Condensed Matter Physics

Frederico Gama Carvalho

The Group's field of research is the development and characterisation of materials, using radiation as a tool to investigate the structure and/or induce structural modifications in samples. The group is also active in the area of instrument development, including both hardware and software, design, construction, and test of systems and components for low-energy neutron scattering and X-ray diffraction. Materials currently under investigation include high temperature alloys and organic-inorganic hybrid materials. The development of scientific collaboration with the academic community and the policy of open access for external users to facilities and installations operated by the Group are placed high in the ranking of priorities. There are numerous links to foreign institutions and fellow research groups in both areas of neutron and X- ray work. Co-operation with European neutron scattering centres is stimulated by the participation, starting 1998, of the Group's co-ordinator in the regular meetings of the European Neutron Scattering Association (ENSA).

Neutron beam facilities. The Two-Axis Neutron Diffractometer, DIDE, and the rotating chopper Time-of-Flight Diffractometer, ETV, are installed in two of the RPI research reactor beam tubes. A Small Angle Neutron Scattering Instrument (EPA) is currently under installation. Routine operation of DIDE and EPA will contribute to significantly increase the reactor utilisation and thus justify the continued operation of the reactor. The TOF diffractometer is dedicated to tests and student training. The present RPI reactor flux is adequate for measurements of high dispersive classes of samples, for preliminary measurements preceding data collection at higher flux neutron sources, and in-beam testing of special devices such as detectors, collimators and neutron optical components. The impact of the reactor utilisation would be much improved if the power is increased to 5MW and even more if a cold neutron source is installed. Collaboration of the Nuclear Instrumentation Group of the Physics Department continued to be essential in respect to the design and test of electronics and software for the instruments.

The concept of Converging Multichannel Collimation applied to SANS instruments has been further exploited during 2003 while technical aspects pertaining to the construction of a 100-channel prototype currently under way were further investigated. These included the development of a composite material with convenient physical and nuclear properties to be used in the channel walls. In-beam testing of the prototype is foreseen for the second half of 2004 at a European neutron source. This work was supported by the National Science Foundation and the IAEA.

The performance of neutron guide assemblies for beam tailoring under specific constraints has been carried out by Monte Carlo simulation. Results will have a relevance on the foreseen upgrade of the present EPA beam line for noise reduction. Finally, a study of the wavelength dependence of the performance of a SANS instrument installed at a steady source was carried out.

Co-operation with the Budapest Neutron Center in the area of instrument development, collaboration with the Glass and Ceramics Dept. of Aveiro University in the study of organic-inorganic hybrids and collaboration with Laboratoire Léon Brillouin (CEA-CNRS-Saclay), in both areas, have continued in 2003.

The activity at the MA^{3}T laboratory. During 2003, the research objectives at the High Temperature Materials Laboratory (MA^{3}T) were two fold: the characterisation of advanced materials and the development of the Hotbird capabilities through the implementation of new hardware components and software applications.

The current research activity is centred on the study of nano-structured materials. This has been a tendency over the years owing in part to the enhanced capabilities of the Hotbird diffractometer to study very thin layer structures when compared to commercial diffractometers. However, our current research projects spread over a wide range of problems and materials. Examples are the study of nanostructures of semiconductor materials used in the electronic industry (Field Emission Transistors of SiGe, Quantum Dots based devices on GaAs and SiGe, Light emitters of GaN, etc.) as well as high-temperature alloys used in the aeronautical industry (coatings on superalloys) and other industrial materials. Although most of this work was centred on single crystalline materials several polycrystalline materials have also been studied, namely magnetic multilayer sensors, nano-precipitates in implanted materials, ceramic powders, etc. Many of these studies are performed in collaboration with foreign and national research groups and are resumed in the next pages.

Two new projects have started in the beginning of 2003 to study (1) *nanometer-thick buried layers in SiGe devices* and to characterise (2) *magnetic tunnel junctions* used for hard-disk reading heads. This has allowed to reinforce the team with two new students.

The laboratory still needs to be upgraded in the direction pointed in the application to the *National Program for the Large Scale Facilities* submitted last year to the FCT. If approved this would allow to enhance of the MA^{3}T laboratory capabilities with new techniques not yet available in Portugal.

Condensed Matter Physics

Research Team

Researchers

- F.G. CARVALHO, Senior Research (75%)
- J.F.SALGADO, Senior Research (30%)
- F.M.A. MARGAÇA, Research
- A.N. FALCÃO, Research Officer
- A.D. SEQUEIRA, Auxiliary Research Officer
- J.S. NEVES, Auxiliary Research Officer (20%)
- C.M.M. CRUZ, Auxiliary Research Officer (20%)

Students

– N.P. FRANCO, PhD student, FCT grant

– A. FONSECA, PhD student, FCT grant

– I. YAVOROSVKYI, PhD student, FCT grant

– P. FERREIRA, PhD student, IST/ITN

– J.L. COSTA, PhD student, IST/ITN, FCT grant

– M. CARRAPIÇO, BIC POCTI, MSc student

– A. BEIRANTE, undergraduate student IST/ITN

– D. SILVA, undergraduate student, ITN Fellowship

Funding (€)

Research Projects:	51.213,73
Services:	0
Total:	**51.213,73**

Publications

Journals:	4 and 2 in press
Proceedings:	3 and 5 in press
Conf. Communications:	6
Other publications:	2
Theses:	2 BSc

Study of Spin Tunnel Junctions for Hard Drive Reading Heads

A.D. Sequeira, N.P. Barradas[1], P.P. Freitas[2]

Objectives

The aim of this project is then to characterise in detail new and conceptually different technology for reading heads of hard-disk magnetic data storage using a spin tunnel junctions (TJ). In particular we are interested in the changes in layer structure and composition that take place upon annealing, including diffusion and layer intermixing.

Hard disk magnetic data storage is rapidily approaching areal densites of 100 Gbit/in^2. The mainstream read head technology uses deep submicron shielded spin valve heads, where the required linear resolution is achieved by the read gap.

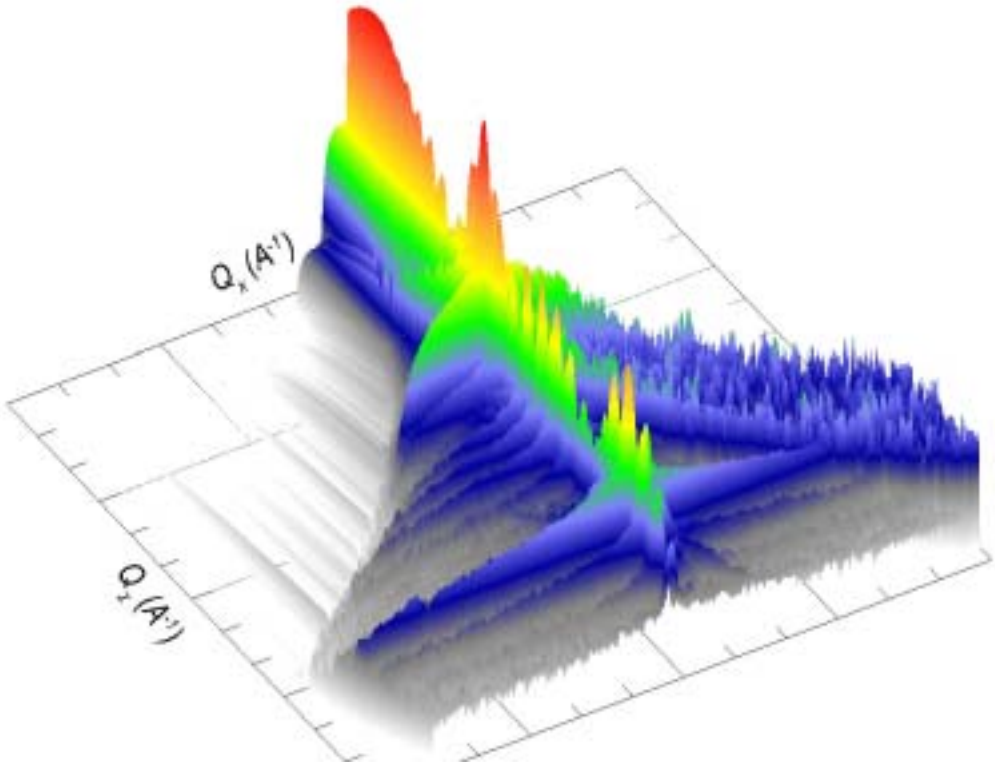


Fig. - Two-dimensional Reciprocal Space Reflectivity Mapping of a tunnel

For 100Gbit/in^2 the read gap will approach 50nm, meaning 25nm gap oxide on each side of the read sensor. The new and conceptually different technology, avoiding this very thin half gap oxide, consists in using a spin tunnel junction sensor, directly between both shields. In this case, the junction thickness in itself (< 25-30nm) is the limiting read gap, and shields act as current leads.

Results

High resolution X-ray diffraction, reflectometry and Rutherford backscattering are being used for the structural characterization of this new system. The figure illustrates a 2-Dimensional reflectivity measurement of one of the tunnel junctions composed of a superlattice structure of very thin layers with thicknesses of 2 to 8nm. From these experiments it has been possible to determine the layer structure and the quality of the interfaces. The ongoing research includes the identification of the phases present in the device before and after the annealing. This research is carried out under a FCT-POCTI Project.

Published, accepted or in press work

1. N.P. Barradas, V. Matias, A.D. Sequeira, J.C. Soares, U. Kreissig, J.U. Wang, P.P. Freitas. He-RBS, He-ERDA and heavy ion-ERDA analysis of Si/Ta 70Å/CoFe 35Å/ HfAlOx /CoFe 35Å/Ta 30Å systems. Accepted in *Nuclear Instruments and Methods B*.

[1] Nuclear Solid State Physics using ion Beams group
[2] INESC, R. Alves Redol 9-1, 1000-029 Lisboa, Portugal.

Structural characterisation and photoluminescence of nanostructures: MOSFET of SiGe/Si, Quantum Dots of SiGe and GaAs

A.D. Sequeira, N. Franco, A. Fonseca, K.D. Chtcherbatchev[1], N.P. Barradas[2], E. Alves[3], N. Sobolev[3], M. Myronov[4], O.A. Mironov[4], E.H.C. Parker[4]

Objectives

Under these line of activity we are studying a series of semiconductor materials by means of high-resolution X-ray diffraction, reflectometry and Rutherford backscattering and Photoluminescence. Emphasis has been put on the structural characterisation doped $Si_{1-x}Ge_x$ heterostructures, SiGe and GaAs Quantum Dots (QD).

Results

Typical results include the characterisation of the strain, thickness and thermal stability of HMOS transistors after thermal annealing at temperatures ranging from 600 to 900ºC.

The structure of multilayered heterostructures with Ge/Si quantum dots (QD) are characterised by means of X-ray *reflectometry* (XRR) and *reciprocal space maps*. The layers typically are fully pseudomorphic, strained and without any tilt relative to the substrate denoting and present good crystalline quality of the superstructure. The layer periodicity are determined both from XRR data and reciprocal space maps. To extract additional structural information, i.e. the composition, thickness and the roughness of the layers, a model-fitting *Windows* program was developed to obtain quantitative analyse the XRR data.

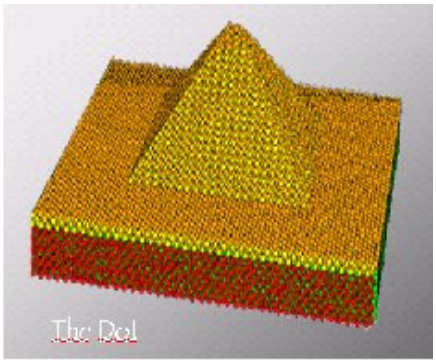


Fig. 1 - Model of a Si-Ge Quantum Dot.

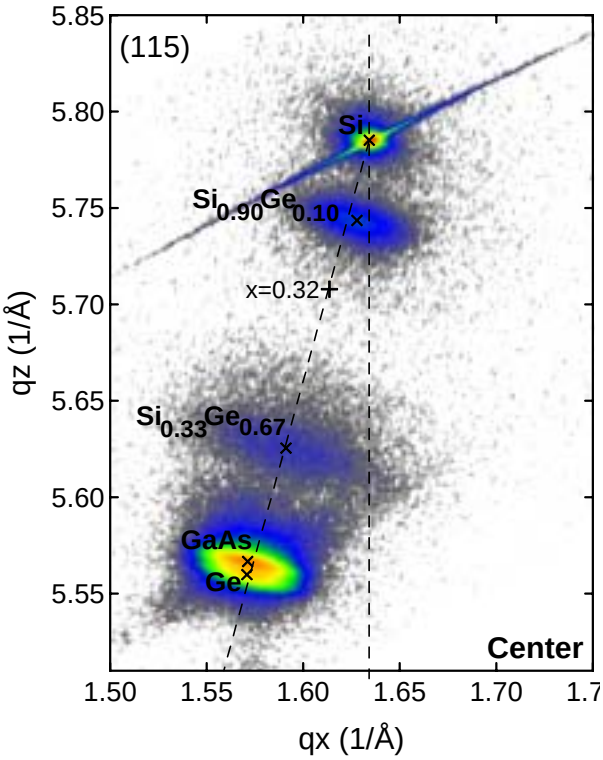


Fig. 2 - ω-2θ Reciprocal Space Map of a Si-Ge multilayer.

The determination of the Ge concentration average in the QD was obtained directly from the QD diffraction peak.

Published, accepted or in press work

1. A. Fonseca, N.A. Sobolev, J.P. Leitão, M.C. Carmo, N. Franco, H. Presting and A.D. Sequeira. Structural Characterization and Luminescence of Ge/Si Quantum Dots. Oral Communication. Accepted in *Mat. Sci. Forum*.

[1] Moscow State Institute of Steel and Alloys, Russian Federation.
[2] Nuclear Solid State Physics using ion Beams group.
[3] Physics Department, Aveiro University.
[4] Department of Physics, University of Warwick, Coventry, CV47AL, UK.

Structure determination of 2212 Superconductors & Defect density determination

A.D. Sequeira, F. Costa[1], K. Chtcherbatchev[2], E. Alves[3], N.P.Barradas[3]

Objectives

The aim of the current line of activity is twofold: First, structure determination and phase analysis of superconductor fibres containing phases of the type $Bi_2Sr_2CaCu_2O_8$ produced by laser irradiation (LFZ). One aims, among other things, to understand the influence of the electric current used during the growth of the fibres on the chemical changes on the phases present.
Second, one studies the defect characterisation on implanted GaAs crystals as a function of the dose.

Results

The structure determination of the superconductors phases is produced by simulation and fitting of XRD experimental data (program FOX).

The characterisation of the samples is performed using two main techniques: high-resolution X-ray diffraction (XRD) and Rutherford backscattering spectroscopy (RBS). These studies are performed under a FCT/POCTI contract.

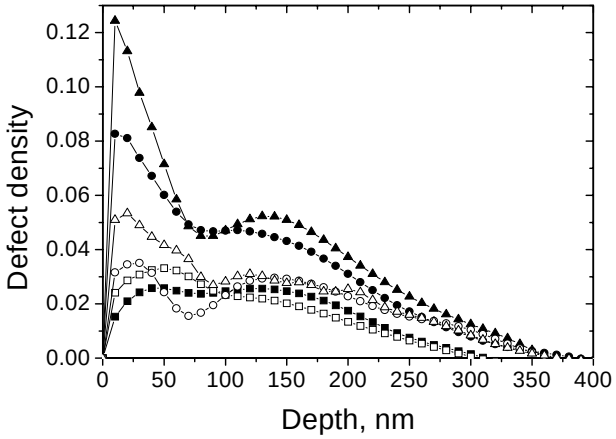


Fig. 1 - Relative concentration of displaced lattice atoms as a function of depth for 200 keV Ar+ implantation into GaAs with various doses. Opened symbols corresponds to UV irradiated sample.

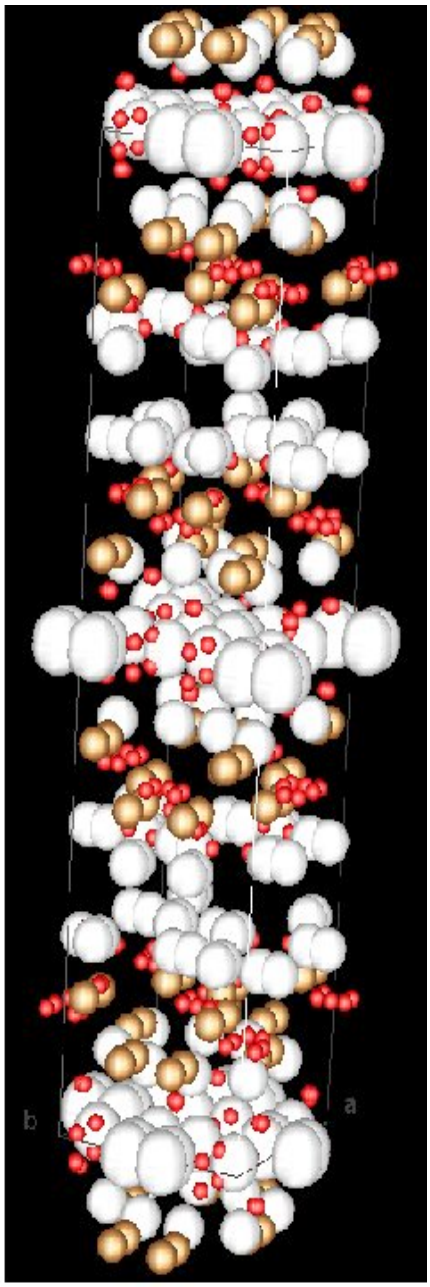


Fig. 2 – Model of the 2212 phase obtained from the model-fitting of XRD data using the program FOX.

Published, accepted or in press work

1. K.D. Chtcherbatchev, V.T. Bublik, A.S. Markevich, V.N. Mordkovich, E. Alves, N.P. Barradas and A.D. Sequeira The influence of in situ photo-excitation on a defect structure generation of GaAs crystals. *J. Phys. D: Appl. Phys.* 36 (2003) A143-146.

[1] Physics Department of University of Aveiro.
[2] Moscow State Institute of Steel and Alloys, Russian Federation.
[3] Nuclear Solid State Physics using ion Beams group.

Structural Properties of InGaN for Light Emitting Diodes

A.D. Sequeira, N.P. Franco, S. Pereira[1], E. Alves[2], K.P. O'Donnell[3]

Objectives

The current project aims for the structural characterisation study of epitaxial layers anf quantum wells of $In_xGa_{1-x}N$ and the influence their optical properties. The main characterisation techniques are high-resolution x-ray diffraction, RBS and photoluminescence.

Results

The material. Group III nitride epilayers are currently a major topic of research due to their widespread use in light emitting diodes (LED) and laser diodes (LD).

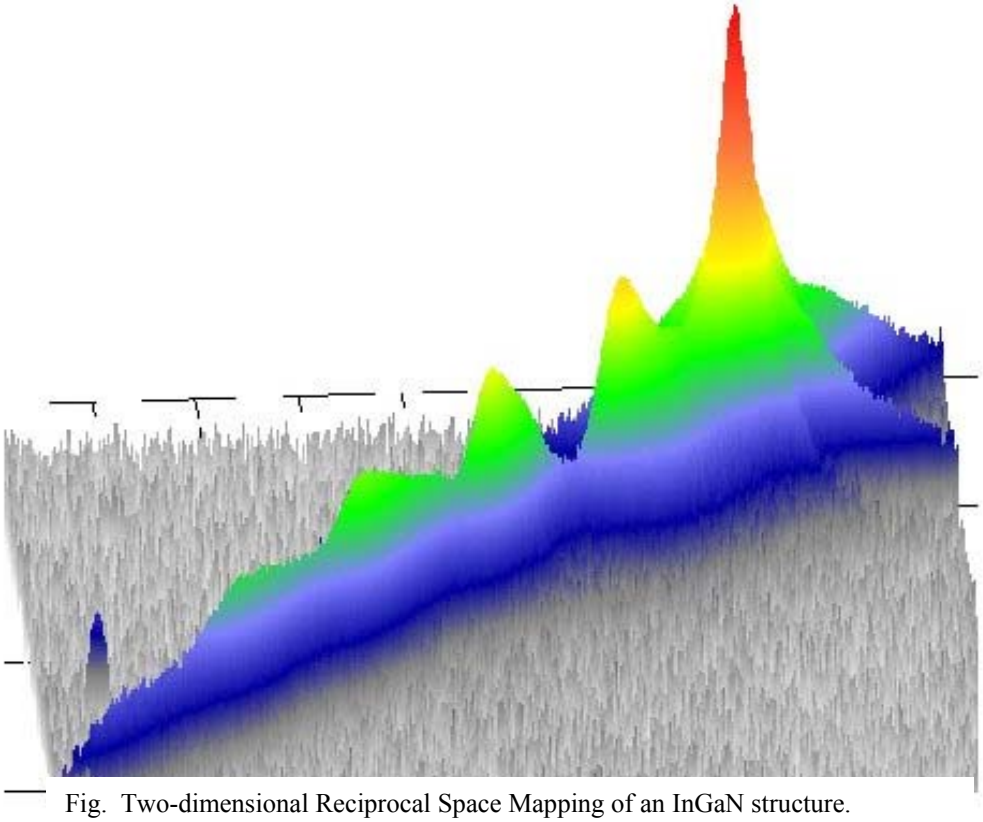


Fig. Two-dimensional Reciprocal Space Mapping of an InGaN structure.

Commercial indium gallium nitride (InGaN) LEDs, developed over the last decade, enjoy unrivalled performance in the UV, blue and green spectral regions

XRD analysis. In this study emphasis has been given to the characterization the structural properties of InGaN structures of low dimensionality in particular multilayers and quantum dots (an example is give in the Fig.). The reciprocal space maping is a technique particularly suited to determine structural parameters of these structures. In particular the strain status of the InGaN layers relative to the GaN substrate. Some of the typical problems that have been addressed and published are:

- Detailed compositional analysis of $In_xGa_{1-x}N$/GaN multiple quantum wells (MQWs) and depth profiles of the InN fraction, x, in the MQWs determined by grazing incidence Rutherford backscattering spectrometry (RBS).

- Influence of interdiffusion on the emission properties of MQWs are revealed by luminescence results.

Published, accepted or in press work

1. N. Franco, S. Pereira and A.D. Sequeira. Absolute Scale Reciprocal Space Mapping on X-ray Diffractometers Incorporating a Position Sensitive Detector: Application to III-Nitride Semiconductors. Accepted in *Mat. Sci. Forum*.

[1] Departamento de Física, Universidade de Aveiro, 3810-193 Aveiro, Portugal
[2] Nuclear Solid State Physics using ion Beams group.
[3] Department of Physics, University of Strathclyde, Glasgow G4 0NG, Scotland, UK.

Coatings for industrial Applications as High-temperature Turbine Blades, Hard Coatings for tools and Solar Panels

A.D. Sequeira, R. Vilar[1], C. Nunes[2], M.L. Prates[2], N.P. Barradas[3] and V. Teixeira[4]

Objectives

The aim of this line of activity is to produce and characterise several types of materials for industrial applications. Examples are

1) MCrAlY single crystalline coatings for turbine blade applications, using Laser Cladding;
2) Multilayered solar graded cermet selective coatings based on chromium and titanium deposited on Cu substrates to be used on solar energy collectors;
3) Very hard ceramic coatings for industrial tools and high-temperature components.

Results

To illustrate some of the research in this line of activity Fig.1 shows a cross section of single crystalline 3D structure produced by laser cladding. Fig. 2 represents the RSM maps collected in the marked areas. From these and similar measurements it was possible to determine the crystal growth in the deposited layers is epitaxial with the substrate but the crystallographic cell is deformed asymmetrically. This deformation depends on the growth direction.

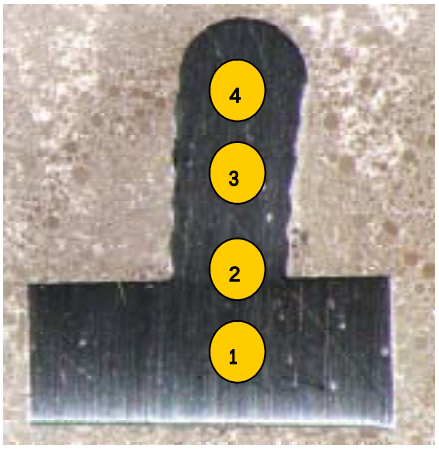


Fig.1 - Cross section of a single crystalline 3D structure composed of six consecutive layers. The circles indicate the measurements performed (see Fig.2).

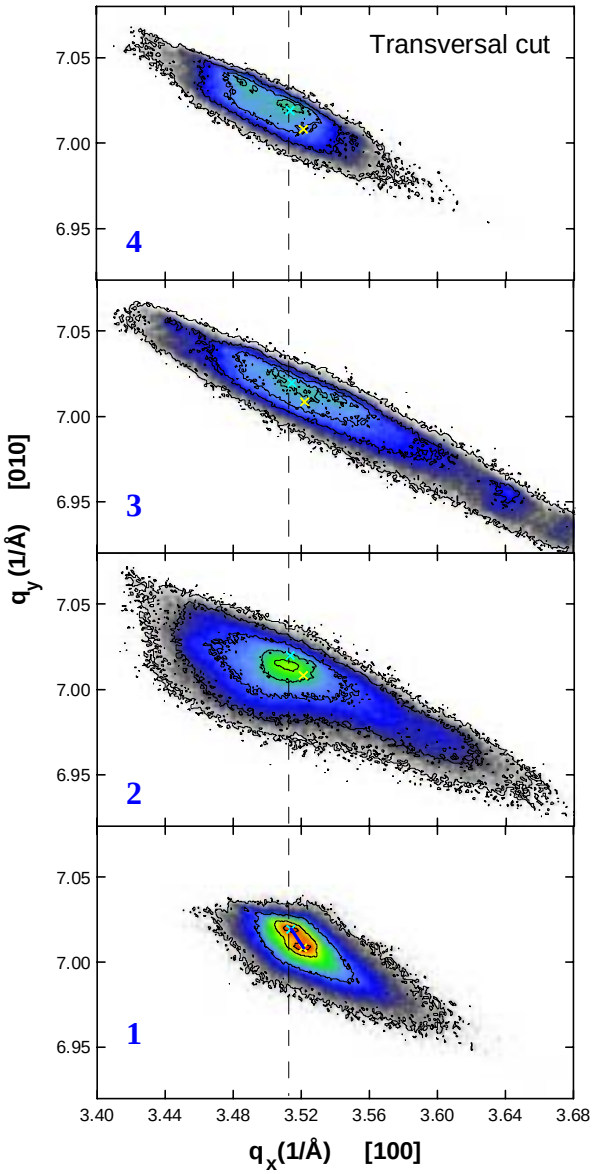


Fig. 2 - RSM maps along the 3D structure.

Published, accepted or in press work

1. C. Nunes, V. Teixeira, M.L. Prates, N.P. Barradas, A.D. Sequeira, Graded selective coatings based on chromium and titanium oxynitride, Thin Solid Films 442, 1-2 (2003) 173-178.
2. P.N. Ferreira, R. Vilar, R.C. da Silva and A.D. Sequeira. Structure of MCrAlY Coatings Deposited on Single Crystal Alloy Turbine Blades by Laser Cladding. Powder Materials: Current Research and Industrial Practices III, Edited by Fernand D.S. Marquis. USA, (2003) 234-242.

[1] IST, Av. Rovisco Pais, 1096 Lisboa Codex, Portugal.
[2] INETI, ITE. Lisboa, Portugal.
[3] Nuclear Solid State Physics using ion Beams group.
[4] CFUM-Centro de Física da Universidade do Minho, Universidade do Minho, Portugal.

Software and Hardware Development at Hotbird

N.P. Franco, Igor Yavarovskiy and A.D. Sequeira

Objectives

The aim of the current line of activity is the continuous development of hardware and software to enlarge the experimental facilities available and to expand the library of available software at the Ma^{3}t Laboratory to improve its functionality.

Results

One of the most powerful features of the Ma3t Laboratory is its versatility. This was achieved through the local development of hardware components and, in particular, of software routines that allow the control of the instruments and the advanced data analysis.

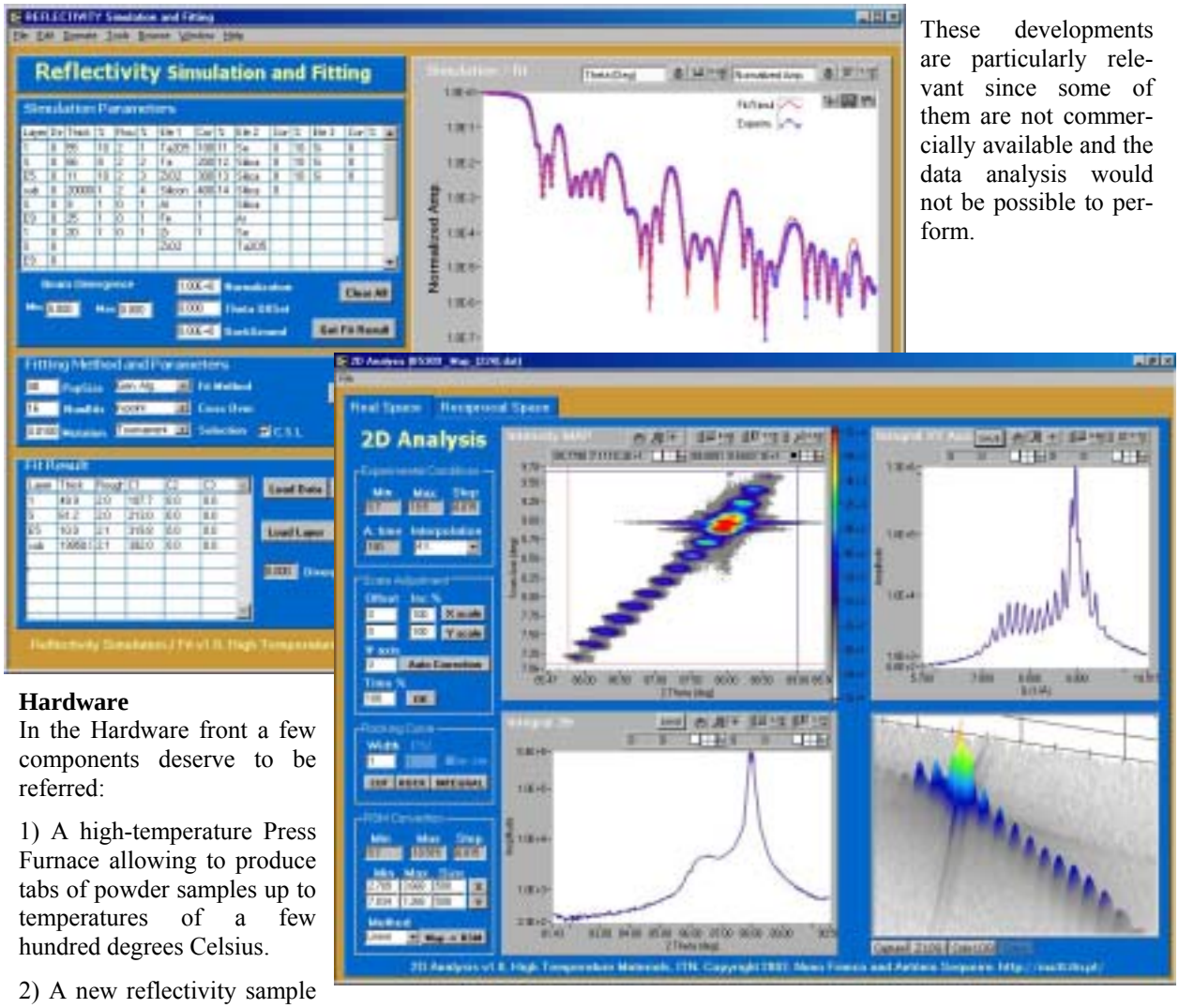
Software

In the software front we emphasize a few very important additions:

1) the *"2D analysis"* program that allows the quantitative detailed analysis of two dimensional reciprocal space maps both of diffraction mode and 2D reflectivity;

2) the "*2-Dimensional Reflectivity*" mapping procedure to perform reflectivity experiments in 2D;

3) the *"Reflectivity - Simulation and Fitting"* program that allows the analysis of reflectivity data.



These developments are particularly relevant since some of them are not commercially available and the data analysis would not be possible to perform.

Hardware

In the Hardware front a few components deserve to be referred:

1) A high-temperature Press Furnace allowing to produce tabs of powder samples up to temperatures of a few hundred degrees Celsius.

2) A new reflectivity sample holder includes a cutting blade and a spring device that guarantees the exact position of the sample surface independent of the sample thickness. This activity is performed under a Sapiens contract.

3) A method was developed to obtain RSM maps in an absolute scale (see paper on Mat. Sci Forum).

Published, accepted or in press work

1. N. Franco, S. Pereira and A.D. Sequeira. Absolute Scale Reciprocal Space Mapping on X-ray Diffractometers Incorporating a Position Sensitive Detector: Application to III-Nitride Semiconductors. Accepted in *Mat. Sci. Forum*.

Application of the SANS technique to the characterization of materials

F.M.A. Margaça, I.M.M. Salvado[1] and J. Teixeira[2]

Objectives

To investigate the microstructure, at a nanometer scale, of glass matrix composites and silica-zirconia xerogels, in order to complement the information obtained by conventional techniques.

Results

Small Angle Neutron Scattering (SANS) was used to study the microstructure of β-spodumene/glass matrix composites (GMC) prepared by sintering of soda-lime glass powder and sol-gel prepared β-spodumene ($LiAlSi_2O_6$) up to 25wt.%. The glass matrix reinforcement with β-spodumene results in improved fracture toughness, hardness and thermal shock resistance.

SANS proved to be a powerful technique to assess the porosity distribution in the GMC samples as SANS intensities come from the contrast between the solid material and the pores. It revealed the presence of micro-pores inside β-spodumene agglomerates and large sized pores in the glass matrix that result from incomplete densification during the sintering cycle.

SEM showed, in all samples, that the glass matrix had large-sized pores resulting from incomplete densification during the sintering cycle. But, when β-spodumene agglomerates are present, micro-porosity coupled with such defects is clearly evidenced by SANS which indicates a high total surface area without significant porosity enhancement.

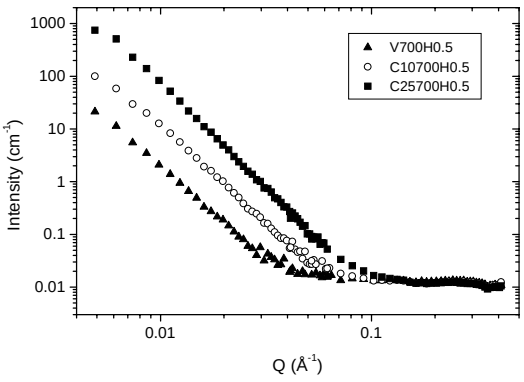


Fig.1 Scattered intensities for samples with different content of β-spodumene, heat-treated at 700 ºC for 0.5 h.

SANS results clarified that for sintering at high temperatures and long times when a decrease of densification occurs, micro-porosity is not developing. Thus, only large pores or cracks are formed due to phase transformation dimensional changes.

Xerogels with composition $xZrO_2$. (1-x) SiO_2 with x=10 mol% prepared by sol-gel were also studied.

Samples were prepared as usual except that before gelation at 30°C or at 60°C a fresh sol with the same composition and experimental conditions of preparation was added to the prepared sols. The time interval between additions and the number of additions was varied. After all additions the sols were left at 30°C or at 60°C until gelation occurred. After two weeks at the gelation temperature the obtained gels were dried at 120°C for 48 hours. The dried gels were then heat-treated for 5,5 hours at 850°C.

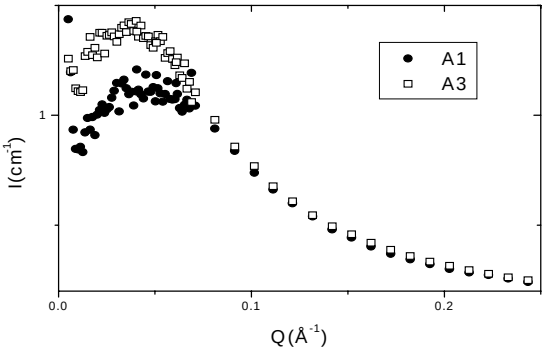


Fig.2 SANS data for one (A1) and three (A3) additions.

It was known that addition of fresh sols to an aged sol leads to densification of the xerogel. SANS results showed that densification is due to the increase of the number density of oxide regions developing in the sol.

Published, accepted or in press work

1. F.M.A. Margaça, M. Moreira, J. Teixeira, R.F. Silva, I.M. Miranda Salvado, Porosity assessment of β-Spodumene/Glass matrix composites by Small Angle Neutron Scattering, Communication (oral) presented at *Materials2003 – II Intern. Materials Symposium, Caparica, Portugal, 14-16 April 2003.* Accepted for publication in Proceedings.

2. I.M.M. Salvado, J.S. Sousa, F.M.A. Margaça, J. Teixeira, Densification of SiO_2-ZrO_2 xerogels by addition of fresh sols before gelation, *Proceedings of the 47th Annual Meeting of the Brazilian Ceramic Society, João Pessoa, PB, Brazil, 15-18 June* 2003, (ed. in CD-ROM), 2026-2035.

[1] Glass and Ceramics Engineering Dep., University of Aveiro, 3810-193 Aveiro, Portugal
[2] Laboratoire Léon-Brillouin, CEA/CNRS, Saclay, 91191 Gif-sur-Yvette Cedex, France

Investigation of the total reflection of neutrons by the strips used for the walls of the variable geometry multiple-channel collimator

A.N. Falcão, F.G. Carvalho, F.M.A. Margaça, J.F. Salgado and J. Teixeira [1]

Objectives

To develop thin strips of a strongly neutron absorbing material, to be used as building units of the walls of a variable geometry converging multichannel collimator.

Results

The variable geometry CMC has walls made up of thin absorbing strips of strongly neutron absorbing material. A computer simulation, that accounted for total reflection at the surface of the strips, showed that when the critical angle for total reflection exceeds a few mrad, there will be some contamination of the direct beam, affecting negatively the resolution function. Since the critical angle for total reflection is proportional to the mean coherent scattering length of the elements in the material, the addition of Ti powder was considered.

Strips were prepared by mixing an epoxy resin with Gd_2O_3 and different percentages of Ti powders. The mixtures were poured into grooves made in a Teflon mould. When the cure was complete the strips were peeled out of the mould. Each strip shows two different sides: That in contact with the mould that is plane with a rough surface. The other one (that has been in contact with air) with a slightly convex shape with glossy and smooth surface.

To evaluate the effect of total reflection processes at the strip surface, test work was performed at a SANS instrument (PAXE at LLB). The scattering intensity was recorded by a position sensitive detector, perpendicular to the incoming beam, for samples prepared with and without Ti and showing different surface types to the beam. For each sample the incident angle providing the highest reflection intensity was used to collect the spectrum. This was done with the incident 10 Å beam, attenuated by 2 mm plexyglass , in order to avoid using the beam stop at the detector.

The results obtained show that the presence of reflection is hardly noticeable except for the case of the smooth surface of the sample prepared without addition of Ti. All strips with Ti show a significant decrease in the scattering intensity, the scattering angular range remaining unchanged. On the other hand, the quality of the surface interferes with the angular spread of the scattering: smooth surface gives larger angular spread whereas rough surface produces a scattering with lower angular spread.

[1]LLB CEA/CNRS, Saclay, 91191 Gif-sur-Yvette Cedex, France

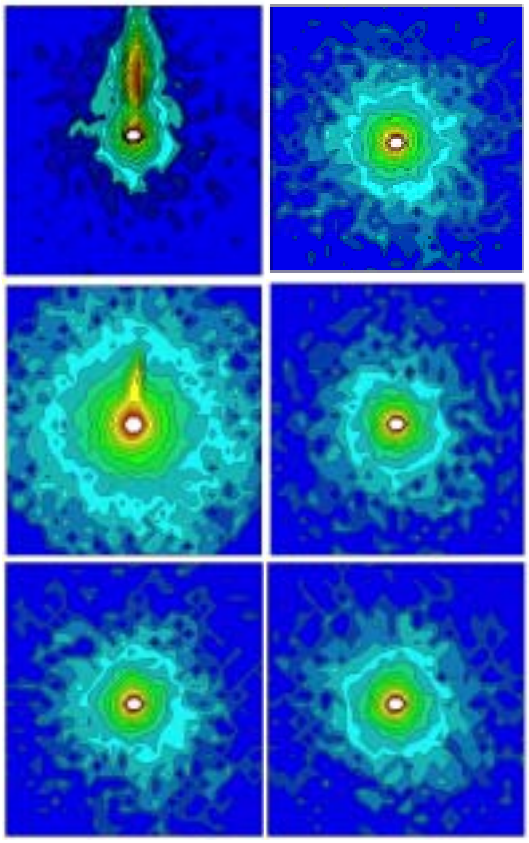


Fig. Spectra, in logarithmic scale, recorded at a PSD placed perpendicularly to the incident beam. Top right – Empty beam; Top left – recorded from an Aluminium plate (included for the sake of comparison); Middle - spectra from strips made of Gd_2O_3: rough side (right), glossy side (left); Bottom – spectra from strips made with addition of 16.7 weight % Ti.

While the results obtained are promising, a complete interpretation requires more accurate reflectometry measurements. For that, beam time has been granted at the reflectometer EROS of the LLB.

Published, accepted or in press work

1. A.N. Falcão, F.G. Carvalho, F.M.A. Margaça, J.F. Salgado, J. Teixeira, Investigation of the neutron scattering properties of the absorbing material for the multiple-channel collimator striped walls, accepted (poster), 3rd European Conference on Neutron Scattering, ECNS2003, Montpellier, 3-6 Sept., 2003.
2. A.N. Falcão, 3d Research Co-ordination Meeting of the IAEA CRP "Development and Practical Utilization of the Small Angle Neutron Scattering Applications", IAEA Headquarters, Vienna, Dec. 8-10, 2003 (oral).

Contribution to the Development of the SANS Technique

F.G. Carvalho, A.N. Falcão, F.M.A. Margaça and J. F. Salgado

Objectives

To contribute to the optimisation of SANS facilities by combining theoretical analysis, computer simulation of systems and devices and the design of special components.

Results

An analytical study was carried out [1,2] on the wavelength dependence of the performance of a SANS instrument that fulfils the so-called matching conditions and uses a continuous neutron beam from a Maxwellian source.

The detector count rate increases with F(λ) – the product of the detector efficiency by the Maxwellian exponential term of the thermal beam spectrum. For neutrons of wavelength λ, lying in the plateau region of F(λ) the performance of a SANS instrument is independent of the choice of the pair of variables (λ, L), L being the sample-to-detector distance. Otherwise the instrument performance depends strongly on the chosen value of λ, whatever the Q-range accessed, the detector intensity increasing with the wavelength.

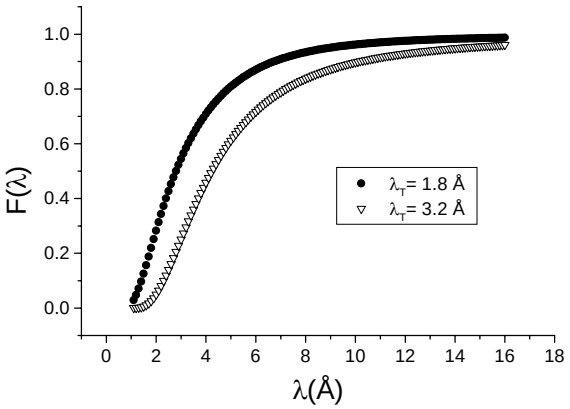


Fig.1 F(λ) for a SANS instrument installed at a cold source

It is shown that the best performance is obtained by choosing λ as close as possible to the plateau region of F(λ) provided the signal-to-background ratio is acceptable.

To study the performance of SANS instruments an existing computer simulation code was upgraded, by including a module that simulates the transmission of neutron guide tubes. The new module studies rectangular shaped cross section guides, with or without intermediate vertical reflecting surfaces. Any geometry of the flight path can be simulated. The program includes ballistic effects, and gives spatial and angular distributions of the transmitted neutrons. It was used to evaluate the performance of a guide system to be installed at the new FRM II reactor (Munich) and to optimise the design of the flight path geometry.

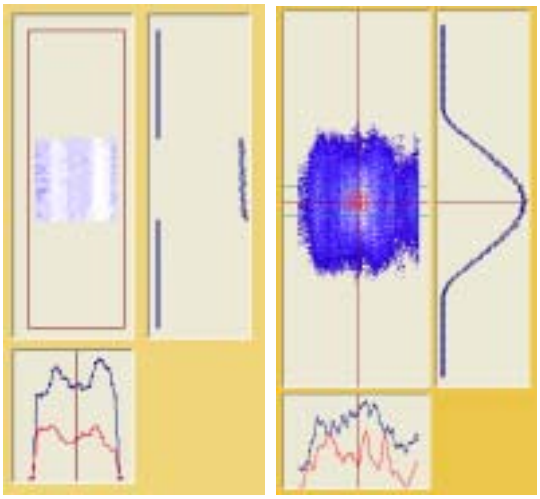


Fig.2 Spatial distribution at guide exit (left), and at sample placed 20 m away from the guide exit (right), for a S shaped guide with 24 m (12 m curved left, 12 m curved right) followed by a 4 m straight guide section. The curved sections have a curvature radius of 480 m. The results shown were obtained for 4 Å neutrons. The contour plots and blue curves are for a guide 50 cm wide, divided in two channels by an intermediate vertical reflecting surface, whereas the red curve was obtained for a single channel 50 cm wide.

The programme was also used to evaluate the feasibility of the installation of a curved neutron guide to produce a reduced background neutron beam to feed the SANS facility under installation at the Portuguese Research Reactor.

Published, accepted or in press work

1. A.N. Falcão and F.G. Carvalho, Research Contract No.11361/RO "Study and Design of a New Generation of SANS Instruments: Smaller, Modular, with Enhanced Capabilities and Low Servicing Requirements", Final Progress Report presented at the 3d Research Co-ordination Meeting of the IAEA CRP "Development and practical utilization of the small angle neutron scattering applications", IAEA Headquarters, Vienna, Dec. 8-10, 2003.
2. F.M.A. Margaça, A.N. Falcão, J.F. Salgado and F.G. Carvalho, Wavelength dependence of the performance of a SANS instrument installed at a steady source, (2003) to be submitted.

Neutron Spectrometers at the Portuguese Research Reactor

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Objectives

The purpose of the present programme is the implementation at the ITN campus of a set of basic instruments for neutron beam work, open to external users, using neutrons from the RPI reactor. This infrastructure is expected to help develop the use of neutron scattering techniques both for research and training, while contributing to a better utilisation of the RPI reactor.

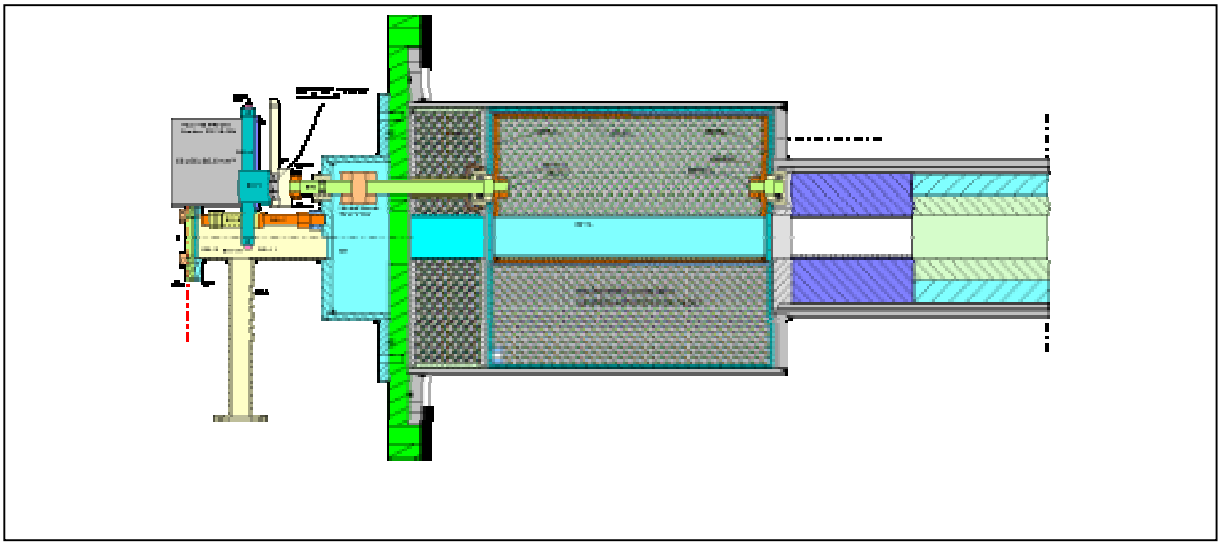
Results

Construction work of a new in-pile beam shutter for the Small Angle Neutron Scattering Instrument (EPA) of improved design was completed. Installation took place in the Autumn followed by first tests of the beam conditions. Further tests have been postponed pending the acquisition of thin neutron proportional counters.

In 2003 it was possible to find the funds to improve the sample environment of the two axis diffractometer DIDE. A cryostat enabling cooling down to 1.5 K was ordered and should be available by early 2004.

An extensive evaluation of the 800-channel BF_3 detector electronics was undertaken in collaboration with a technician from the LLB. Problems related to electromagnetic interference in the reactor hall could not be satisfactorily solved. During the tests, it was observed that a white powder had developed at some of the glass-metal welding positions. The powder was analysed and its composition found to be compatible with that of an epoxy resin. It is presumed that the powder resulted from the decomposition of an epoxy used to seal small leaks that may have been observed in the past, but no confirmation of this hypotheses could be obtained. A decision concerning the detection system of the diffractometer will be taken in early 2004.

Upgrading of the ^{3}He detector banks of the neutron TOF diffractometer ETV was completed.



Cross-section of the new beam shutter showing the driving system with synchronous motor that actuates the drum with the cylindrical channel that gives passage to the neutrons in an exocentric position.

Published, accepted or in press work

1. F.G. Carvalho, F.M.A. Margaça and A.N. Falcão, Report for the Safety Analysis of the New In-pile Shutter of the EPA Spectrometer (in Portuguese), Internal Report, March 2003