Micro- and Nanotechnology

Micro- and Nanostructures

- Optical lithography
  - resolution limits, -enhancement
  - resist chemistry and -kinetics
  - phase shift masks
- Electron beam lithography
- Device scaling
- Basic concepts of nanotechnologies

Micro- and Nanotechnology

Thin Films

- Preperation of thin films
- Vacuum-based deposition techniques
- Film formation
- Physical properties of thin films
- Characterisation techniques

Smart Materials and Sensors

Materials for Sensors and Electronics

- Dielectrics
- Pyro-, piezo-, ferroelectrics
- Inhomogeneous and composite materials
- Charge conduction in solids

- Dia-, para-, ferromagnetics
- Magnetic recording, XMR-effects

Smart Materials and Sensors

Selected Topics of Sensor Technology

- Lecture series from experts on:
  - Fibre optical sensors
    (Prof. Dr. R. Willsch, IPHT Jena)
  - Integrated optical sensors
    (Dr. Ruske, Guided Color Technologies Jena),
  - Biosensor technology
    (Prof. Dr. K.-H. Feller, EAH Jena),
  - Magnetoresistive sensors
    (Dr. R. Mattheis, IPHT Jena),
  - Accelleration sensors and their applications
    (U. Oertel, Bachmann Monitoring GmbH Rudolstadt)

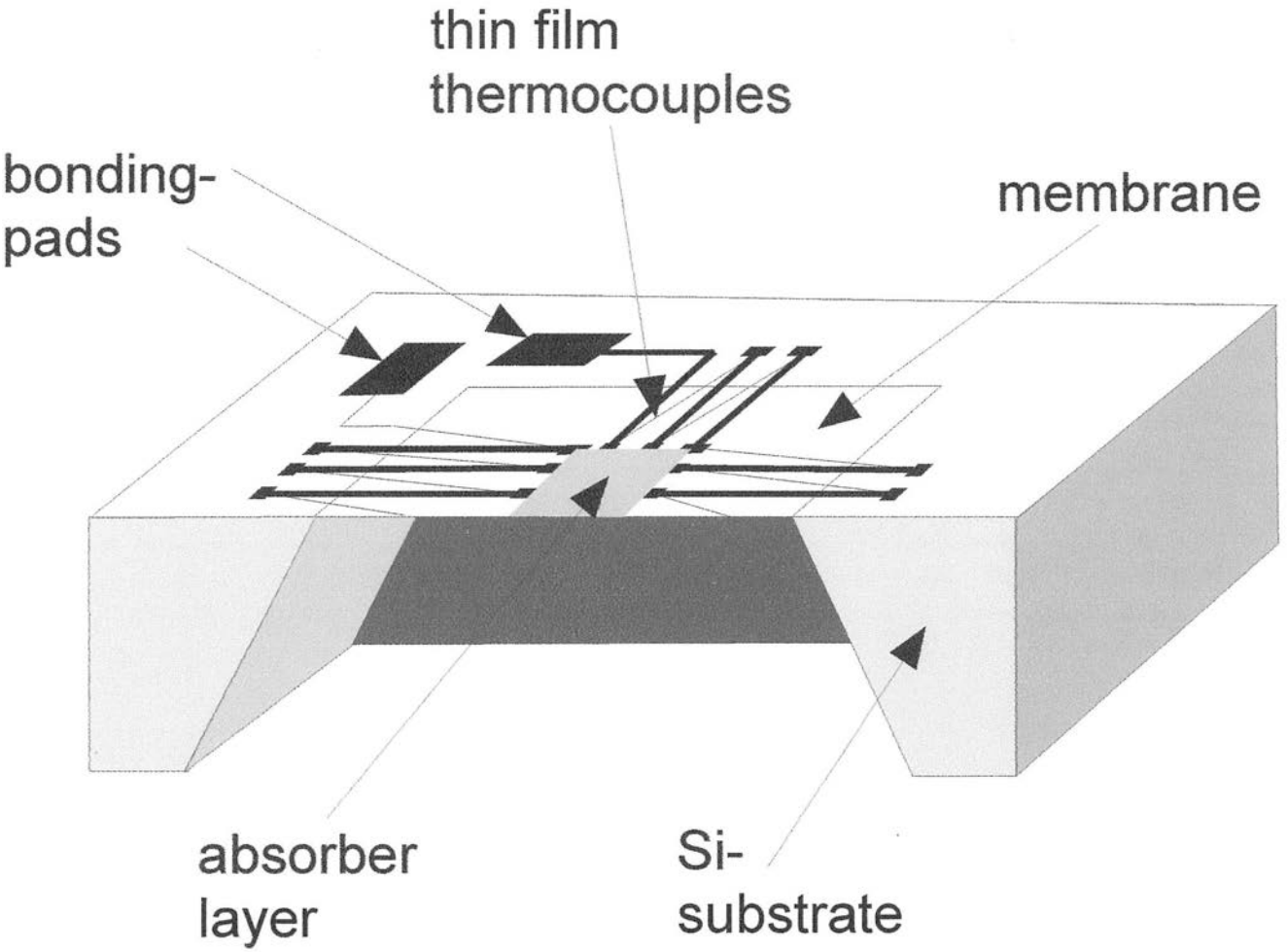
Example Device: Radiation sensor

Required Know-how from
Smart Materials and Sensors & Micro- and Nanotechnology

Fabricated in thin film technology

Picture: thermocouples

Also possible: pyroelectric material (PVDF)



Scientific Computing

- Mathematic modelling
- Discretisation
- Fundamental concepts of functional analysis
- Inverse an ill-posed problems
- Regularisation methods

- Multivariate data analysis, test of linear models
- Data analysis using SPSS

Scientific Computing

Fundamental Concepts of Functional Analysis

- Banach-, Hilbert-, Sobolevspace
- Dense sets
- Operators, esp. compact and adjoint operators between function spaces
- Eigen-, singular values, Eigenfunctions of operators
- Singular value decomposition
- Regularisation techniques for operator equations

Scientific Computing

Inverse and ill-posed problems

- Heat conduction forward in time:

  => ``well-behaved''
- Heat conduction backward:

  => ill-posed

Applications in:

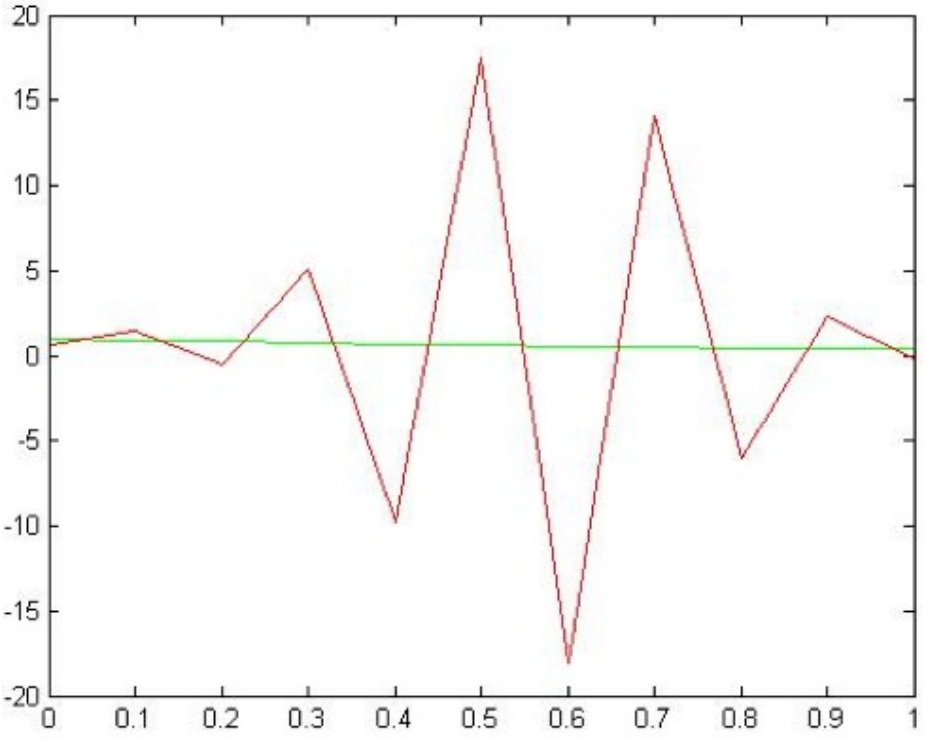
- Medical imaging (CT, ultrasonography etc.)
- geological research, climatic modelling

Scientific Computing

Example: $$\int_0^1 (x+1)e^{-xy}\varphi(y)\,\mathrm{d}y = 1 - e^{-(x+1)},\ 0 \le x \le 1$$

Analytical solution: $\varphi(x) = e^{-x}$

Comparison with numerical solution:



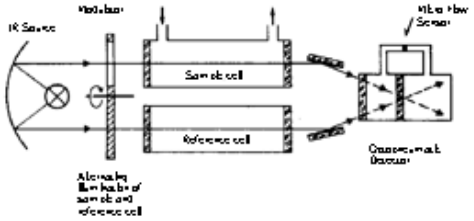
Arising questions:

- Why is numerical solution completely useless?
- How can a sensible solutions be found?

Scientific Computing

Software Available in Pools

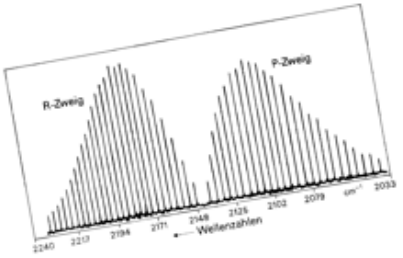
- Matlab
- Mathematica
- Maple
- Mupad
- SPSS
- Scilab
- Comsol Multiphysics (FEM)

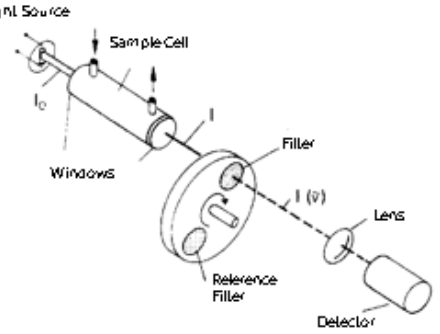


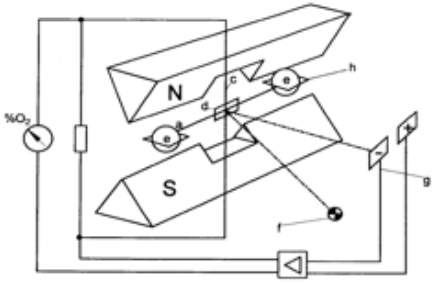
Metrology and Analytics

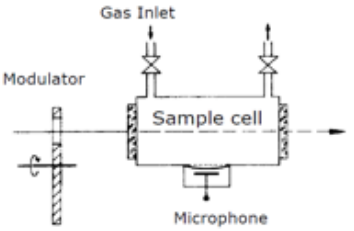
Gas Sensing and Aerosol Measurement

- Instrumentation for gas sensing
  - Spectroscopy
  - Electrochemical sensors
  - Semiconductor sensors
- Aerosols
  - Properties of aerosols
  - Mass concentration measurement
  - Particle counters
  - Instrumentation for particle sizing









Metrology and Analytics

Instrumental Chemical Analytics

is replaced by

Advanced characterization methods in materials science

Design

FEM & Simulation (Prof. Dr.-Ing. Frank Dienerowitz)

Proposal of scope (exact scope yet to be defined):

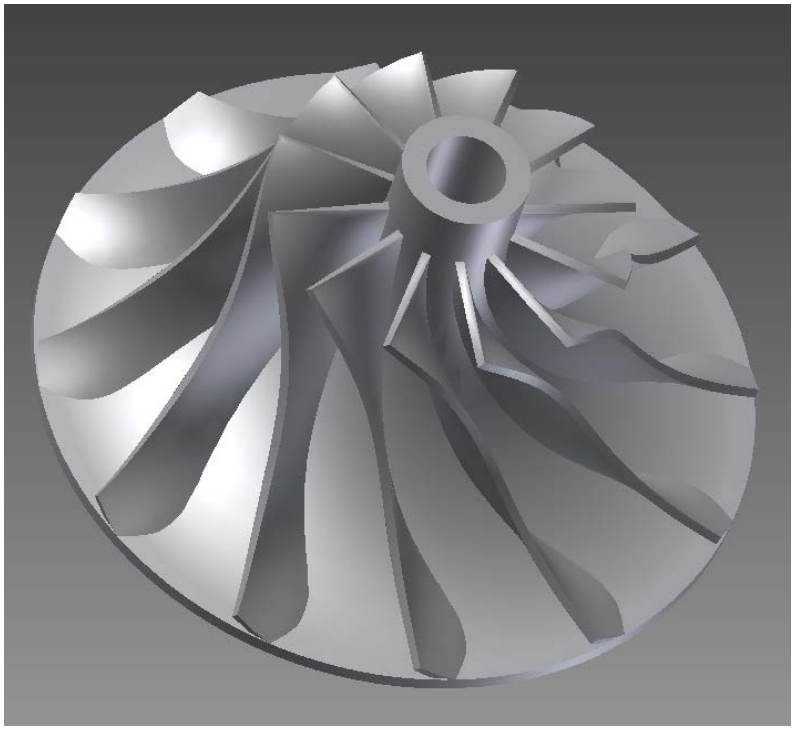
- **Ca. 65% advanced FEA simulations using *ANSYS Workbench*:**
  - Contact problems, e.g. snap lock
  - Structural-thermal problems, e.g. temperature induced stresses
  - Multibody Dynamics, e.g. kinematic simulation of a mechanism
  - Modal analysis, i.e. natural vibration frequencies and mode shapes
  - Optimisation of design

- **Ca. 35% simulations using *Matlab Simulink*:**
  - Introduction to Matlab Simulink
  - Modeling and simulation of systems, also with controllers

Design

Advanced 3D-Design

- **Lecture and lab**
- **Design project based on lecture and lab**
- Parametric design
- Design guideline
- Surface modelling
- Integrated simulation
- 3D-CAD Software Autodesk Inventor



Design

Precision Instrumentation

- Lecture, project, presentation, report
- Project topics assigned by lecturer

- Basic rules for design of precision instruments
- Influences on instrument accuracy, error prevention principles
- State of the art designs for special task (e. g. precision drives and motion stages)