KAZAN (VOLGA REGION) FEDERAL UNIVERSITY
INSTITUTE OF PHYSICS
DEPARTMENT OF SOLID STATE PHYSICS
EDUCATIONAL AND SCIENTIFIC LABORATORY

«THE GAMMA-RESONANCE STUDY OF MATERIALS OF THE ELECTRONIC TECHNIQUES»

Behind the Main Building of KFU

Institute of Physics

ESLab GRSMET, room 4

Educational and Scientific Laboratory «The gamma-resonance study of materials of the electronic techniques» (ESLab GRSMET)

created in collaboration with Ioffe Physical-Technical Institute of the Russian Academy of Sciences, Saint-Petersburg

Basic area of interest:

- Depth-selective conversion electrons mossbauer spectroscopy (DCEMS) for surface investigations
- Thin films obtained by ion implantation

Other interests:

- Experimental technique and methodology
- Magnetometry of thin magnetic films, surface magneto-optic Kerr effect (SMOKE), alternative current magnetic susceptibility (ACMS)
- X-ray fluorescence spectroscopy (XFS)

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Educational work

In this laboratory implemented:

- special workshop on physics for first year postgraduate students
- summer practical lessons for 3-4 years students
- research works of graduate and postgraduate students

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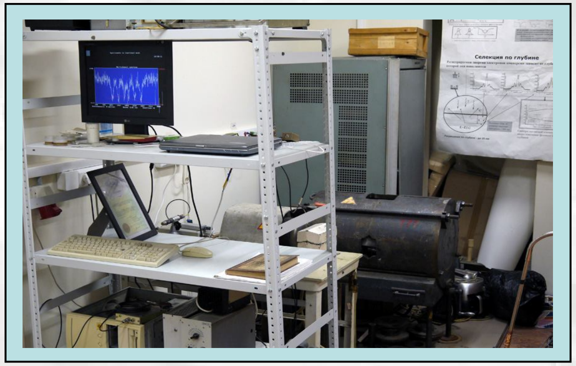
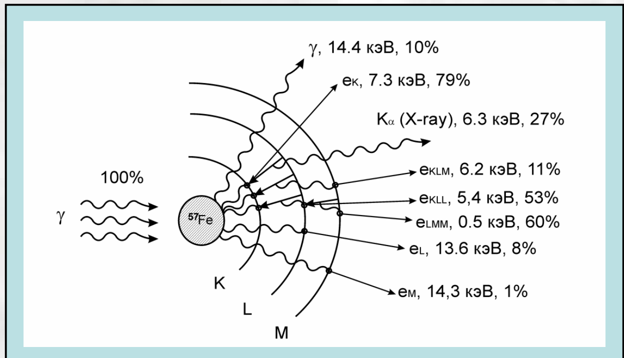


Laboratory-based work 1: Introduction to DCEMS

- Registration of integral by depth CEMS-spectrum from iron foil. Gas-flow proportional detector as a detector of conversion electrons

- Determination of hyperfine interaction parameters from the spectrum. Determination of magnetic texture of the sample

- Estimation of energy resolution of the proportional detector on L-edge of conversion electrons



the setup was developed and created in our laboratory

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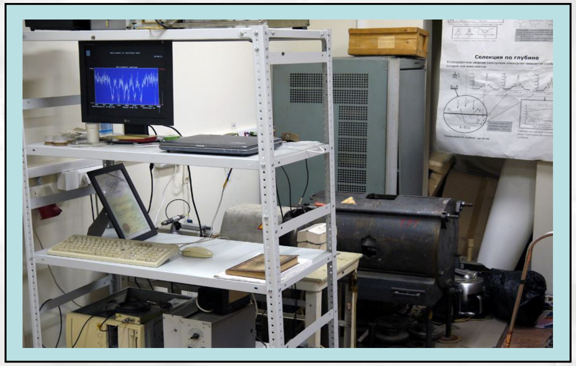

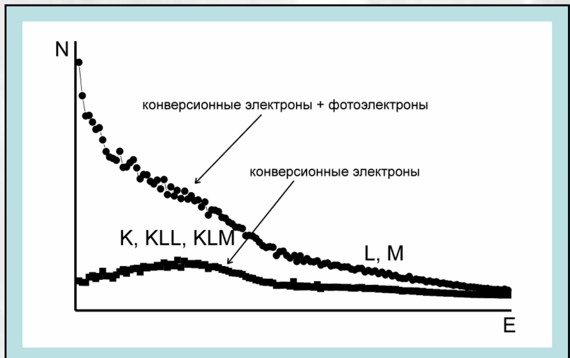

Laboratory-based work 2:
Study of corrosion processes in dry air

• Phase composition analysis from integral by depth CEMS-spectrum

• Selective by depth analysis in graphical form. Drawing of the graph which represents dependence of each phase relative part as a function of registered electrons energy

• The model of the oxidation process offered by students (it may be collective work, based on papers analysis)

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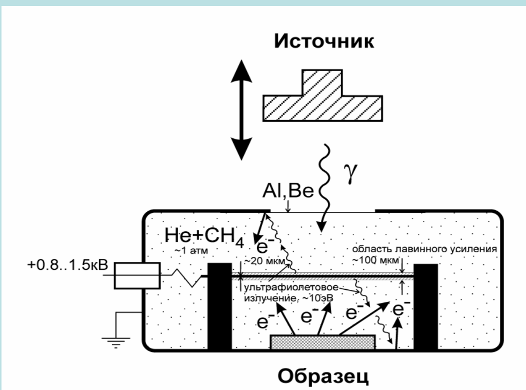

Laboratory-based work 3:

Study of corrosion processes in wet environment

• Phase composition analysis from integral by depth CEMS-spectrum

• Selective by depth analysis in graphical form. Drawing of the graph which represents dependence of each phase relative part as a function of registered electrons energy

• Comparative analysis of the corrosion results in dry air and in wet environment

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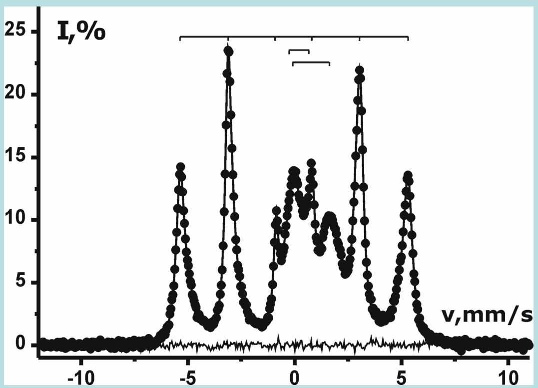

Laboratory-based work 4: Study of superparamagnetic layer

$SiO_2 \leftarrow Fe^+$

- Mossbauer spectrum of superparamagnetic sample measurements with (1 kOe) and without external magnetic field. The sample is an ion implanted layer
- Identification of phase composition from spectra with/without magnetic field
- Estimation of minimal size of superparamagnetic particles supposing the Lande g-factor equal two
- Estimation of average distance between particles with known implantation fluence of ions and their energy. Estimation of blocking T of superparamagnetic

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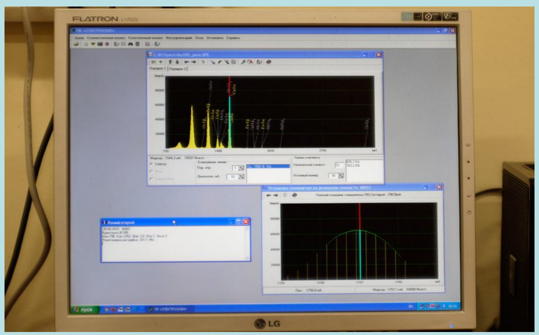

Laboratory-based work 5: Introduction to XFS

• XFS spectrum of reference sample with known composition (pure Ni or Fe metal plates) is measured. Calibration of wavelength goniometric scale

• Measurement of any solid sample selected by student

• Analysis of XFS spectrum obtained with 1-st and 2-nd order of diffraction. After determination of elemental composition of the sample a rough quantitative calculation of element parts performs.

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РОССИЙСКАЯ ФЕДЕРАЦИЯ

ПАТЕНТ

НА ИЗОБРЕТЕНИЕ

№ 2399069

СПОСОБ РЕАЛИЗАЦИИ ПАРАМЕТРИЧЕСКОГО РЕЖИМА В МЕССБАУЭРОВСКОМ СПЕКТРОМЕТРЕ И УСТРОЙСТВО ДЛЯ ЕГО РЕАЛИЗАЦИИ

Патентообладатель(ли): *Федеральное государственное учреждение высшего профессионального образования "Казанский государственный университет им. В.И. Ульянова-Ленина" (RU), Дулов Евгений Николаевич (RU), Ивойлов Николай Григорьевич (RU), Хрипунов Дмитрий Михайлович (RU)*

Автор(ы): *см. на обороте*

Заявка № **2009120720**

Приоритет изобретения **01 июня 2009 г.**

Зарегистрировано в Государственном реестре изобретений Российской Федерации ***10 сентября 2010 г.***

Срок действия патента истекает **01 июня 2029 г.**

Руководитель Федеральной службы по интеллектуальной собственности, патентам и товарным знакам

Б.П. Симонов

Scientific work

Technique of Mossbauer experiment:

• Multilevel Mossbauer spectroscopy, 128 spectra corresponding to 128 discrete amplitude of pulses from detectors, 2001

• Parametric Mossbauer spectroscopy, set of spectra for any discretized external physical value, 2009, patent of Russian Federation from 2010

• Digital pulses processing, demonstration of a simple algorithm which suitable for realization with modern microcontrollers, 2014

• Designing and producing universal parametric gamma spectrometer – present time

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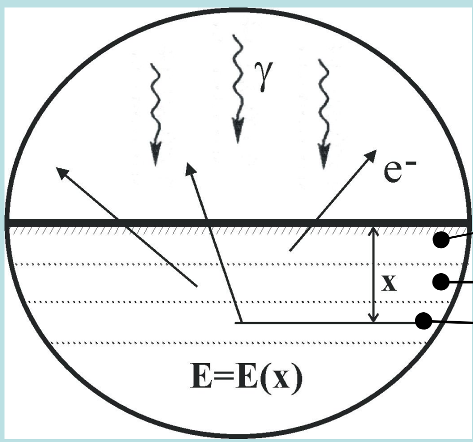
Scientific work

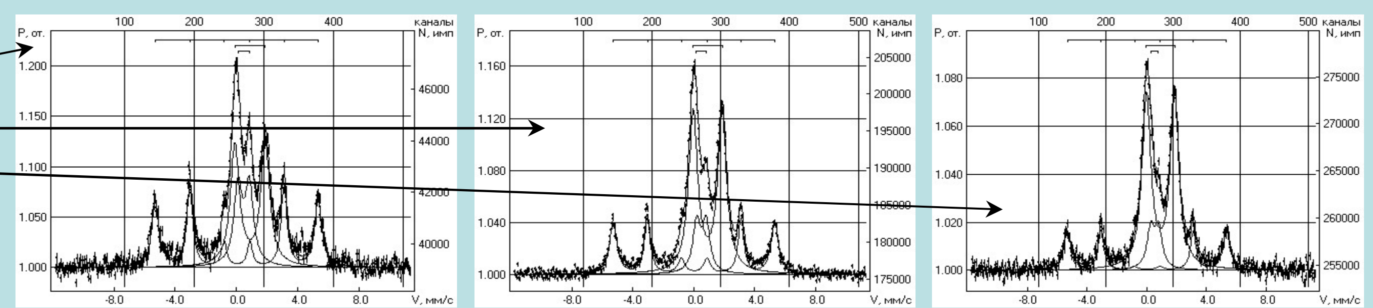
DCEMS study with developed in our laboratory technique.

This technique allows to record simultaneously a huge amount of Mossbauer spectra for many discrete values of pulse amplitudes from detector. Set of amplitudes corresponds to set of different depth 0..200nm from surface of sample.

This technique has been used to investigate promising materials of microelectronics and spintronics. Usually these materials have form of thin films obtained by ion implantation or by ion beam sputtering deposition methods:

- **Si←Fe^+, $SrTiO_3$←Fe^+, $BaTiO_3$←Fe^+, ZnO←Fe^+, SiO_2←Fe^+, TiO_2←Fe^+, TiO_2-Fe-Si, Fe-SS (stainless steel), …**





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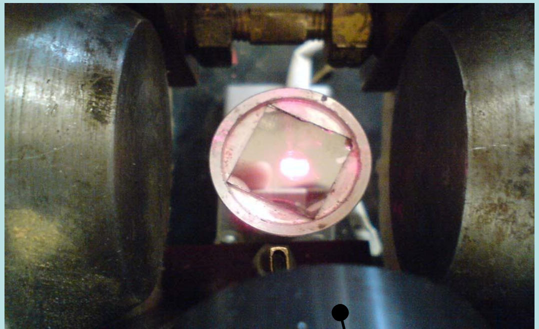
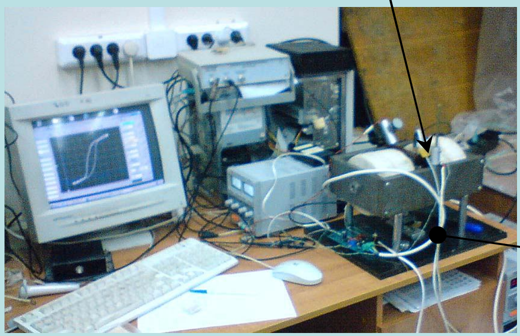
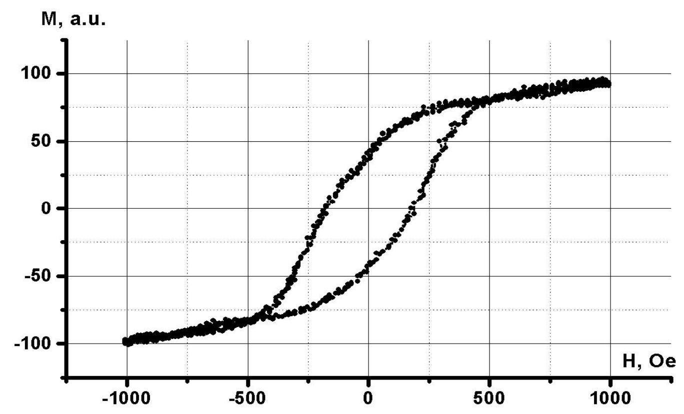


Scientific work

Surface magneto-optic Kerr effect (SMOKE) with registration of intensity of reflected light for ion implanted thin magnetic films





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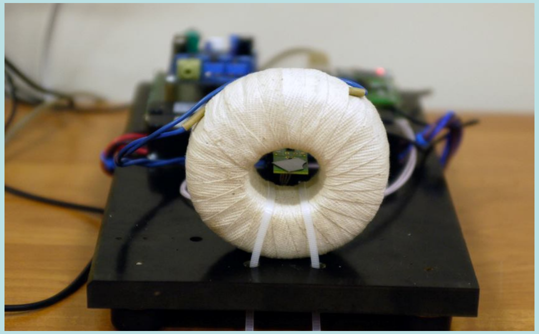
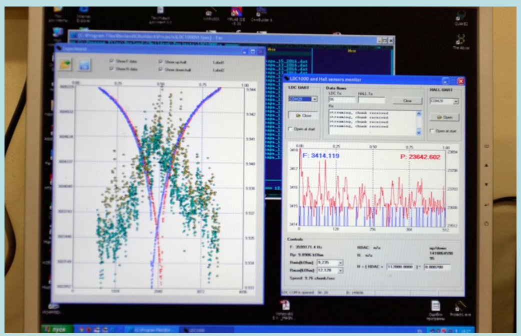


Scientific work

Alternative current magnetic susceptibility (ACMS) technique applied to thin magnetic films. This technique exists in our laboratory since 1999.

In 2013 an integrated solution from Texas Instruments appears. It is chips of LDC10xx series which allows to obtain conductivity response from samples behind differential magnetic susceptibility.

First setup for low-field measurements (-35..+35Oe) was based on evaluation module LDC1000EVM



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Main publications

E.N. Dulov, N.G. Ivoilov, O.A. Strebkov, L.R. Tagirov, V.I. Nuzhdin, R.I. Khaibullin, S. Kazan, F.A. Mikailzade Magnetic phase composition of strontium titanate implanted with iron ions // Materials Research Bulletin. – 2011. – V.46. – P. 2304-2307.

E.N. Dulov, D.M. Khripunov Voigt lineshape function as a solution of the parabolic partial differential equation // Journal of Quantitative Spectroscopy and Radiative Transfer. – 2007. - V.107. – P. 421 – 428.

E.N. Dulov, D.M. Khripunov Instrumental broadening of spectral line profiles due to discrete representation of a continuous physical quantity // Journal of Quantitative Spectroscopy and Radiative Transfer. – 2008. – V.109, N.10. – P.1922-1930.

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E.N. Dulov, N.G. Ivoilov, D.M. Khripunov, L.R. Tagirov, R.I. Khaibullin, V.F. Valeev, V.I. Nuzhdin Mössbauer study of the magnetic phase composition of single-crystalline rutile (TiO2) implanted with iron ions // Technical Physics Letters. – 2009. - V.35 (6). – P.483-486.

N.I. Khalitov, R.I. Khaibullin, V.F. Valeev, E.N. Dulov, N.G. Ivoilov, L.R. Tagirov, S. Kazan, A.G. Şale, F.A. Mikailzade Structural and magnetic studies of Co and Fe implanted BaTiO3 crystals // Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. – 2012. – V.272. – P.104-107.

N.I. Khalitov, N.M. Lyadov, V.F. Valeev, R.I. Khaibullin, I.A. Faizrakhmanov, E.N. Dulov, L.R. Tagirov, Sh.Z. Ibragimov, K.E. Prikhodko, V.V. Roddatis, M. Maksutoglu, S. Kazan, F.A. Mikailzade Ion beam synthesis and investigation of nanocomposite multiferroics based on barium titanate with 3d metal nanoparticles // Physics of the Solid State. – 2013. – V.55 (6) . – P. 1279-1288.