
Thin film fabrication technologies

MSE-465

Lecturer:

Johann Michler, Empa





WELCOME

Prof. Dr Johann Michler
Empa, Materials Science and Technology, Thun, Switzerland



Prof. Dr. Johann Michler

Education:

- 1999 **Ph.D.** thesis at the Department of Materials Science, Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland
- 1995 **Dipl.-Ing.** (Engineering Diploma), in **Materials Science** at the Technical University of Erlangen-Nürnberg, Germany

Positions:

since 2007 Head of „Laboratory for Mechanics of Materials and Nanostructures “ at Empa, Thun



Entrepreneur:

- 2020 Co-founder of spin-off, **SwissCluster AG** (thin film deposition equipment)
- 2010 Co-founder of spin-off, **Eleoss GmbH** (watch components via UV-LIGA and electroplating)
- 2007 Co-founder of spin-off, **Alemnis AG** (micromechanical test equipment)

Laboratory for Mechanics of Materials and Nanostructures



~40 FTE

Lab head – J. Michler
 3 Scientists – I. Utke, X. Maeder, J. Schwiedrzik
 2 Technical staff
 21 non-permanents post-docs and scientists
 7 PhD students
 4 Thun site administration

TT

Start-ups (~100 FTE, >50 PhDs)
 Mostly active in the academic market for
 scientific instruments & deposition equipment

infrastructure

TOPWERK
 Total of High-Resolution Spectrometry

MatExpert

alemnis
 engineering your ideas

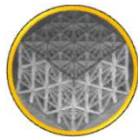
ELEOSS
 electrodeposition of stainless steel

Swiss Cluster
 Amanuensis
 serving your science



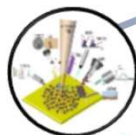
Nanomechanics labs

Nanoindenter, -in-situ SEM tester, HT mechanics
 HT Tribom., Env. Tribom, industrial Tribom



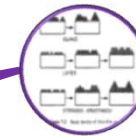
Clean rooms

Class 10000/ Iso 7, +/-0.5°
 2 Photon lithography, Laser litho, UV lithography



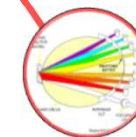
Microscopy labs

Cs-cor. TEM, SEMs, FIBs with EBSD, EDS, EDX, ToF-Sims, XRF, μ -Raman, AFM's



Thin film deposition labs

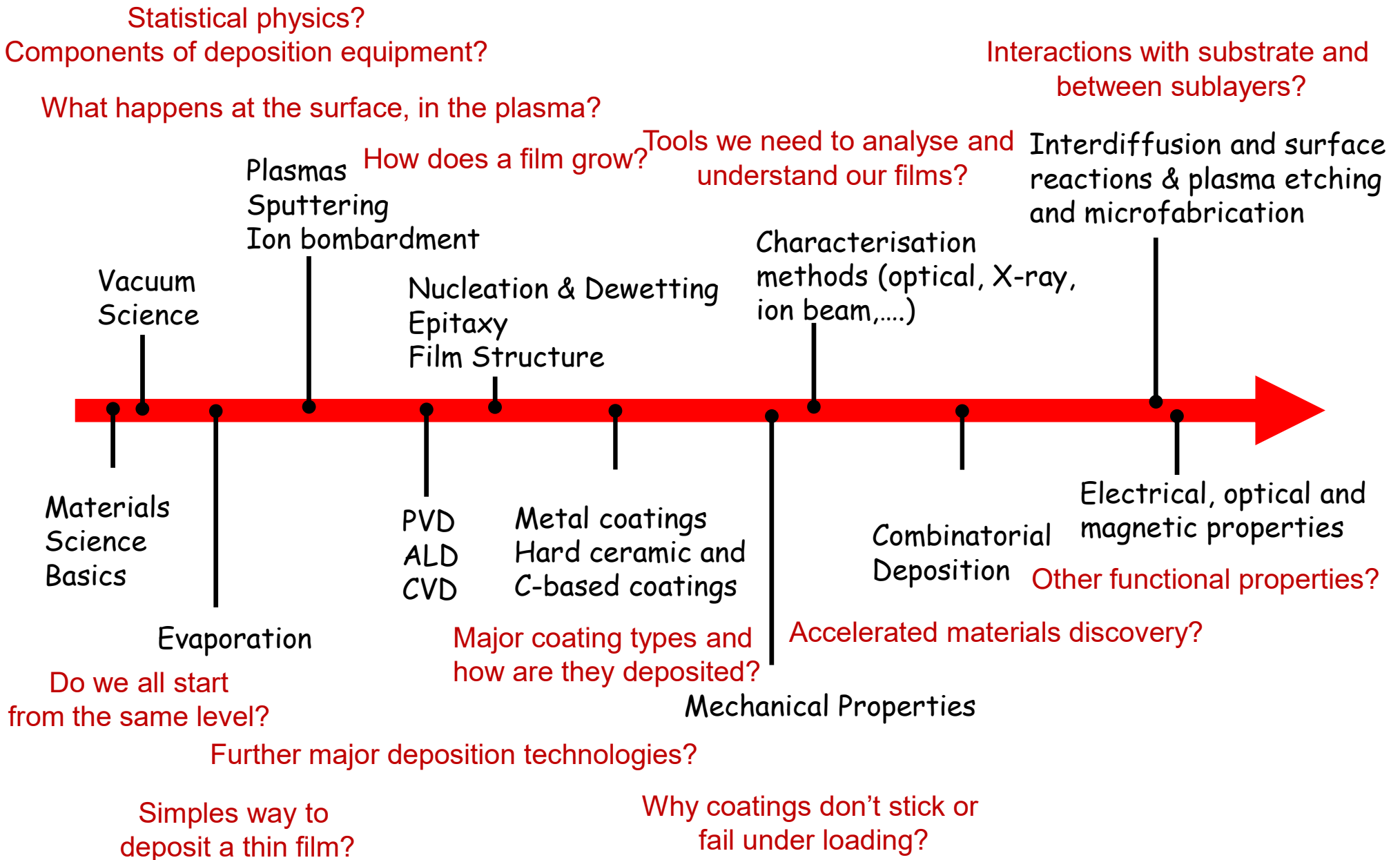
Galvano, PVD, ALD



Chemical & Microstructure analysis labs

GDOES, XRD, XRF, TOFSIMS, Raman, FTIR, DTA, Metallography, optical spectroscopy
 RBS, LA-ICMPS (Empa central, start-ups etc.)

Course roadmap



outline of the course

Wednesday I

Introduction & overview
Review of required elements of Materials Science
Vacuum Science
Evaporation

Wednesday II

Discharges and Plasmas
Sputtering and Ion bombardment
Plasma and Ion beam processing

Wednesday III

Chemical Vapor Deposition
Atomic Layer Deposition

Wednesday April IV

Diamond and amorphous carbon
Nucleation & Dewetting
Epitaxy

Every 2 weeks
4 x 45min

outline of the course

Wednesday May V

Film Structure
Residual Stresses in Thin Films

Wednesday May VI

Mechanical Properties & Tribology
Hard Coatings

Wednesday June VII

Outlook on selected topics:





- Combinatorial deposition & optical properties
- advanced (surface) analytical and techniques
- interdiffusion and surface reactions
- dry etching and deposition on 3D surfaces
- in-situ characterisation methods

(Virtual) laboratory tour @ Empa

Questions and Answers

Format of lectures

Lecture series numbering:

-  100 Introduction
-  110 Course roadmap and motivation
-  120 Review of Materials Science
-  130 Vacuum Science questions

Lecture:

- all recorded mpeg format & pdf slide printout (length of videos are not 45min as the life lectures as they are compiled per topic and don't include breaks)
- table of content, lecture, summary, questions as support for exam preparation and solutions will be provided at the end of the course
- 1-2 slides virtual company visit or interview (if applicable; not exam relevant)

Exam: Oral exam



introductory books - references

Main reference:

Ohring 2002: Ohring Milton (2002) Materials Science of Thin Films, Deposition and Structure, 2nd edition, 2002, San Diego: Academic Press

Other references:

Smith 1995: Smith Donald L (1997) Thin-Film Deposition - Principles and Practice, New York: McGraw-Hill

Kääriäinen 2013, Tommi Kääriäinen, David Cameron, Marja-Leena Kääriäinen, and Arthur Sherman (2013) Atomic Layer Deposition - Principles, Characteristics, and Nanotechnology Applications, Wiley, Scrivener Publishing LLC

Pohl 2020, U.W.Pohl, Epitaxy of Semiconductors, Springer

Machlin 2005: Eugene Machlin (2005) Materials Science in Microelectronics I - The Relationships Between Thin Film Processing and Structure, 2nd edition., Morgan Kaufmann

Schultrich 2018: Bernt Schultrich (2018) Tetrahedrally Bonded Amorphous Carbon Films I - Basics, Structure and Preparation, Springer Series in Materials Science 263, Springer-Verlag GmbH Germany

Mitterer 2014: Christian Mitterer (2014) PVD and CVD Hard Coatings, in: Reference Module in Materials Science and Materials Engineering, Comprehensive Hard Materials Volume 2, 2014, Pages 449 - 467, Elsevier

introductory books - references

- Rostislav 2013: Rostislav Daniel, Jindrich Musil (2013) Novel Nanocomposite Coatings - Advances and Industrial Applications, CRC Press, Taylor & Francis Group
- Nix W.D. (2014) Metallic thin films: stresses and mechanical properties, in: Metallic Films for Electronic, Optical and Magnetic Applications: Structure, Processing and Properties, Woodhead Publishing Limited, p353-421
- Madou M.J. (2012) Fundamentals of Microfabrication and Nanotechnology, Three-Volume Set, CRC Press Taylor & Francis Group, Boca Raton
- Harsha K.S.S. (2005) Principles of Vapor Deposition of Thin Films, Elsevier Science, Amsterdam
- Blasek G. (2010) Vakuum - Plasma - Technologien, Beschichtung und Modifizierung von Oberflächen, EUGEN G. LEUZE VERLAG KG , BAD SAULGAU
- Mattox D.M. (2010) Handbook of Physical Vapor Deposition (PVD) Processing, William Andrew (Elsevier), Oxford
- Jousten K (2016) Handbook of Vacuum Technology, Wiley-VCH Verlag GmbH & Co., Weinheim

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