

**MCDPCM**  
**MULTIDISCIPLINARY CENTER FOR THE DEVELOPMENT OF**  
**CERAMIC MATERIALS**

**REPORT 5**

***PARTIAL REPORT OF THE MCDPCM ACTIVITIES COVERING THE BASIC RESEARCH ,  
TECHNOLOGICAL RESULTS AND EDUCATIONAL ACTIVITIES***

**PERIOD FROM MARCH 2005 to DECEMBER 2005**

December 31, 2005

## 1. OVERVIEW

This report describes all the activities developed in the center during the last year (march-november). This report shows that in this year the activities of the center were as intense as in the last years for all levels, including the scientific production, innovation activities as well as the continuous education and dissemination of knowledge to the society. The productivity of the majority of the groups has been improved year by year, demonstrating that the synergy of the groups by means of collaboration is the key factor. As stated in the former report, the collaborations among members of the center and also with other researchers not belonging to the center in the national and international level can be extracted in this report. The members of the center have been published about 95 papers being 86 in international periodicals and about 9 in national periodicals. Considering the several research areas of the Research Division, the number of papers per area was: Chemical Synthesis = 23; Semiconductors and Ferroelectric Materials = 21; Optical and Electrochromic Materials = 19; Crystal Growth and Non-Crystalline Materials = 5; and Design, Fabrication and Characterization of Materials = 9, Theoretical = 6, Kinetics = 9 and, finally, Nanomaterials = 3. Figure 1 shows the relative productivity by research lines.

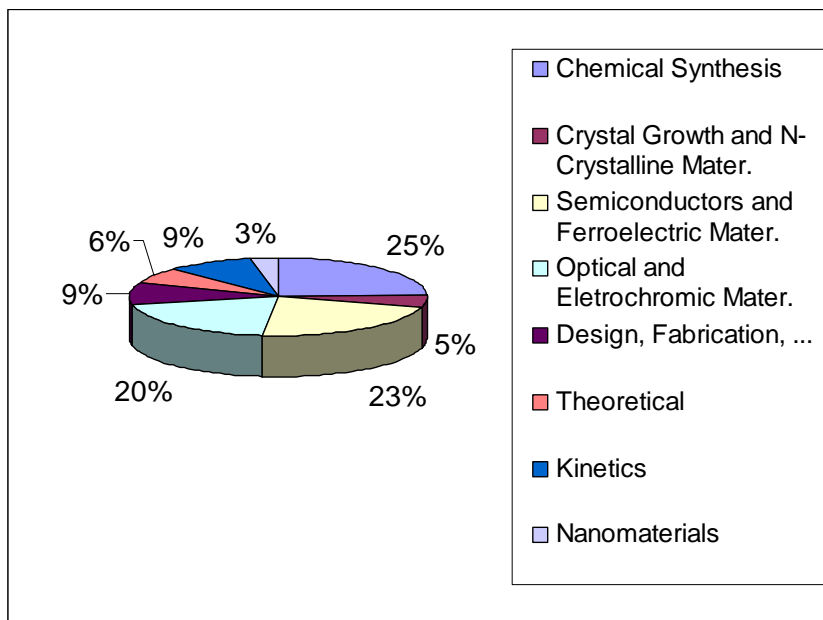


Figure 1: Relative production of 2005 (March- November).

As indicated by the total number of papers, the scientific production is still very good. We can observe also that the number of papers in nanostructured materials increased and nowadays is an important research field in the basic research division . Besides this remarkable performance, other good results that we got during this period were the continuation of some partnerships. For instance, the interaction with Prof. Michael Graetzel, from EPFL Switzerland, in the field of nanostructured materials for solar cell technology. Also the partnership with Prof. Michel Aegeter from INM Germany, aiming the development of nanostructured semiconductors oxides thin films for electrochromic application. In this period we consolidated the interaction with the Prof. Juan Andres, from Spain, regarding theoretical study of metal oxides. The driving force for this new international collaboration was the symposium organized in the MRS Spring meeting of 2004 in San Francisco. In this meeting we showed that we can organize a high level symposium and that our work in nanostructured materials is of international level, allowing us to start this kind of interaction.

The results in the Innovation Division of the Center are growing with other companies join to the center by means of technological research projects. We consolidate in this period the creation of two spin-off companies in collaboration with former students of the center. One of this companies are related to material and chemical characterization and the other are involved with the development of ceramics thin films for corrosion protection and surface modification of glasses and stainless steel. It is important to point out also that we are working with projects in nanotechnology with Brazilian (CSN) and multi-national (Faber-Castell) companies, in order to apply ceramics nanoparticles in traditional products. The main idea behind these projects is to increase the performance of products and process using nanoparticles.

The continuous education and dissemination division of the center has increased and diversified the numbers of activities reaching a well-established program Many diversified activities like hosting teachers and high school students, basic courses for craftsman located in several locations, production of educational video, linking PhD studants to industrial sector, among others has been performed.

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## **2. RESULTS IN BASIC RESEARCH**

### 2.1 – Chemical Synthesis

Nanostructured ceramic materials have become a topic of increasing interest in our research center. This is mainly due to the ability of these materials to display novel or better properties when compared to bulk materials which may lead to the development of electronic and opto-electronic nanodevices with superior performance. It is well known that size and morphology are crucial parameters in nanostructures. Therefore, it is of fundamental importance to be able to control these features and reproduce them, in order to control the final properties of the material. The hydrolysis of metal halides and inorganic salts is a method widely employed to process metal oxide nanoparticles, such as TiO<sub>2</sub>, doped and undoped SnO<sub>2</sub>, ZnO, and ZrO<sub>2</sub>. The cation is normally hydrolyzed by changing pH, which promotes the precipitation of an insoluble amorphous hydrous metal oxide. The main concern of this approach is the crystallization step, since heat treatment or hydrothermal treatment is required to promote crystallization. During crystallization, each hydrous metal oxide particle can generate several nuclei, rendering it very difficult to control particle morphology and shape. The synthesis of metal

oxides based on the hydrolysis of inorganic salts or metal alkoxides, with a high degree of crystallinity at room temperature, is still a challenge.

In a recent work, published in the *Journal of Nanoscience and Nanotechnology*, we describe the synthesis, at room temperature, of doped and undoped SnO<sub>2</sub> nanocrystals (particle size ranging from 1-3nm) with no thermal or hydrothermal treatment. To the best of our knowledge, this is the first time that the synthesis of doped and/or undoped SnO<sub>2</sub> nanocrystals at room temperature has been reported. This new method of synthesis is based on the controlled oxidation, hydrolysis, and polycondensation of tin ions, in an ethanolic media. Moreover, surfactants can be used in this method, which may provide improved control over the particle size. This method allowed us to conduct several basic studies concerning nanocrystal growth as well as optical properties of nanostructured SnO<sub>2</sub>. For instance, we studied the effect of the initial tin (II) ion concentration, in an ethanolic solution, on the mean particle size of the nanoparticles. The Sn<sup>2+</sup> concentration was varied from 0.0025 M to 0.1 M, while all other synthesis parameters were fixed. Besides, an investigation of the effect of agglomeration on the nanoparticle characteristics (i.e. size and morphology) was also accomplished, by modifying the pH of SnO<sub>2</sub> suspensions. Several samples were characterized by transmission electron microscopy, optical absorption spectroscopy in the ultraviolet range and photoluminescence measurements. The results show that higher initial ion concentration and agglomeration lead to bigger nanoparticles. The concentration effect is explained by an enhanced growth due to a higher supersaturation of the liquid medium. On the other hand, it was observed that agglomeration of the nanoparticles in suspension induces coarsening by the oriented attachment mechanism. This study was published in the *J. Phys. Chem. B*.

We also studied the quantum confinement effect in colloidal SnO<sub>2</sub> nanocrystals. We observed by photoluminescence (PL) study that SnO<sub>2</sub> nanocrystal presents an intense PL peak at around 320 nm. This PL was attributed to band-to-band transition and the gap energy showed a dependence with crystal size. This crystal size dependence suggests that the PL behavior stem from a free exciton decay process. This dependence was well described by the weak confinement regime predicted by the effective mass model. This work was published in the *Appl. Phys. Letters*.

In this period, we maintained the development of ferroelectric oxides. We started the crystallization study of amorphous precursor processed by oxidant peroxo method (OPM) under hydrothermal condition. The OPM process is an interesting route which allows to obtain an inorganic amorphous precursor free of carbon and Cl and its crystallization occurs around 600°C. The crystallization of the precursor under hydrothermal condition is a project that was developed in our laboratory. The preliminary results showed that it is possible to obtain crystalline lead titanate (PT) in a temperature as

low as 120°C. Other important result was the control over the particle morphology of PT. Particles with cubic and fibers morphology were obtained, changing the lead concentration and temperature during the hydrothermal treatment. Conventional (zirconia- and barium cerate-based) and non-conventional (bismuth-copper-oxide and lanthanum-molybdenum-oxide) oxide ion solid electrolytes were synthesized also using different chemical techniques for the production of nanosized sinteractive ceramic powders. Intergranular and intragranular conductivities were determined and related to the microstructure. Regarding the research in semiconductors oxides, the focus was also in the grain boundary properties of tin oxide ceramics, as well as, in the synthesis of SnO<sub>2</sub> and ITO (Indium tin oxide) nanobelts by carbothermal reduction process. For instance, we reported for the first time in the literature the synthesis of ITO nanobelts (communication published in the Appl. Phys. A).

The increasing interest in nanotechnology has also been motivated by the possibility of tailor-making nanomaterials with defined properties by controlling some of the characteristics of the nanostructures, such as their size and morphology. Hence, there has been a considerable effort to understand how nucleation and aggregation processes affect these characteristics. In a recent paper, a simple kinetic model was presented to evaluate the influence of synthesis parameters on the growth behavior of nanoparticles in colloidal suspensions. The proposed model describes well the growth behavior of dispersed nanoparticles during the initial stages of nanoparticles synthesis and during growth induced by hydrothermal treatments. Theoretical values are in a good agreement with experimental values indicating the feasibility of the proposed model.

## 2.2 – Semiconductors and Ferroelectric Materials

The main results obtained during the present period in the area of ferroelectric thin films and ceramics are discussed below. The main goal in this period was to develop ferroelectric thin films by controlling the chemical and microstructural features aiming for applications in FeRAM and DRAM memories. Also the fatigue resistance and retention characteristics of the films deposited on metal and oxide conductor electrodes as well as the preparation of amorphous films were investigated for DRAM memory. Significant advances in the processing and microstructural features of ferroelectric ceramics indicate that the chemical phase control with more than two cations is extremely important, especially to obtain very good electrical properties. The use of microwave oven allows the preparation of bottom electrodes and ferroelectric thin films with great stoichiometric control and with superior properties than films annealed in the conventional furnace. The advantages of microwave oven for thin films and

ceramics are: decrease in the temperature and time of the thermal treatment, low cost, better production quality. To obtain reasonable ferroelectric and dielectric properties it is necessary to grow textured films. For this purpose, the microwave annealing is an excellent choice because crystallization starts from the interface of film-substrate leading to an ordered film. Several ferroelectric systems have been investigated in the thin films and ceramics forms such as: Pure lead zirconate titanate (PZT) and modified with niobium (PZTN), pure lead magnesium niobate (PMN) and modified with lead titanate (PMN-PT), lithium niobate and tantalate (LNO e LT), strontium titanate (STO), barium strontium titanate (BST), pure lead titanate and modified with calcium and strontium (PCT and PST), strontium and barium niobate and tantalate (SBT, SBN, BBT and BBN), barium and zirconium titanate (BZT), lanthanum bismuth titanate (BIT and BLT).

The main activities developed in this period in this field were:

Ferroelectric phases were obtained by the polymeric precursor method. The powders were compacted and sintered and their crystal structure and microstructure characterized;

The polymeric solutions were prepared and their viscosities and ionic concentrations adjusted. The films were deposited onto silicon and platinum coated silicon substrates and thermally treated in a conventional furnace to obtain the desired crystalline phase;

Crystalline phases obtained in both thin films and ceramic powder forms were characterized by Rietveld method. The micro-deformation and crystallite size were also investigated;

Atomic force microscopy, scanning electron microscopy and transmission electron microscopy were used to characterize thin films and ceramics.

The electrical characterization of thin films and ceramics were performed by depositing conducting electrodes by using platinum and gold "sputtering";

Thermal treatments in the microwave furnace were performed with aiming to avoid interfacial reactions and favor the texture growth of the films.

### 2.3 – Optical and Electrochromic Materials

The main focus of the research in optical properties has been the study of photoluminescence (PL) in amorphous materials (basically amorphous oxides). Based on theoretical calculations, we have been trying to understand the source of PL in amorphous phase of thin films and ceramic powders of several oxides, such as BaWO<sub>4</sub>, PbWO<sub>4</sub>, CaWO<sub>4</sub>, Li<sub>2</sub>TiSiO<sub>5</sub>, BaTiO<sub>3</sub>, and so on. Besides theoretical studies, thin films and powders were experimentally evaluated in order to investigate the PL properties of such

oxides. By combining theoretical and experimental models, based on quantum mechanics, it has been possible to understand the source of photoluminescence in amorphous materials.

#### 2.4 – Crystal Growth and Non-crystalline Materials

The main results are related to the use of laser to develop dense ceramics and single crystal fibers. We have used the laser sintering technique with success to produce dense ferroelectric ceramics and translucent thermoluminescence ceramics. We also grown single crystal fibers with high optical quality for solid state laser development. Other interesting results were the preparation and characterization of  $\text{-BaB}_2\text{O}_4$  (BBO) for second harmonic generation. The second harmonic generation intensity of a BBO layer was controlled by the adjustment of the fraction of crystallized layer.  $\text{Ge}_{25}\text{Ga}_{10}\text{S}_{65}$  glasses also were produced and its optical properties characterized.

### 3. TECHNOLOGICAL RESULTS

The Center developed several projects of strong industrial interest, which resulted in several patents and papers. The interaction with industries was conducted through specific projects with different industrial sectors.

The projects developed with the metallurgical sector consisted in advanced refractories to be applied in the preparation high quality metal considering the economical and environment aspects. During their use, refractories must not only support high temperatures but also stress (thermal and / or mechanical) as well resist combined attack by liquids such as molten metals, slags and fluxes.

Researchers of the MCDCM also support the improvement of the quality of ceramic products by means of determining the characteristics of the products being produced by several companies and improving the preparation of those products, and developing new products

The most important projects related to the technological section are:

3.1 Study of the behavior of  $\text{Al}_2\text{O}_3\text{-Cr}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  refractory systems, working in close contact with molten glasses for production of biocompatible ceramic fibers. This study was contracted

by RCR Corporation and it was concluded. The main objective was to verify the influence of impurities that come from the refractory during the production of biocompatible glasses (or fibers).

Enhanced behavior of the torpedo refractory cars using nanoparticulated titania or  $MgAl_2O_4$  impregnation technique. This project was contracted by CSN and it was concluded. A titanium or Mg and Al solution was developed to fill the free pores in the microstructure of the torpedo refractory cars lining aiming the enhancement of the corrosion resistance. It was observed that the nanoscale protection mechanism introduced by the use of nanoparticulated cerium impregnation technique. After the dynamic slag and fracture energy tests, it was verified that this new corrosion prevention technique decreased to 11% the damages in the torpedo refractory car lining.

Recycling of Ceramic Industry Waste. The group has demonstrated that it is possible to recycle virgin (despite un-appropriate to sell) scrap from the brick, floor and roof tile and sanitary ware industry, as a substitute for the normal coarse aggregate and sand in non structural concrete and mortars for laying and masonry purposes.

3.2 Development of automotive temperature sensors. Metalurgica Iguaçu Ltda Different kinds of perovskite-based NTC temperature sensors have been synthesized by mixing, pressing and sintering Ni, Cu, Mn, and Co oxides. Some compositions have also been synthesized by a modified polymeric precursor technique. The electrical characterization was carried out by dc methods. An experimental sequence for producing large quantities of each composition was evaluated for the scaling up of the thermistor production. The challenge proposed by a local industries looking for Brazilian-made temperature sensors for application in the automotive industry has been overcome: four out of six thermistors with behavior similar to commercial thermistors have been successfully developed.

3.3 Development of translucent alumina or zirconia pieces for dentistry applications. This project was contracted by Tecnident Ltda, of the dentistry sector aiming to produce translucent alumina or zirconia bracts.

3.4 Refractory products for anode baking furnaces. Refractories used in anode baking furnaces must be renewed regularly. There are several stresses acting on the refractory lining. The extent of these stresses will vary somewhat between an open and a closed pit furnace, but generally the origin and the implications of the stresses are the same. This project contracted by Togni S.A. Materiais Refratários has been concluded. A post mortem study objective of determining the mechanism of the corrosion developed during the industrial application. It was concluded that containing a high amount of calcium

and sodium aluminum-silicate interacts with the microstructure of the refractory promoting the corrosion.

3.5 Development of a Glass Reject Based Deffloculant for Masses in the Ceramic Triaxial. This development was one of the last ramifications of the SEBRAE PROJECT implemented with the Ceramic Industry Union of Porto Ferreira – SP. The project also is part of our Research Division on Recycling. This new deffloculant was technologically evaluated comparatively to the sodium silicate. It is cheaper and as effective as this last one.

Present Status - A Patent request was submitted for FAPESP analysis and sponsorship and presently is under scrutiny of FAPESP reviewers.

3.6 Development of a Vitreous Silica Based refractory Composition For the Crucibles Used on The Foundry of Dental metallic Alloys and Precious metals (assaying). Sponsoring Company – Deflotec Ind. Com. de Produtos Refratários LTDA Localization – São Carlos – SP.

Crucibles made by slip casting the above developed mix, performed very well comparatively to imported materials based on the same mineralogical phases. Comparatively to the commonly used mulcorite based crucibles, the ones developed at LAMARCO performed 10 times better (number of runs).

Present Status - The crucibles are being produced and commercialized by Deflotec who sponsored the research.

3.7 Fireclay Refractories Produced with Low Temperature (<500°C) Refractory Aggregates (grog) Sponsoring Company – Deflotec Ind. Com. Produtos Químicos e Refratários Localization – São Carlos - SP

A new processing route was developed for the production of fireclay aggregates (grog) to be used in the fabrication of fireclay refractories (class of 30 –35%  $Al_2O_3$ ). There is a great demand for this kind of aluminum silicate refractories, specially in the sugar cane and agro business. The generic use of hard fired fireclay grogs (>1300°C) leads to a low profit margin in the final product. The developed technology is very attractive commercially considering it brought the grog cost to one third of the current one, providing a larger profit margin.

Present Status - This Project was successfully tested at Scandelari Company Lapa Paraná who built a new facility to implement this new technology whose started up in august 2005.

### 3.8 A New Method for The Dosing of Structural Concrete

The new dosing method was developed as a Master Thesis Theme under the orientation of Prof. Dr. João B. Baldo. The rationale behind the new method was the use of the principles of particle packing instead of pre-designed requirements of the concrete mixes (as usually done). The water amount determination was based on the parcels needed by each of the solid components of the concrete. Finally a judicious mixing order was employed. When these three procedures are combined a structural concrete of the 40 MPa strength can be made using half of the cement normally used when the current methods are used. A patent request is being prepared and will be applied to FAPESP scrutiny and sponsorship.

3.9 The preparation and characterization of Pt metallics films allows the preparation of low cost electrodes. The development of new electrochromic counter electrodes with enhanced stability. The preparation of supercapacitors from binary  $\text{RuO}_2\text{-TiO}_2$ .

3.10 Study of the Behavior of  $\text{Al}_2\text{O}_3\text{-Cr}_2\text{O}_3$  and  $\text{Al}_2\text{O}_3\text{-ZrO}_2$  Refractory Systems, Working in Close Contact with Molten Glasses, for the Production of Bio-Compatible Ceramic Fibers. PI0405197 - "Fibra ou Lã Cerâmica de Escória de Alto Forno e Processo de Fabricação".

## 4. CONTINUOUS EDUCATION AND DISSEMINATION DIVISION

**Our activities in this year can be resumed in the following projects:**

**4.1 A trip to the ceramic world** - This activity started last year and has teaching scientific knowledge to students from fundamental and high schools living up to 400 km far from MCDMC. Four cities were involved in this project: São Carlos, Ribeirão Bonito, Ribeirão Preto and Cajuru all located in the northeast region of the São Paulo state. 1591 students took part on the activities. The idea was to explain the difference among glass, crystal and traditional and advanced ceramics. Several experiments were shown to introduce basic concepts associated with chemical reaction, fluids, optical, magnetic and electrical phenomena. It was possible also to speak on the importance take their formation up to the end of the high school and also to introduce how beautiful and exciting are the scientific themes.

**4.2 Teaching Physics Through Experiments** - As part of this project, high school students from São Carlos, Ribeirão Preto and Cajuru (nearby town) participated on physic experiments demonstration and lectures about "The nanometric world" at the Institute of Physics of São Carlos. 113 students took part

on that activity. The students from high schools used one morning talking and discussing science. All those activities have two major objectives: the first one is to teach the basic concepts of science with a different point of view and pointing out where those concepts are applied in day by day situations. The second one is to show to those students (potential future undergraduate students) and teachers the ambient of the university life and to try to create the questioning and thinking behavior on several issues in a different way that they should be.

**4.3 Students at the MCDCM labs** - As an extension of the earlier projects, we introduce a new approach in teaching the concepts of chemical and physical process involved in the ceramic production and properties. This project proposed to transform the high school senior students from nearby cities in undergraduate students for one day. The students have the opportunity to live as real undergraduate students, with a visit to the Universidade de São Paulo and MCDCM laboratory activities. The visit starts with a lecture about the Universidade de São Paulo Campus, and after that high school students are invited to visit several units of the campus, including restaurants, sports center, etc... During the lunch the high school students had the opportunity to talk with actual graduate students about the undergraduate courses which they are interested in. In the afternoon, the students are separated into groups of 3-5 and visit the research laboratories of MCDCM. During this activity they are treated as real researchers and some simple laboratory experiments and tasks are proposed to the group. They work as a team and they actually feel the need of rationalizing about a problem, and how it is important the basic knowledge in physics and chemistry.

#### **4.4 School on Crystal Growth and Advanced Materials (Ilha Solteira, SP)**

The objective of the School on Crystal Growth and Advanced Materials (SCGChA) is to foster activities connected with the growth and characterization of crystals, with particular emphasis on training, scientific research and technological applications. The idea is that researchers in this field from all over Brazil will be able to meet and talk each to other. The SCGChA also promoted the training and development of young students and researchers. Symposia in fundamentals and methods of crystal growth were presented together with different characterization techniques. The SCGChA was a forum for discussion of all aspects of crystal growth, their challenges, and perspectives for the future.

#### **4.5 The Ceramic Center Hosts High School Teachers and Students**

In this period, visits to the Ceramic Center of high school teachers and students were scheduled. The visits were held at the Group of Crystal Growth and Ceramic Materials – USP and at the

Interdisciplinary Laboratory of Electrochemistry and Ceramics of the Department of Chemistry of UFSCar and UNESP. During a 8 hour period, these students received explanations and participated of mini-analyses in several different techniques: X-ray diffractometer, scanning electron microscopy, atomic force microscopy and tunneling microscopy. They participated also in a short lecture on Molecular Modeling using the first principles of Quantum Mechanics. The four modules were taught in practical classes of 100 minutes. These courses are opened the whole year, only needing that the high school to be registered at USP or LIEC-UFSCar.

The activities undertaken by the Ceramic Center were shown to be perfectly aligned with such tendency of high school students getting in touch with laboratories during scheduled visits. Therefore, there is a team in the MCDMC available to organize and carry out such diffusion work. High schools from the cities of São Carlos, Cajuru, Praia Grande and Ribeirão Bonito visited the Center.

#### **4.6 Comic's Book**

Researchers of the MCDMC staff have developed a specific text of elementary level to be distributed to the students during their activities in schools aiming at motivating them to read and to discuss themes on Materials Science. This book has been also used with the Ceramic Materials Education Project. The chosen theme of the first book is clay. The second book will be in glasses and recycling.

#### **4.7 Production of 3D Animation**

In this period, five 3D animations (films during 2 or 3 minutes) were elaborated. They were exhibited in high schools and in oral presentations in meetings congress in Brazil and abroad. The basic objective of the animations is to show in a clear and scientific way the development of the research activities of the Center, and also in nanostructured ceramics, nanoparticles, ceramics interfaces, refractory corrosion, hair care and sensors. On the other hand, there has been a great interest from the regional TV channels to show the animations associated with the research activities undertaken by the Center, what resulted in an average of one monthly interview in TV channel of highest audience in the region. Nowadays, this way of diffusion has already guaranteed presentation time in pay per view TV channels.

#### **4.8 Participation of the Center Members as National and International Reviewers**

a) The Ceramic Center, by means of Prof. Dr. Reginaldo Muccillo selects and edits the Revista Cerâmica, official magazine of the Brazilian Ceramic Society. Prof. Dr. J. A. Varela and Prof. Dr. E. Longo, members of the Center are members of the editorial committee of Revista Cerâmica.

b) The Center has also a strong participation in the review *Revista Cerâmica Informação*, edited by Faenza Editrice do Brasil Ltda. Prof. Dr. J.O. Paschoal, a member of the Center is the Technical – Scientific Editor of the review and Prof. Dr. E. Longo is also one of the members of the technical – scientific council of the review.

c) Members of the ceramic center had strong participation as reviewer of international journal such as *J. Am. Ceram Soc.*, *Advanced Materials*, *J. Am. Chem. Soc* and others. The group has members of the editorial board of the *J. Nanoscience and Nanotechnology*, *Ceramics International* and *Science of Sintering* (Edson R. Leite and José A. Varela).

#### **4.9 Extension Courses for Teachers**

High school teachers who participated in the Extension Course for Teachers concluded: A great amount of knowledge with a lot of practical work in the classroom. In this course, it was offered fundamentals of chemistry using practical experiments, involving also video and 3D animation. The participation of 70 teachers in the course showing the interest of them to obtain up to date knowledge to make their classes more interesting. On the other hand, each participant received a set of 30 Craftsman Handouts, which were employed to teach the students in the ceramic art and its relationship with chemistry and physics, associated with materials. This program incorporated around 3000 high school students in Praia Grande and Ribeirão Bonito.

#### **4.10 New Method for the Dosing of Structural Concrete.**

LAMARCO has been actived in the following professional enhancement and academic supplementation.

**4.11 Mini-Baja Project** – The building of out of road monopost cars by engineering students and their participation in national competitions. Prof. Libardi from Lamarco is the Coordinator of this Program.

**4.12 Professional Enhancement Program** – Prof. Baldo from Lamarco gave a Short Course for 30 Engineers of Petrobrás ( Brazilian Oil Company) in Advanced Refractory Castables under the support of The Brazilian Ceramic Society.

**4.13. Aero-Design Project** - The building of low scale airplane models by engineering students and their participation on national competitions. Prof. Libardi from Lamarco is the Coordinator of this Program. (DUPLICADO)

#### **4.14 Diffusion in Newspapers, Radio and TV**

It is important to point out the interface of MCDCM with the media. In this period, information about Ceramic Materials was disseminated by means of the written press, radio and TV.

Newspapers from São Carlos (Primeira Página, A Folha, Notícias FIESP/CIESP and Tribuna), Araraquara (Imparcial), São José do Rio Preto (A Tribuna) and Bauru (Journal da Cidade) covered news about MCDCM achievements in the Innovation Projects, emphasizing the development of materials in partnership with CSN, White Martins (PRAXAIR), CBMM, and Faber-Castell. O Diário Oficial (Imprensa Oficial) and O Estado de São Paulo, covered also the achievements of MCDCM emphasizing the advantages that the industrial partners of MCDCM are having with such a fruitful partnership, Magazines: Ciência Hoje and Pesquisa (FAPESP).

The technical developments obtained in Materials (photoluminescence, nanoparticles, and nanostructure) benefited the whole region, showing clearly the multiplying role of the University-Company interaction. As a consequence, EPTV, a TV Company covering the whole Central Region, Jornal da Band, produced a series of reports covering the activities of MCDCM as well as the TV-Cabo Branco of Paraíba.