

Solid State

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The Solid State Group in the Chemistry Department has developed during the past years a broad range of expertise in complementary areas of solid state science and focused, under a global approach, on selected new materials with unconventional electrical and magnetic properties. The nature of the group is multidisciplinary combining expertise ranging from the synthetic chemistry of either molecular materials with transition metal complexes or intermetallic compounds, to many different specialised solid state characterisation techniques. Among the more relevant facilities developed, operated, maintained and used by in the group are a high temperature laboratory with crystal growth techniques (Czochralski, Bridgman and float zone), X-ray diffraction both in single crystal and powders, EPR spectroscopy, a Mössbauer spectroscopy laboratory, magnetisation measurements by Faraday and extraction techniques and AC-susceptibility measurements, different electron transport measurements, heat capacity, in a broad range of temperature and magnetic fields. The use of all these specialised characterisation techniques, often requiring low temperatures down to 0.3 K and high magnetic fields up to 18 T, lead to the development of a strong expertise in cryogenics. The group was the main promoter of the installation at ITN in 1991 of a helium liquefier, which since then remains the only one operational in Portugal, providing helium also to many users outside ITN, under the supervision of the group.

The rare combination of the **preparative chemistry** expertise with the specialised **solid state physics** techniques enables the group to deal with different problems of modern materials science. Thanks to the valuable techniques developed, the group often act as a key partner of many national and international research projects. Due to strategic reasons his activities have been centred in selected type of materials namely:

- Molecule based conducting and magnetic materials.
- Intermetallic compounds of uranium and lanthanides

The specific ongoing research projects are described in more detail in the following sections.

The **molecular conductors** have since the discovery of the first organic metals in 1973 remained one of the most active areas of research of modern materials science, and the group has an established tradition of 30 years of research in this field. During 2004 the two chain compounds, originally reported by the group almost 3 decades ago, were used as model Charge Density Wave (CDW) systems to probe, not only the

behaviour of a CDW under large magnetic field, but also the subsequent induction of a cascade of new CDW transitions under larger fields related to small interchain coupling details.

In order to take profit from common molecular precursors, synthetic procedures and characterisation techniques, the interests of the group in molecular materials have recently been extended to **molecular magnetism**. In this field a significant achievement this year was the enlargement of the study of the first series of isostructural molecular spin ladder systems, and the study of the magnetism of metallocenium-metalbisdithiolate salts.

The group intends to further develop its expertise in molecular design and chemical synthesis to the crystal engineering of new molecular materials with desired electrical and magnetic properties and in this field he participates in a Network of Excellence entitled Molecular Approach to Nanomagnets and Multifunctional Materials- MAGMANet, recently approved by the EC proposals within the VI Framework Program.

The research on **intermetallic compounds** was initiated by 1992 in structures thought to be good candidates for hard magnets and, due to specific characteristics of ITN as a nuclear centre, containing mainly U and Fe. The Mössbauer spectroscopy was used as a valuable tool to probe the role of iron atoms in the magnetic properties of these materials in complement to all other techniques. The group extended recently its activities to the system Dy-Fe-Sn that can be also studied by Mössbauer spectroscopy with different sources and to borides which have interest also to thermoelectric applications.

The **Mössbauer spectroscopy** developed in the group during almost two decades, has been during this last year increasingly used in an large variety of other projects with outside partners, in different fields such as geology, ceramic materials, and biological samples with the additional involvement of two pos-doctoral fellows.

A major output of the group has been the **training and education of young scientists** which always play a major role in its projects. The group members have been active in several education activities such as undergraduate courses, and advanced training activities in collaboration with the University of Lisbon. 3 PhD thesis done under the group were defended this year

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Research Team

Researchers

- M. ALMEIDA, Principal Res., Group Leader
- R. T. HENRIQUES, Assoc. Professor, IST
- V. GAMA, Aux. Researcher
- J. C. WAERENBORGH, Aux. Researcher
- A. P. GONÇALVES, Aux. Researcher
- E. B. LOPES, Aux. Researcher
- L. C. J. PEREIRA, Aux. Researcher
- I. C. SANTOS, Aux. Researcher
- D. BELO, Pos Doctoral, FCT grant
- P. SALAMAKHA, Pos Doctoral, FCT grant^a
- D.P. ROJAS, Pos Doctoral, FCT grant^b
- S. RABAÇA, Pos Doctoral, FCT grant
- S. SÉRIO, Pos Doctoral, FCT grant
- P. GACZYŃSKI, Pos Doctoral grant

Students

- H. ALVES, PhD Student, FCT grant
- J. C. DIAS, PhD Student, FCT grant
- S. SÉRIO, PhD Student, FCT grant
- R. MEIRA, PhD Student, FCT grant
- A. ROSA, FCUL PhD Student, FCT grant
- M. FIGUEIRA, BIC grant
- J. P. SEIÇA, BIC grant (until February)

Technical Personnel

- I. FALCÃO, ITN Grant

Funding (€)

Research Projects:	25.490,70
Services:	0
Total:	25.490,70

Publications

Books:	1 in press
Journals:	34 and 15 in press
Proceedings:	1
Conf. Communications:	23
Other publications:	
Theses: PhD	3

a- died June 2004

b- left September 2004