepts of heterogeneous catalysis (volcano plot etc.)
- nanocatalysis

4. Thermodynamic Aspects of Surfaces

- the surface excess
- surface stress, surface free energy and surface tension
- chemical potential and Laplace pressure
- phase transitions and phase equilibrium
- applications of capillary concepts

5. Epitaxy and Thin Films

- nucleation
- kinetic processes and homoepitaxy
- epitaxy and elastic energy in thin films, quantum dots
- organic thin films
- applications (hard coatings, semiconductor thin films)

6. Surface and Thin Film Magnetism

- fundamentals of band magnetism
- magnetic impurities
- surface, interface and shape anisotropy
- exchange coupling and the GMR effect
- atomic scale magnetism
- magnetic imaging

7. Ion Beam Processes at Surfaces

- sputtering and collision cascades
- linear stability analysis and pattern formation
- implantation
- applications (SIMS, Smartcut, FIB)

8. Clusters

- cluster preparation
- cluster properties (magnetic, catalytic, electronic)
- applications

Script and Overheads

<http://www.ph2.uni-koeln.de/de/lehre/>

user: Master

password: nano

Literature

- H. Ibach: Physics of Surfaces and Interfaces, Springer, 80 €
in depth treatment, partly difficult, special attention to electrochemical interfaces
- K. Oura et al: Surface Science, Springer, 96 €
easy introduction, sometimes a little cursory
- M. Prutton: Introduction to Surface Physics, Oxford University Press, 39 €
simple, often too simple introduction, written for undergraduates, but an easy starting point
- H. Lüth: Solid Surfaces, Interfaces and Thin Films, Springer, 68 €
emphasis on electronic structure and semiconductor interfaces
- M. Henzler/ W. Göpel: Oberflächenphysik des Festkörpers, 45 €
cheap, slightly outdated but reasonable introduction, ugly pictures
- A. Zangwill: Physics at surfaces, 52 €
introduction from the theoretical point of view
- J. Venables: Introduction to Surface and Thin Film Processes, 51 €
not really a textbook, more like a collection of ideas and concepts
- G. Ertl J. Küppers: Low Energy Electrons and Surface Chemistry, antiquarian
mainly on techniques, well written but somewhat outdated
- C.B. Duke, E.W. Plummer: Frontiers in Surface Science, Vol. 500 of the journal „Surface Science“, collection of stimulating review papers covering many aspects of surface, interface and nanostructure science.