CURSO DE PÓS-GRADUAÇÃO EM
ENGENHARIA E TECNOLOGIA ESPACIAIS

ÁREA DE CONCENTRAÇÃO EM
CIÊNCIA E TECNOLOGIA DE MATERIAIS E SENSORES

Coordenadoria Acadêmica do Curso

Walter Abrahão dos Santos

Coordenadoria Acadêmica da Área de Concentração

Sergio Luiz Mineiro

Docentes Permanentes

Carina Barros Mello, Doutora, INPE, Brasil, 2011
Eduardo Abramof, Doutor, Univ. Johannes Kepler, Áustria, 1993
Evaldo José Corat, Doutor, ITA, Brasil, 1993
Maria do Carmo de Andrade Nono, Doutora, ITA, Brasil, 1990
Mario Ueda, Doutor, Cornell, E.U.A, 1986
Maurício Ribeiro Baldan, Doutor, ITA, Brasil, 1997
Neidenei Gomes Ferreira, Doutora, UNICAMP, Brasil, 1994
Paulo Henrique de Oliveira Rappl, Doutor, ITA, Brasil, 1998
Rogério de Moraes Oliveira, Doutor, INPE, Brasil, 2004

Docentes Colaboradores

Luiz Ângelo Berni, Doutor, UNICAMP, Brasil, 1996
Sergio Luiz Mineiro, doutor, INPE, Brasil, 2007
Patrícia Regina Pereira Barreto, Doutora, ITA. Brasil, 1998
Vladimir Jesus Trava-Airoldi, Doutor, ITA, Brasil, 1986
Waldeir Amaral Vilela, Doutor, INPE, Brasil, 2010

Colaboradores Especiais

Andrea Boldarini Couto, Doutora, UFSCar, Brasil, 2005
Chen Ying An, Doutor, ITA, Brasil, 1998
Eder Paduan Alves, Doutor, INPE, Brasil, 2016
Francisco Piorino Neto, Doutor, FAENQUIL, Brasil, 2000
João Marcos Kruszynski de Assis, Doutor, INPE, Brasil, 2014
Rafael Cardoso Toledo, Doutor, INPE, Brasil, 2013

CURSO DE PÓS-GRADUAÇÃO EM
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1º Período Letivo

Obrigatória para o Mestrado

CMS-200-4	Materials Science I

Obrigatória para o Mestrado e o Doutorado

CMS-203-0	Seminars I

Eletiva

CMS-205-4	Mathematical methods applied to materials science

2º Período Letivo

Obrigatória para o Mestrado e o Doutorado

CMS-204-0	Seminars II

Obrigatórias adicionais para o Mestrado (*)

CMS-207-4	Experimental techniques in materials science I
CMS-206-4	Elements from Theory of errors and statistical treatment of data
CMS-306-4	Physics of Ceramics
CMS-307-4	Physics and chemistry of Solid surfaces
CMS-337-4	Introduction to nanoscience and nanotechnology materials

(*) O aluno de mestrado deverá cursar uma disciplina (total de 4 créditos) desta lista, que será considerada obrigatória. As demais disciplinas cursadas passarão a ser consideradas como eletivas.

Eletivas

CMS-300-4	Quantum mechanics
CMS-405-4	Growth of CVD Diamond films
CMS-410-4	Plasma technology for surface treatment
CMS-421-4	Introduction to microscopy of materials

3º Período Letivo e Seguintes

Eletivas

CMS-301-4	Solid state physics
CMS-308-4	Physics of Nanostructures
CMS-323-4	Silicon solar cells and radiation sensors: basic concepts, techniques of Manufacture and characterization
CMS–329-4	Chemical kinetics
CMS-336-4	Mechanical characterization of materials
CMS-347-4	Introduction to Radiometry
CMS-403-4	Surfaces and Interfaces of materials: Modification and characterization
CMS-404-4	Thin films technology
CMS-406-4	Porous Materials
CMS-407-4	Covalent ceramics and aerospace applications
CMS-409-4	Environmental sensors and control
CMS-419-4	Principles of electrochemistry
CMS-414-4	Processing and characterization of advanced ceramics
CMS-415-4	Processing and characterization of nanostructured ceramics
CMS-416-4	Nanoparticle powders: obtaining, characterization and applications
CMS-417-4	Nanostructured films: production, Characterization and applications
CMS-420-4	X-ray diffractometry for characterization of crystalline structure of materials
CMS-315-1	Special topics in science and physics of materials I (*)
CMS-316-2	Special topics in science and physics of materials II (*)
CMS-339-3	Special topics in science and physics of materials III (*)
CMS-340-4	Special topics in science and physics of materials IV (*)
CMS-317-1	Special topics in materials processing I (*)
CMS-318-2	Special topics in materials processing II (*)
CMS-341-3	Special topics in materials processing III (*)
CMS-342-4	Special topics in materials processing IV (*)
CMS-319-1	Special topics in materials characterization techniques I (*)
CMS-320-2	Special topics in materials characterization techniques II (*)
CMS-343-3	Special topics in materials characterization techniques III (*)
CMS-344-4	Special topics in materials characterization techniques IV (*)
CMS-324-4	Research in physics of materials I (*)
CMS-325-4	Research in physics of materials II (*)
CMS-326-4	Research in physics of materials III (*)
CMS-330-4	Research in physics of materials IV (*)
CMS-331-4	Research in physics of materials V (*)
CMS-332-4	Research in physics of materials VI (*)
CMS-345-4	Research in physics of materials VII (*)

CMS-321-4	Research in science and technology of materials I (*)
CMS-327-4	Research in science and technology of materials II (*)
CMS-328-4	Research in science and technology of materials III (*)
CMS-333-4	Research in science and technology of materials IV (*)
CMS-334-4	Research in science and technology of materials V (*)
CMS-335-4	Research in science and technology of materials VI (*)
CMS-346-4	Research in science and technology of materials VII (*)

(*) Disciplinas com ementas específicas para cada assunto

EMENTAS DAS DISCIPLINAS DA ÁREA DE CONCENTRAÇÃO EM CIÊNCIA E TECNOLOGIA DE MATERIAIS E SENSORES

CMS-200-4	**Materials Science I**

Obligatory for the Master Degree
Prerequisites: none
Credit Hours: 60 hours

Atomic structures and interatomic bonds. Crystalline and non-crystalline structures of solids. Imperfections in solids. Atomic and Ionic mobility. Nucleation and development of microstructures. Phase equilibrium diagrams. Mechanical properties. Thermal properties. Electrical and dielectric properties. Magnetic properties. Optical properties.

References
SHACKELFORD, J. F. Introduction to Materials Science for Engineers. MacMillan Publishing Company, new York, U.S.A., 1992
CALLISTER Jr., W. D. Materials Science and Engineering - An Introduction. John Wiley & Sons Inc., 3th edition, U.S.A., 1994
ORING, M. Engineering Materials Science. Academic Press, U.S.A., 1995
S. M. ALLEN and E. L. THOMAS, The Structure of Materials, Wiley, New York, 1999
KITTEL, C. Introduction to Solid State Physics. John Willey & Sons, Inc, New York, 1996.

CMS-203-0	**Seminars I**

Obligatory for the Master Degree and Doctorate
Prerequisites: none
Credit Hours: 15 hours

Issues of interest in lectures given by professors of the graduate program and guests.

CMS-204-0	**Seminars II**

Obligatory for the Master Degree and Doctorate
Prerequisites: none
Credit Hours: 15 hours

Issues of interest in lectures given by professors of the graduate program and guests.

CMS-205-4	**Mathematical methods applied to materials science**

Elective
Prerequisites: none
Credit Hours: 60 hours

Introduction to derivatives. Rules of derivation. Maxima and minima. Closed intervals minimum. Applications involving derivatives. Introduction to integral. Techniques of integration. Double integration. Polar coordinates. Ordinary differential equations, classification, separation solution. Vectors and bases. Scalar and vector fields. Gradient, divergence and curl in orthogonal coordinates, representation, cylindrical and spherical. Introduction to computational tools: Mathematica and Maple.

References

BUTKOV, E. Física Matemática. Guanabara Dois, Rio de Janeiro, RJ, 1978.
ARFKEN, G. Mathematical Methods for Physicists. Academic Press, New York, 1970.

CMS-206-4	**Elements from the Theory of errors and statistical treatment of data**

Elective
Prerequisites: none
Credit Hours: 60 hours

Elements from the Theory of Errors. Physical quantity and significant figures.
True value, uncertainties, types of errors and source of errors. Population, sampling, frequency distribution and histogram. Probability distribution and types of distribution curves. Expected value, standard deviation, variance, standard deviation and chi-squared (χ^2). Error propagation, variances and covariances.
Statistical treatment of data. Maximum-likelihood estimation (MLE - maximum likelihood method). Method of least squares. Adjustment of curves using linear function. Linear and polynomial regression. Evaluation of the quality of an adjustment.

References

VUOLO, J. H. Fundamentos da Teoria de Erros. Edgard Blücher Ltda, São Paulo, 1992.
HELENE, O. A. M.; VANIN, V. R. Tratamento Estatístico de Dados em Física Experimental. Edgard Blücher Ltda, São Paulo, 1981.
BEVINGTON, P. R. Data Reduction and Error Analysis for the Physical Sciences. McGraw-Hill Inc., 1969.

CMS-207-4	**Experimental techniques in materials science I**

Additional Obligatory
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

X-ray diffraction techniques. Raman spectroscopy. Scanning electron microscopy and EDS analysis. Atomic force microscopy. Mechanical properties of materials.

References

KITTEL, C. Introduction to Solid State Physics. John Willey & Sons, Inc, New York, 1992.
ATKINS, P.W. Physical Chemistry. Oxford University Press, Oxford, UK, 2001.
GOLDSTEIN, J.I. et al. Scanning Electron Microscopy and X-Ray Microanalysis. Plenum Press, New York, 2nd. Ed., 1992.
CHEESCOE, D. AND; GOODSHEW, J. The Operation of Transmission and Scanning Electron Microscopes. Oxford Science Publications, Royal Microscopical Society, 1990.
CHEN, J. Introduction to Scanning Tunneling Microscopy, Oxford Series in Optical and Image Sciences 4. Oxford University Press, Oxford, UK, 1993.
WIESENDANGER, R. Scanning Probe Microscopy and Spectroscopy: Methods and Applications. Cambridge University Press, Cambridge, UK, 1994.
MEYER, E. et al. Scanning Probe Microscopy: The Lab on a Tip. Springer-Verlag, 2003
CULLITY, D. B. Elements of X-Ray Diffraction. 2nd. Edition. Addison-Wesley, Reading-MA, 1978.
BERTIN, E.P. Introduction to X-Ray Spectrometric Analysis. Plenum Press, New York, 1978.

JENKINS, R. et al. Quantitative X-Ray Spectrometry. Marcel Dekker, Inc., New York, 1981.
Metals Handbook, 9th Edition, Vol.10, Materials Characterization. American Society for Metals, 1986.
Catálogos de equipamentos.
Artigos de periódicos especializados.

CMS-300-4	Quantum mechanics

Additional Obligatory
Prerequisites: none
Credit Hours: 60 hours

The limits of classical physics. Wave packets and uncertainty relations. The Schrödinger equation. Eigenfunctions and eigenvalues. One-dimensional potentials. Vector spaces and operators. Many particle systems. Schrödinger equation in 3 dimensions and the hydrogen atom. Spin. Time-independent perturbation theory. Atoms and the periodic table. Molecules. Time-dependent perturbation theory. Polarizability and dielectric function.

References
COHEN-TENNOUDJI, C.; DIU, B.; LAOË, F. Quantum Mechanics. John Willey & Sons, Inc, New York, 1977.
GASIOROWICZ, S. Quantum Physics. 2ª edition, Wiley & Sons, 1996.
McQUARRIE, D. A. Quantum Chemistry. University Science Books, 1983.
McQUARRIE, D. A.; SIMON, J. D. Simon; CHOI, Physical Chemistry: A Molecular Approach. University Science Books, 1997.
LEVINE, I. Quantum Chemistry. Prentice Hall, 1996.

CMS-301-4	Solid State Physics

Elective
Prerequisites: none
Credit Hours: 60 hours

Bravais lattice, reciprocal lattice, crystalline structure, and crystal diffraction, network vibrations: phonons, electronic levels in a periodic potential: Bloch's theorem, energy bands, Fermi surface, Brillouin zones, model of Drude and Sommerfeld, classic model of driving, dielectric properties, homogeneous and non-homogeneous semiconductors, magnetic properties: diamagnetism, Paramagnetism and ferromagnetism.

References
KITTEL, C. Introduction to Solid State Physics. John Willey & Sons, Inc, New York, 1967.
ASHCROFT, N. W.; MERMIN, N. D. Solid State Physics. Saunders College Publishing, NY, 1976.
Artigos selecionados de publicações especializadas.

CMS-306-4	Physical ceramics

Additional Obligatory
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Characteristics of the solid ceramics. Crystalline structures. Glass structures. Structural imperfections. Surfaces, interfaces and grain boundary. Atomic mobility. Phase equilibrium. Development of the microstructure in Ceramics: reactions with and between solids, grain growth, sintering and glazing.

References

CHIANG, Y. M.; BIRNIE, D. P.; KINGERY, W. D. Physical Ceramics: Principles for Ceramic Science and Engineering. Wiley & Sons, New York, 1996.
KINGERY, W. D. Introduction to Ceramics. et al., 2nd edition, Wiley & sons, New York, 1976.
RING, T.A. Fundamentals of Ceramic Powder Processing and Synthesis. Academic Press, New York, 1995.
TURTON, R. J. The Physics of Solids, Oxford University Press, England, 2000.
Artigos selecionados de publicações específicas.

CMS-307-4	Physical and chemical surfaces of solids

Additional Obligatory
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Scientific and technological importance. Atomic structure on the surface of solids and liquids. Electronic structure on the surface. Surface tension. Thermodynamics of systems with a component. Thermodynamics of multicomponent systems. Surface mobility. Physical Adsorption. Adsorption chemistry. Modification of surface reactivity. Electron-surface interactions. Ion-surface interactions. Phonon-surface interactions. Internal surfaces: interfaces. Types of interfaces. Mechanisms for the formation of defined, diluted and multiple interfaces.

References

HUDSON, J. B. Surface Science: An Introduction. Pergamon Press Inc., New York, 1994.
TURTON, R. J. The Physics of Solids, Oxford University Press, England, 2000.
PRUTTON, M. Introduction to Surface Physics, Oxford University Press, England, 1996.
LUTH, H. Surfaces and Interfaces of Solid Materials. Pergamon Press, New York, 1998.
SUTTON, A. P.; BALLUFFI, R. W. Interfaces in Crystalline Materials, Oxford University Press, Oxford, 1996.
OHRING, M. The Materials Science of Thin Films. Academic Press, USA, 1991.
ADAMSON, A.W. Physical Chemistry of Surfaces. John Wiley & Sons, U.S.A., 1967.
S. M. ALLEN and E. L. THOMAS, The Structure of Materials, Wiley, New York, 1999.
CALLISTER Jr., W. D. Materials Science and Engineering - An Introduction. John Wiley & Sons Inc., 3th edition, U.S.A., 1994.

CMS-308-4	Physics of nanostructures

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Nanometric scale, quantum confinement, mesoscopic phenomena, molecular nanostructures, electronic structure and optical and transport properties of superlattices, quantum wells, wires and dots, quantized Hall effect, spin-dependent properties, devices and new structures.

References

FERRY, D. K.; GOODNIK, S. M. Transport in Nanostructures. Cambridge University Press, 1999.
BASTARD, G. Wave mechanics applied to semiconductor heterostructures. Les Éditions de Physique, France, 1990.
DATTA, S. Quantum Phenomena. Addinson-Wesley Press, USA, 1989.

CMS-323-4	**Silicon solar cells and radiation sensors: basic concepts, manufacturing techniques and characterization**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Introduction: General aspects of solar energy. Solar energy conversion into thermal energy and electricity. Different types of solar cells. Key differences between solar-cells used for terrestrial and space applications. Solar spectrum. Solar Simulator. Silicon: Material considerations. Light absorption in silicon. Band diagram. Manufacturing processes: Obtaining and preparing the blade itself. Formation of the n-p and p-n junction. Contacts and anti-reflective coating. Theory: p–n junction. Photovoltaic effect. current density vector J. Quantum efficiency. Characterization: Characteristic IxV in dark and under illumination. Equivalent circuit. Determination of resistance in series and parallel. Spectral response and quantum efficiency: measures of diffusion length and life time for minority carriers. Reflectivity: reflectivity speculate and diffuse. Layers anti-reflective coating texturing. Porous silicon. Basic concepts about radiation sensors. Calibration techniques and characterization of solar radiation sensors.

References

WORLD METEOROLOGICAL ORGANIZATION**.** Guide to Meteorological Instruments and Methods of Observation. 7ª. s.l. : Chairperson, Publications Board, 2008. ISBN 978-92-63-10008-5.
MCCLUNEY, W. R. Introduction to Radiometry and Photometry. Boston / London : Artech House, inc., 1994. ISBN 0-89006-678-7.
PARK, JOHN e MACKAY, STEVE. Pratical Data Acquisition for Instrumentation and Control Systems. Oxford: Elsevier, 2003. ISBN 07506 57960.
RAUSCHENBACH, H. S. Solar array design handbook. New York, Litton Educational Publishing, 1980.
Artigos selecionados de revistas de revistas especializadas.

CMS–329-4	**Chemical Kinetics**

Elective
Prerequisites: none
Credit Hours: 60 hours

Basics of chemistry, concept of the thermodynamic properties of the mixtures. First and second law for mixtures. Chemical equilibrium. Thermodynamic functions from the point of view of the kinetic theory of gases. Simple and multiple reactions. Reaction speed. Calculation of the constant reaction of the kinetic theory of gases. Reactions in condensed phases. Types of chemical reactors and their characteristics. Complex reactions and reduced kinetics.

References

MISSEN, R. W; MIMS, C. A.; SAVILLE, B. A. Introduction to Chemical reaction Engineering and Kinetics. John Wiley & Sons, Inc., 1999.

MONCRIEF, J. W. Elements of Physical Chemistry, Addison Wesley Publishing Company, 1977.
DENBIGH, K. G. The Principles of Chemical Equilibrium: With Applications in Chemistry and Chemical Engineering, Cambridge University Press, 1981.

CMS-336-4	**Mechanical characterization of materials**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Fundamentals of materials resistance. Materials for structural applications: mechanical properties of metallic, ceramic and polymeric materials. Stress and strain curve. Fundamentals of fracture, ductile and brittle fracture. Conventional mechanical testing of materials: traction, tensile, tests related to fragile fracture, hardness testing, fatigue test. Mechanical tests of metallic materials, ceramic materials (Weibull statistics), polymeric materials and composite materials. Mechanical characterization of materials in temperatures above the environment.

Note: The discipline is divided into theoretical classes and laboratory practices.

References
BUDINSKI, K.; BUDINSKI, M. Engineering Materials, Properties and Selection, 6th ed., Prentice-Hall Inc., 1999.
CALLISTER JR, W. Materials Science and Engineering an Introduction. John Wiley and Sons, 1999.
SMITH, W. F. Princípios de Ciência e Engenharia dos Materiais., 3ª ed.,. McGraw-Hill, Portugal, 1998.
SHAH, V. Handbook of Plastics Testing Technology, 2ª ed. John Wiley and Sons, 1998.
ANDERSO, J. C. et ali. Materials Science, 4ª ed. Chapman & Hall, 1991.
EVANS, R.W.; WILSHIRE, B. Introduction to Creep, The Institute of Materials, London, 1993.
GARCIA, A.; ALVARES, J.; ALEXANDRE, C. Ensaios de Materiais, LTC Editora, Rio de Janeiro, 2000.
SOUZA, C. L. Ensaios Mecânicos de Materiais Metálicos. Editora Edgard Blücher Ltda., São Paulo, 1982.
Selected papers.

CMS-337-4	**Introduction to nanoscience and nanotechnology of materials**

Additional Obligatory
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

The Nanometric universe. Definitions of nanoscience and nanotechnology. Scientific and technological importance: advantages and limitations. Introduction to Nanomaterials: Atomic structure, nanostructures, defects, thermodynamics, surfaces and interfaces. Introduction to the physics and chemistry of nanomaterials. Molecular nanotechnology. Nanopowders. Nanotubes. Nanofilms. Nanocomposites. Nanoelectronics. Nanocomputers. Fuel cells. Nanomaterials in environmental recovery. Nanotechnology in medicine. Nanotechnology in the areas for aeronautics and space applications. Legal and ethical considerations.

References

HU, S. E.; ROCO, M. C. Nanostructure Science and Technology: A Worldwise Study. National Science and Technology Council (NSTC), Maryland, USA, 1999.
BRUECK, S. J. et all. Implications of Emerging Micro-and Nanotechnologies. National Academies Press, Washigton, 2003.
BACHMANN, G. et all. Applications of Nanotechnology in Space Developments and Systems. Future Technologies, n 47. VDI Technology Center, Germany, 2003.
TOMA, H. E. O Mundo Nanométrico: A Dimensão do Novo Século. Livraria Politécnica Ltda., São Paulo, 2004.
BRUSHAN, B. (editor). Springer Handbook of Nanotechnology. Springer, 2004.
GOLDSTEIN, A. N. (editor). Handbook of Nanophase Materials. Marcel Dekker, Inc., New York, NY, USA, 1997.
THEODORE, L. Nanotechnology: Basic Calculations for Engineers and Scientists. Wiley & Sons, Inc., Hoboken, NJ, USA, 2006.
Selected papers.

CMS-347-4	**Introduction to Radiometry**

Elective
Prerequisites: none
Credit Hours: 60 hours

Introduction to the basic concepts of radiometry and photometry and their applications. Electromagnetic spectrum. Laws of radiometry and photometry. Propagation of electromagnetic radiation in optical systems. Optical properties of materials. Aberrations in optical systems, sources of Radiation (e.g.: black body, filament lamps, fluorescent lamps, gas discharge, LED, laser, plasma and sun). Radiation detectors (e.g.: thermopile, photomultipliers, photodiodes and CCD). Optical systems used in laboratories (monochromator, integrating sphere, solar simulators, angular and spectral sensor response measure). calibration and laboratory activities.

References
McCLUNEY, R. Introduction to Radiometry and Photometry.
PALMER, J. M.; GRANT, B. G. The Art of Radiometry.

CMS-403-4	**Materials surfaces and Interfaces: modification and characterization**

Elective
Prerequisites: CMS-307-4 or equivalent
Credit Hours: 60 hours

Scientific and technological importance. Types of surfaces and interfaces. Main features, advantages and limitations. Modifications of chemical surfaces, thermochemical, electrochemical, mechanical, thermomechanical and conventional vaporization, sputtering, electron beam, laser, plasmas (nitriding, carburizing, nitro-carburizing, boriding, carbo- boriding, nitro- boriding, plasma jet, ion planting, PVD, CVD) and implantation of ions (by ion beam, plasma immersion implantation and ion mixing). Chemical characterization of surfaces and interfaces. Physical characterization of surfaces and interfaces. Analysis of phases and states of mechanical tensions on surfaces and interfaces. Analysis of the parameters of mechanical properties.

References
BURAKOWSKI, T.; WIERZCHON, T. Surface Engineering of Metals: Principles, Equipments and Technologies. CRC Press, New York, 1999.

OHRING, M. The materials science of thin films. Academic Press, USA, 1991.
MASEL, R. I. Principles of Adsorption and Reaction on Solid Surfaces. John Wiley & Sons Inc., 1st edition, U.S.A., 1996.
LUTH, H. Surfaces and interfaces of solid materials. Pergamon Press Inc., New York, 1998.
SUTTON, A. P.; BALLUFFI, R. W. Interfaces in Crystalline Materials, Oxford University Press, Oxford, 1996.
BROOKS, C. R. Principles of the Surface Treatment of Steels. Technomic Publishing Co. Inc., U.S.A., 1992.
WILSON, S.; BRUNDLE, C. R.; EVANS, C. Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films. Willey & Sons, New York, 1992.
BURAKOWSKI, T.; WIERZCHON, T. Surface Engineering of Metals. CRC Press, New York, 1999.
Handbook of Metals, vol. 10, 9th. edition, 1986.
Selected papers.

CMS-404-4	**Thin films technology**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Scientific and technological importance. Kinetic Theory of gases. Introduction to vacuum technology. Types of substrate surfaces. Techniques for the preparation and cleaning of substrate surfaces. Thin film growth techniques. Nucleation and film growth mechanisms. Formation of interfaces. Techniques of mechanical, chemistry, electrochemical and optical characterization of thin films.

References
OHRING, M. The Materials Science of Thin Films. Academic Press., Inc., San Diego, U.S.A, 1991.
CALISTER Jr., W. D. Materials Science and Engineering - An Introduction. John Wiley & Sons Inc., 3th edition, U.S.A., 1994.
PULKER, H. K. et al. Wear and Corrosion Resistant Coatings by CVD and PVD. Expert Verlag, Suécia, 1989.
Handbook of Metals, vol. 10, 9th edition, 1986.
Selected papers.

CMS-405-4	**CVD Diamond Film Growth**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Introduction: Diamond properties and structure, surface structure. History of low-pressure diamond growth. CVD Diamond growth methods: hot filament, non-isothermal plasma, thermal plasmas, combustion. CVD diamond growth process: chemical kinetics of gaseous phase, growth models, Bachman's ternary diagram, growth mechanisms. Dependence on growth parameters. Characterization Methods of CVD Diamond. Recent and planned applications for Diamond CVD: mechanical, optical, dental, microelectronics, heat dissipation, etc.

References
SPEAR, K. E.; DISMUSKES, J. P. Synthetic Diamond: Emerging CVD Science and Technology. John Wiley & Sons, New York, 1994.

Recent articles in the field.

CMS-406-4	**Porous materials**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Definition of porous and nanoporous materials. Pore structure. Interconnecting pores and surface area. Capillary in porous media. Adsorption and absorption in gas-solid and solid-liquid interfaces. Reactivity on solid surfaces. Techniques for the manufacture of porous and nanoporous materials. Characterization techniques.

References
ROUQUEROL, F.; ROUQUEROL, J.; SING, K. Adsorption by Powders and Porous Solids : Principles, Methodology and Applications. Academic Press Inc., 1998.
DULLIEN, F. A. L. Porous Media : Fluid Transport and Pore Structure. 2nd edition, Academic Press Inc., Boston, 1997.
LICHTNER, P. C. Reactive Transport in Porous Media. Mineralogical Society of America, USA, 1996.
TRÜMMLER; R. OBERACKER, A. An Introduction to Powder Metallurgy. The Institute of Materials, 1 Carlton House Terrace, London, 1993.
RING, T. A. Fundamentals of Ceramic Powder Processing. Academic Press Inc., 1996.

CMS-407-4	**Covalent ceramics and aerospace applications**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Types of covalent ceramics. Covalent composites. Synthesis of silicon nitride, silicon carbide and boron carbide powders. Silicon nitride matrix reinforced with silicon carbide particles, silicon carbide whiskers and silicon carbide fibers. Nanocomposites of structural covalent ceramics. Fluency and tenacity to the fracture of silicon nitride.

References
SŌMIYA, S. INOMATA, Y. (Ed.). Silicon carbide ceramics - 2: gas phase reactions, fibrers and whisker, joining. London: Elsevier Applied Science (Ceramic Research and development in Japan Series), 1991.
KINGERY, W. D. Introduction to Ceramics. New York: John Wiley & Sons, 1960.
REED, J. S. Introduction to the principles of ceramic processing. New York: John Wiley & Sons, 1988.

CMS-409-4	**Environmental sensors and control**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Principles of detection and monitoring of physical and chemical parameters. Basic electrical circuits and detection principles. Electromagnetic radiation sensors. Temperature sensors. Pressure, sound and mechanical deformation sensors. Chemical sensors (gases and liquids). Humidity sensors. Other.

References

MIDDELHOEK, S.; IAWANSSON, K.; SINAPIUS, G.; HOORNAERT, W. (editors). Handbook of Sensors and Actuators (series). Elsevier Science B.V., 1999.
SINCLAIR, I. R. Sensors and Transducers – A guide to technicians, second edition, Butterworth-Heinemann Ltd, 1992.
DE SILVA, C. W. Control Sensors and Actuators, Prentice-Hall Inc., 1989.
SEIPPEL, R. G. Transducers, Sensors and Detectors, Reston Publishing Company Inc., 1983.
Selected papers.

CMS-410-4	**Plasma Technology for surface treatment**

Elective
Prerequisites: none
Credit Hours: 60 hours

The course consists of five separate modules, described below:
-Basic plasma concepts: concepts and definitions of plasma discharge parameters.
-Plasma sources: plasma discharges produced by different sources (DC luminescent, arc, radio frequency, microwave).
-Plasma Diagnostics: most used techniques to obtain relevant plasma parameters, with emphasis on electrostatic probes and optical emission spectroscopy.
-Plasma Surface treatment processes: The peculiarities and applications of different plasma surface treatment processes, plasma immersion ion implantation, nitriding and obtaining of DLC.
-Application of a treatment method in materials: experimental activity for surface treatment of polished samples, by one of the plasma processes described in the course.

References

HUTCHINSON, I. H. Principles of Plasma Diagnostics. Cambridge University Press – 2nd Edition, 2002.
CHEN, F. F. Introduction to Plasma Physics and Controlled Fusion. Springer – 1st Edition, 1995.
ANDERS, A. Handbook Of Plasma Immersion Ion Implantation And Deposition. John Wiley & Sons, 1st edition, 2000.

CMS-414-4	**Advanced ceramics processing and characterization**

Elective
Prerequisites: CMS-306-4 or equivalent
Credit Hours: 60 hours

Scientific and technological importance. General concepts of processing of ceramics from powders. Comminution and classification of ceramic powders. Powder synthesis. Other processes for powder production. Powder characterization. Ceramics forming: dry and humid. Sintering. Characterization of sintered ceramics. Final finish. Non-destructive tests.

References

RING, T. A. Fundamentals of Ceramic Powder Processing and Synthesis. Academic Press Inc., San Diego, U.S.A., 1996.
REED, J. S., Introduction to the Principles of Ceramic Processing, John Wiley & Sons, 1991.

SCHWARTZ, M. Handbook of Structural Ceramics. Academic Press Inc., New York, 1998.
Selected papers.

CMS-415-4	**Processing and characterization of nanostructured ceramics**

Elective
Prerequisites: CMS-306-4 or equivalent
Credit Hours: 60 hours

Scientific and technological importance. General concepts of processing of ceramics from powder. Definition of nanoparticles, physical and chemical characteristics. Techniques of obtaining: physical, mechanical and chemical. Techniques of physical and chemical characterization. Ceramics forming: dry and humid. Sintering. Characterization of sintered ceramics. Analysis, interpretation and correlation of experimental results.

References

YING, J, Y.-R.; YING, J. Nanostructured Materials. Academic Press Inc., U.S.A., 2001.
WANG, Z. L. Characterization of Nanophase Materials. Wiley-VCH Verlag, Alemanha, 2001.
WASEDA, Y.; MURAMATSU, A. Morfology control of materials and nanoparticles: advanced materials processing and characterization. John Wiley & Sons, USA, 2004.
SCHMID, G. Nanoparticles: from theory to application. John Wiley & Sons, USA, 2004.
RING. T. A. Fundamentals of Ceramic Powder Processing and Synthesis. Academic Press Inc., San Diego, U.S.A., 1996.
HENCH, L.; ULRICH, D. R. Ceramic chemical processing. John Wiley & Sons, USA, 1986.
MAKENZIE, J. D.; ULRICH, D. R. Ultrastructure processing of advanced ceramics. John Wiley & Sons, USA, 1988.
Artigos de periódicos especializados.

CMS-416-4	**Nanoparticle powder: Obtaining, characterization and applications**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Importance of the science and technology of nanoparticles. Definition of nanoparticles, physical and chemical characteristics. Nanoparticle powders (nanopowders) and flocculation, agglomeration and aggregation mechanisms. Techniques of obtaining nanopowders: physical, mechanical and chemical. Main techniques for obtaining powders and ceramic and metallic nanoparticle compounds by chemical methods. The importance of conventional and microwave thermal treatments. Obtaining nanoparticle chemical compounds by mechanical allowing. Techniques of physical and chemical characterization of nanoparticle powders (ATD-ATG, Porosimetry, BET, X-ray diffraction, particle size distribution, SEM, TEM, FEG-SEM, EDS, XPS). Analysis, interpretation and correlation of experimental results (real case studies). Applications.

References

WASEDA, Y.; MURAMATSU, A. Morfology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization. John Wiley & Sons, USA, 2004.
FENDLER, J. H. Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications. Wiley-VCH Verlag, Weinhein, Germany, 1998.
SCHMID, G. Nanoparticles: from theory to application. John Wiley & Sons, USA, 2004.
RAO, C. N. R.; MÜLLER, A.; CHEETHAM, A. K. (Editors). The Chemistry of

Nanomaterials: Synthesis, Properties and Applications. John Wiley & Sons, USA, 2004.
WINTERER, M. Nano-crystalline Ceramics: Synthesis and Strucuture. Spring-Verlag, Berlin, Germany, 2002.
FREER, R. Nanoceramics. Institute of Materials, Manchester, England, 1993.
THEODORE, L. Nanotechnology: Basic Calculations for Engineers and Scientists. Wiley & Sons, Inc., Hoboken, NJ, USA, 2006.
GOLDSTEIN, A. N. (editor). Handbook of Nanophase Materials. Marcel Dekker, Inc., New York, NY, USA, 1997.
BRUSHAN, B. (editor). Springer Handbook of Nanotechnology. Springer, 2004.
MAKENZIE, J.D.; ULRICH, D.R. Ultrastructure processing of advanced ceramics. John Wiley & Sons, USA, 1988.
Selected papers.

CMS-417-4	**Nanostructured films: Obtaining, characterizing and applications**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Nanostructured Ceramic and Metallic films: Scientific and technological importance: advantages and limitations. Techniques for the preparation of adherent polycrystalline films (chemical and physical). Surface and interface characterization techniques (X-ray diffraction, electron scanning microscopy, transmission electron microscopy, atomic force microscopy, Raman spreading spectroscopy, dispersive energy spectrometry, Auger electron spectroscopy, photoelectron X-ray spectroscopy, adhesion measurements, nanohardness and fracture tenacity. Main applications of these types of films.
Nanostructured Carbon-based films: Scientific and technical importance: advantages and limitations. Obtaining, characterization and applications. Carbon fibers, reticulated vitreous carbon, nanostructured graphite. Carbon nanotubes, DLC films and hydrogenated DLC. NanoDiamond Films. Raman spreading spectroscopy and X-ray diffraction techniques.
Nanostructured films of semiconductor compounds IV-VI: Scientific and technological importance: advantages and limitations. Epitaxial growth techniques. Fundamental aspects of epitaxy by molecular Beam (MBE). Growth Properties. Heterostructures. Dots and quantum pits. Super nets. Multiple self structures.

References
FENDLER, J. H. Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications. Wiley-VCH Verlag, Weinhein, Germany, 1998.
BRUSHAN, B. (editor). Springer Handbook of Nanotechnology. Springer, 2004.
GOLDSTEIN, A. N. (editor). Handbook of Nanophase Materials. Marcel Dekker, Inc., New York, NY, USA, 1997.
THEODORE, L. Nanotechnology: Basic Calculations for Engineers and Scientists. Wiley & Sons, Inc., Hoboken, NJ, USA, 2006.
BENEDEK, G. et al. (Editors). Nanostructured Carbon for Advanced Applications. NATO Science Series II: Mathematics, Physics and Chemistry, Volume 24. 1st edition. Springer, 2001.
Selected papers.

CMS-419-4	**Principles of electrochemical**

Elective
Prerequisites: none
Credit Hours: 60 hours

Basic concepts of electrochemical (oxidation, reduction, galvanic and electrolytic systems, electrode standard potential and redox reactions spontaneity), electrodic processes (Faradaics and non-faradaics, electrode/electrolyte interface, reactions controlled by mass transfer), electrochemical kinetic, electro-chemical techniques (potential and current jump, cyclic and linear voltametry, differential pulse and square wave voltametry). Electrochemical Impedance (IE) methods, circuit elements, graphical representation (Nyquist, Bode), equivalent circuits (electrochemical), impedance study using the software. Examples of IE for diamond electrodes.

References

ATKINS, P., Físico Química – Fundamentos, 3ª edição, LTC editora, 2001.
BARD, A. J.; FAULKNER, L. R. Electrochemical Methods-Fundaments and Applications. John Wiley & Sons, New York, 1980.
BRETT, C. M. A. Electrochemistry, Principles, Methods, and Applications. Oxford Publications, 2000.
BOCKRIS, J. O. M. Modern Electrochemistry, vol 1, 2A, 2B, Kluwer Academic, 2000.

CMS-420-4	**X-ray diffractometry for characterization of crystalline structure of materials**

Elective
Prerequisites: none
Credit Hours: 60 hours

Basic crystallography: unitary cell; Crystalline plans; Interplanar distances; Miller indexes; Crystalline structure; Elements of symmetry and spatial groups; Reciprocal lattice. X-ray diffraction: Introduction to X-ray diffraction theory; Bragg's Law; X-ray Diffractometer; Factors influencing the scattered intensities of x-rays; X-ray generation and detection; Diffractometry of Powder. Experimental practice: Phase identification; database; Peak indexing; Quantitative analysis; Crystallographic guidance; Crystalline structure refinement.

References

CULLITY, D. B.; STOCK, S. R. Elements of X-Ray Diffraction. 3rd. ed., Prentice Hall, New Jersey, 2001.
WASEDA, Y.; MATSUBARA, E.; SHINODA, K. X-Ray diffraction crystallography: introduction, examples and solved problems. Springer-Verlag Berlin Heidelberg, 2011.
PECHARSKY, V. K.; ZAVALIJ, P. Y. Fundamentals of powder diffraction and structural characterization of materials, Springer New York, 2005.
X'pert Pro Panalytical user manual.
Selected papers.

CMS-421-4	**Introduction to microscopy of materials**

Elective
Prerequisites: CMS-200-4 or equivalent
Credit Hours: 60 hours

Basic theory of microscopy; diffraction images formation; optical microscopy; Scanning Image formation; Electron microscopy (scanning and transmission); other scanning microscopies; Microanalysis, EDS, WDS, EELS, STEM, EPMA; sample preparation for microscopy.

References

MANNHEIMER, W. A. Microscopia dos Materiais. SBMM, 2002.
GOLDSTEIN, J. et al. Scanning electron microscopy and x-ray microanalysis. 3rd Ed., New York: Springer Science + Business Media, Inc., 2003.
WIESENDANGER, R. Scanning Probe Microscopy and Spectroscopy: Methods and Applications. Cambridge University Press, Cambridge, UK, 1994.
MEYER, E. et al. Scanning Probe Microscopy: The Lab on a Tip. Springer-Verlag, 2003.
BRUNDLE, C. R. et al. Encyclopedia of Materials Characterization. Butterworth-Heinemann, 1992.

DISCIPLINAS DE EMENTA ABERTA DA ÁREA DE CONCENTRAÇÃO EM CIÊNCIA E TECNOLOGIA DE MATERIAIS E SENSORES

CMS-315-1	**Special topics in science and physics of materials I**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 15 hours

Discipline with appropriate content for each subject to be studied.

CMS-316-2	**Special topics in science and physics of materials II**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 30 hours

Discipline with appropriate content for each subject to be studied.

CMS-339-3	**Special topics in science and physics of materials III**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 45 hours

Discipline with appropriate content for each subject to be studied.

CMS-340-4	**Special topics in science and physics of materials IV**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-317-1	**Special topics in materials processing I**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 15 hours

Discipline with appropriate content for each subject to be studied.

CMS-318-2	**Special topics in materials processing II**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 30 hours

Discipline with appropriate content for each subject to be studied.

CMS-341-3	**Special topics in materials processing III**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 45 hours

Discipline with appropriate content for each subject to be studied.

CMS-342-4	**Special topics in materials processing IV**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-319-1	**Special topics in materials characterization techniques I**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 15 hours

Discipline with appropriate content for each subject to be studied.

CMS-320-2	**Special topics in materials characterization techniques II**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 30 hours

Discipline with appropriate content for each subject to be studied.

CMS-343-3	**Special topics in materials characterization techniques III**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 45 hours

Discipline with appropriate content for each subject to be studied.

CMS-344-4	**Special topics in materials characterization techniques IV**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-324-4	**Research in physics of materials I**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-325-4	**Research in physics of materials II**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-326-4	**Research in physics of materials III**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-330-4	**Research in physics of materials IV**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-331-4	**Research in physics of materials V**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-332-4	**Research in physics of materials VI**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-345-4	**Research in physics of materials VII**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-321-4	**Research in science and technology of materials I**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-327-4	**Research in science and technology of materials II**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-328-4	**Research in science and technology of materials III**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-333-4	**Research in science and technology of materials IV**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-334-4	**Research in science and technology of materials V**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-335-4	**Research in science and technology of materials VI**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

CMS-346-4	**Research in science and technology of materials VII**

Elective
Prerequisites: to be set in accordance with the discipline syllabus
Credit Hours: 60 hours

Discipline with appropriate content for each subject to be studied.

Os trabalhos auxiliares ou finais do programa de pós-graduação serão identificados nas formas abaixo indicadas:

CMS-730	**Pesquisa de Mestrado em Engenharia e Tecnologia Espaciais/CMS***

Obrigatória
Crédito: 0

CMS-750	**Dissertação de Mestrado em Engenharia e Tecnologia Espaciais/CMS**

Obrigatória
Créditos: 12

CMS-780	**Pesquisa de Doutorado em Engenharia e Tecnologia Espaciais/CMS***

Obrigatória
Crédito: 0

CMS-800	**Tese de Doutorado em Engenharia e Tecnologia Espaciais/CMS**

Obrigatória
Crédito: 36

* Atividade *Obrigatória*, em cada período letivo, para todo aluno em fase de Pesquisa, definida pela oficialização de seu Orientador de Pesquisa que avaliará o desempenho do aluno nesta atividade. *Obrigatória*, também, antes da oficialização citada, para o aluno que não esteja matriculado em alguma disciplina: neste caso, a orientação e a avaliação deverão ser feitas por Docente aprovado pelo Coordenador Acadêmico.

Catálogo aprovado pelo CPG em 09/02/2018