

MULTIDISCIPLINARY CENTER
FOR THE DEVELOPMENT OF CERAMIC MATERIALS

MCDCM ACTIVITIES' PARTIAL REPORT:
BASIC RESEARCH, TECHNOLOGICAL RESULTS AND EDUCATIONAL ACTIVITIES

PERIOD FROM JANUARY 2010 TO DECEMBER 2010

February 2011

REPORT (10) – MCDCM

Overview

This report encompasses all the main activities developed in the center last year. It emphasizes that in 2010, the center's activities were as intense as in 2009 at all levels, including in the areas of scientific production, innovation and scientific divulgation to society. However, this report's focus is to demonstrate that the innovation character has become very important. Most of the groups' productivity has been improving year after year, which demonstrates that the synergy between the groups continues to be a key factor. It is also important to note that our collaboration with international groups has been increasing. Our members have been participating in international scientific activities such as writing books and reviews devoted to traditional and modern fields of research.

Our members have published 83 papers, with 82 in international periodicals and 1 in national periodicals. The quality and quantity of these papers can be considered as excellent. We are also committed to modifying the research structure in order to create different types of device-based systems. In Research Division, the papers' number per area was as follows: Chemical Synthesis = 14; Semiconductors and Ferroelectric Materials = 18; Optical and Electrochromic Materials = 21; Crystal Growth and Non-Crystalline Materials = 15; and Design, Fabrication and Characterization of Microdevices Based on Magnetic and Superconducting Thin Films = 15. Figure 1 shows the relative productivity by research lines.

The international scientific community has been recognizing the center's high productivity. Indeed, several of the center's leaders have been invited to hold international meetings or seminars and to write papers about ceramic materials. Two papers were even selected as reviews in the following areas: nanostructured materials for electrochemical energy production and storage and non-classical nanoparticles growth process. It is also important to remind that two of our researchers are International Academy of Ceramics' members.

The center's Innovation Division has been successful in its collaboration with companies on technical research projects. The companies were very satisfied with the projects' results. It is evidenced by the fact that most the companies keep renewing these projects with the center year after year. These achievements can be attributed to

the high motivation as well as the excellent management. Projects have been contracted with large companies such as CSN (more than 20 years) and IIPF-EMS (4 years), as well as with medium and small companies (KosmoScience, Nanox, Unilever, Angelus, Sencer, Togni, etc.) just to name a few. This year, 5 patents were deposited. It is another evidence of the excellent work developed with industries. We also provided companies with technical solution and we published papers some of the companies' members (2). It should be also stressed that many projects with industries are well related with the center's research lines. Many projects are based on Tin Oxide ceramic, which has been studied extensively by the Center's members. Thus, innovation is high. The center's continuous education and dissemination division has been growing and a plethora of activities will be carried out according to a well-established program for the upcoming years. In this second year, our program improved the diffusion through elementary and high schools lectures about several subjects related to chemistry and physics of ceramic materials as well as the Ceramic Materials Educational Project, as it has been described before. Moreover, the center offered a nanotechnology course for undergraduate students in several universities. Various other activities also took place such as hosting teachers and high school students, basic craftsman courses in numerous places, educational video's production of, PhD students' connection with the industrial sector, just to name a few.

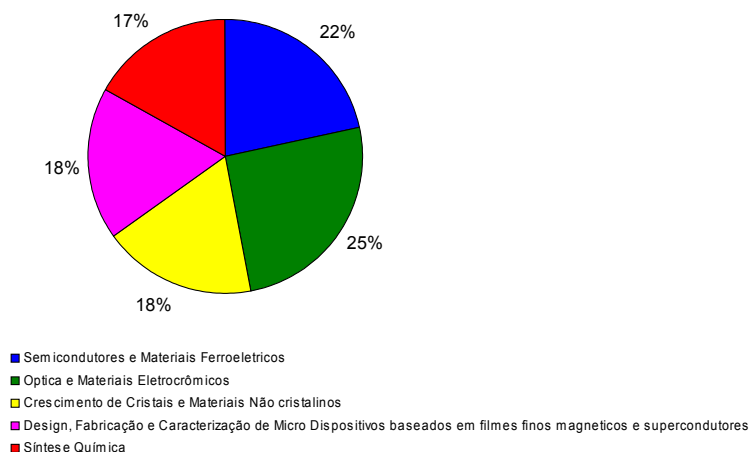


Figure 1 - Innovation Activities developed in our Center.

Basic Research – 2010

In this report, we will describe briefly the basic research activities developed last year (2010). More details about a specific project or a specific development can be obtained in the published paper, related to the specific interest. This description will be divided in topics related to the research areas. The papers' number of is still high and it is clear that the paper's quality has been improved based on the impact factor of the published periodicals.

a) Crystal Growth and Non-Crystalline Solids

Optically transparent single crystal fibers of calcium niobate (CaNb_2O_6) were investigated by polarized micro-Raman spectroscopy. The fibers were obtained by the laser heated pedestal growth technique, in the form of rods with about 0.4mm diameter and up to 20mm long. The crystalline axes were determined by mid-infrared reflectivity and X-ray diffraction. The fibers grew within the Pbcn columbite structure, with their longitudinal axis parallel to the crystallographic a-axis. They were free of cracks or facets, and no secondary phases were detected by the spectroscopic or structural characterizations. Polarized Raman spectra were obtained in adequate parallel and crossed configurations for the orthorhombic D_{2h} point group. In short, a total of 48 Raman phonon modes, which are characteristic of the CaNb_2O_6 columbite crystal, were discerned, in good agreement with group theoretical predictions. The knowledge of the optical phonon characteristics of the CaNb_2O_6 single crystal fibers presented here is an important step to propose and design compact optical devices built with these materials, such as solid state lasers operating in the near-infrared region.

The $\text{Bi}_2\text{O}_3\text{-GeO}_2$ (BGO) system has received attention mainly for the eulytite ($\text{Bi}_4\text{Ge}_3\text{O}_{12}$) and the sillenite ($\text{Bi}_{12}\text{GeO}_{20}$) crystals which have application in scintillation and optoelectronic devices. The study of glassy system, having properties similar to those of crystals, is of high interest due to their lower cost and easier production when compared to ceramics and crystals. Glasses of the bismuth germanate system were prepared by melting/molding method and were investigated concerning their thermal and structural properties. The samples' structural analysis was carried out by micro-Raman and Fourier transform infrared spectroscopes. The glasses' structural analysis of was carried out by micro-Raman and Fourier transform infrared spectroscopes. It was

observed that the glass structure is formed basically by GeO_4 tetrahedral units also with the formation of the GeO_6 octahedral units. Bi^{3+} cations are incorporated in the glass network as BiO_6 units; however, the presence of BiO_3 groups was also observed. FT-IR spectra showed that ceria addition caused changes in the glass network by shifting a band at 1103 cm^{-1} to lower wavenumbers, which was attributed to the linkage vibration of Bi-O-Bi and/or Bi-O-Ge . Deconvolution of micro-Raman spectra of the glassy samples (80BGO and 80BGO:0.2Ce) shows that the addition of 0.2 mol% of ceria do not cause considerable changes in the germanium-oxygen units. Thus, we concluded that the cerium oxide was efficient as oxidant agent to prevent the darkening of bismuth germanate glasses. However, it also plays the role of local network modifier, even for concentrations of 0.2 mol% by causing changes mainly in the BiO_6 octahedral units.

Research on glasses has been intense so far due to the wide applicability of such materials in electrochemical devices as batteries, fuel cells, sensorial elements, displays, etc. Among the glasses with expressive ionic conductivity, the oxyfluoroborate ones have been largely studied, being concluded that fluoride ions are the main charge carriers in these materials. The present study demonstrates that, even in Pt,Ag/Glass/YSZ:PbF₂/Ag,Pt-type electrochemical cells subjected to electric field action, where YSZ:PbF₂ represents composite-like mixtures (formed by Y_2O_3 -doped ZrO_2 and PbF_2) placed between the glass and anode, crystallization was observable in given cases. In summary, supported by (micro) structural and electrical characterizations, clear evidence is provided here that, besides Pb^{2+} reduction at the cathode, crystallization really involves simultaneous F^- oxidation at the anode, completing thus the whole redox electrochemical reaction so far postulated. In these cases, F^- migration to the anode was achievable following PbF_2 percolative-like paths through the YSZ:PbF₂ mixtures.

b) Thin films

Several studies have been performed on crystalline and non-crystalline materials, more specifically on nanostructured thin films, monocrystalline fibers, Dental resins and borate glasses. A summary with more significant results is presented below.

A sol-gel route was used to prepare $\text{Y}_{0.9}\text{Er}_{0.1}\text{Al}_3(\text{BO}_3)_4$ glassy thin films by spin-coating technique looking for the preparation and optimization of planar waveguides

for integrated optics. The optical and guiding properties of the films were studied by m-line spectroscopy. The best films were monomode with 620 nm thickness and a refractive index around 1.664 at 980 nm wavelength. They showed good waveguiding properties with high light-coupling efficiency and low propagation loss at 632.8 and 1550 nm of about 0.88 dB/cm. These results revealed that our rare earth aluminoborate $Y_{0.9}Er_{0.1}Al_3(BO_3)_4$ host exhibits potential waveguide developments.

Sol-gel route has been also used to prepare $CaCu_3Ti_4O_{12}$ (CCTO) thin films on Silicon substrates and its varistor and dielectric behavior have been analyzed. The results show that CCTO thin film display a permittivity of about 1000 with very low dielectric loss. In the same way, the J-V behavior of this film is completely symmetrical.

c) Chemical Synthesis

A combined experimental and theoretical investigation on the photoluminescence properties of $SrTiO_3$ (ST) and $SrSmTiO_3$ (ST_Sm) nanostructures was realized. The nanocrystalline powders were prepared by the polymeric precursor method. The decrease in the broad PL emission band of ST and ST_Sm powders measured at room temperature indicates an increase in the structural order as the annealing temperature increases, i.e. characteristic samarium peaks intensify as the structural order increases in ST_Sm samples. The interactions of the network clusters that form the ST and ST_Sm structures were evaluated by means of the ab initio periodic method at the density functional theory (DFT) level with the hybrid nonlocal B3LYP approximation. The symmetry-breaking process that leads to the presence of non-ideal $[TiO_6]$ and $[SrO_{12}]$ clusters, as well as the relationship between these clusters, provides favorable structural and electronic conditions for the appearance of PL phenomena.

For the first time, we provide evidence for both heterogeneous nucleation at the mesoscopic scale and the progression of the non-classical crystallization process during the microwave synthesis of cupric oxide (CuO) with sea urchin-like morphology. This work sheds light on the general mechanism of the growth of CuO architectures.

In the last five years, several excellent reviews about oriented attachment (OA) have evidenced the advances achieved in this research area, detailing the growth mechanism and the kinetic models. The main focus of the review published in the *Nanoscale* by our research group is to examine the dependence of the OA mechanism

on the colloidal state and to demonstrate how the colloidal state modifies the OA mechanism. Basically, we can define two main possible approaches to achieve self-organization or mutual orientation of adjacent nanocrystals. One is the effective collision of particles with mutual orientation controlled by the number of collisions. This type of growth occurs in a well dispersed colloidal suspension and results in a statistical growth process. The second way is through coalescence induced by particle rotation. This mechanism must be dominant in a weakly flocculated colloidal state in which there is significant interaction among particles. This type of process leads to the formation of complex structures.

d) Electronic ceramics

Barium zirconium titanate ferroelectric ceramics modified with vanadium $\text{Ba}(\text{TiZrV})\text{O}_3$ (BZT:2V) were prepared from powders synthesized using the mixed oxide method. The fine-grained sample showed a 'relaxor-like' ferroelectric behavior. The dielectric permittivity reaches a maximum value (ϵ'') similar to 16,000 at 1 kHz) for the BZT:2V ceramics sintered at 1623 K for 4h. Remnant polarization (P-r) and coercive field were also temperature dependent.

Dielectric and Raman scattering experiments were performed on polycrystalline PbCaSrTiO_3 thin films as a function of temperature. Temperature-dependent dielectric measurements revealed a decreasing ferroelectric-to-paraelectric phase transition temperature and peak dielectric permittivity showed a broad phase transition near room temperature with increasing levels of CaO_{12} and SrO_{12} clusters. Therefore, for higher levels of substitution, the possible random position of the CaO_{12} and SrO_{12} clusters leads to a diffuse state.

A continuing research on the CCTO ceramics were conducted in this year. New experimental results leading to the understanding of this intriguing material were obtained. Both giant dielectric constant behavior and non-linear resistive behavior were considered. Mechanical properties of this material were obtained in both, stoichiometric CCTO and in CCTO with excess in calcium.

The effect of dopants on the dielectric and non-ohmic properties of CCTO were also considered specially with vanadium oxide. In this case the effect of this oxide is to

decrease the dielectric constant and increase the non-linearity of resistance. These results allow to tailor these properties in designing specially a varistor device.

Sol-gel technique was used to obtain porous CCTO thick films in order to explore its gas sensor properties. Since this material exhibit a n-type conductivity it was observed high sensitivity to oxygen with short response times. The CCTO is suitable to be used as gas sensor.

e) Materials in Electrochemistry

The main results concerning the use of nanostructured materials in electrochemistry devices is described below :

Preparation of microelectrodes for pH measurements: Using the characteristics of Pechini method, we have developed a microelectrode for pH determination with a diameter of 25 microns in thickness. The electrode coupled with a reference electrode was mounted in a needle which guarantee mechanical stability. The system is stable, reproducible in the pH range from 2 to 12. With this configuration the usage of the electrode is extended to new applications such as in vivo measurement, fruit and meat non-destructive quality control.

Preparation of core shell electrochemical capacitors: Ru is an expensive chemical once it is a noble metal. Otherwise, its oxide, RuO₂, is one of the most promising materials to build electrochemical capacitors. The main properties of these devices are based on the total surface area. Therefore, we covered an inexpensive TiO₂ with a RuO₂ few monolayers and get the same properties of those obtained with bulk RuO₂ but with a much less cost.

Decorated photo-catalytic based on TiO₂: It is well known that TiO₂ is an interesting material for photo catalysis and solar cell devices. Specifically for photocatalysis, OH· is generated on the surface by the oxidation of water. Of course, if TiO₂ is promising for oxidation it is NOT for reduction processes and, therefore, there is an electron accumulation inside the particles, which degrades their catalytic properties. With this idea in mind, we decorated the TiO₂ particle surface with metallic Pt nanoparticles creating sites adequate for the reduction process to occur. The changes in the rate of the indirect oxidation of azo dyes was increased about 200 times

compared to Pt particles in the dark. The most important highlight in the research is the creation of a NANO-ELECTROCHEMICAL CELL.

f) Other Materials: Dental composite resins

Methacrylate-based composites have been widely used as direct polymeric dental restorative materials because they have excellent aesthetic qualities and relatively high cure efficiency in free radical photo-polymerization. The essential phases of most polymeric dental restorative materials are the matrix, filler, and interphase. An important point to be considered in the treatment of dental cavities with composite resins materials, in order to obtain satisfactory restorative results, is to make an adequate clinical composite filling by means of the photopolymerization process. We have investigated the thermal and structural properties of different commercial dental resins: Filtek™ Z-350®, Grandio®, Tetric Ceram® and TPH Spectrum. The purpose of the present study was to evaluate quantitatively the photo-polymerization behavior and the effect of filler contents on the kinetic cures of the dental resins. It was confirmed that there was a good agreement between the two T_g values, at low and high temperatures, activation energies from thermal degradation of the main chain of the polymer matrix, and the degree of conversion obtained for all samples. The results observed by DSC measurements showed that Tetric Ceram® dental resin presented the higher T_g values (low T_g at 84 °C and high T_g at 140 °C) and the higher activation energy value ($215 \pm 6 \text{ KJ mol}^{-1}$), associated to the thermal degradation from the main chain of the polymer. It was confirmed by the degree of conversion (63%) obtained by FT-IR absorption, which implies that Tetric Ceram_ dental resin presents the major stability when compared to the other commercial resins studied.

2 - Innovations Activities

In terms of technological innovations, the Center developed several projects in collaboration with the industrial sector. These projects resulted in several patents and papers. The interaction with industries was conducted through specific projects with the different Center's members. The projects developed with the different companies are generally classified in the following groups: Technological support, "Spin-off Companies", News products (PIPE projects) and Basic Research. Figure 2 illustrates the projects' classification in the different groups.

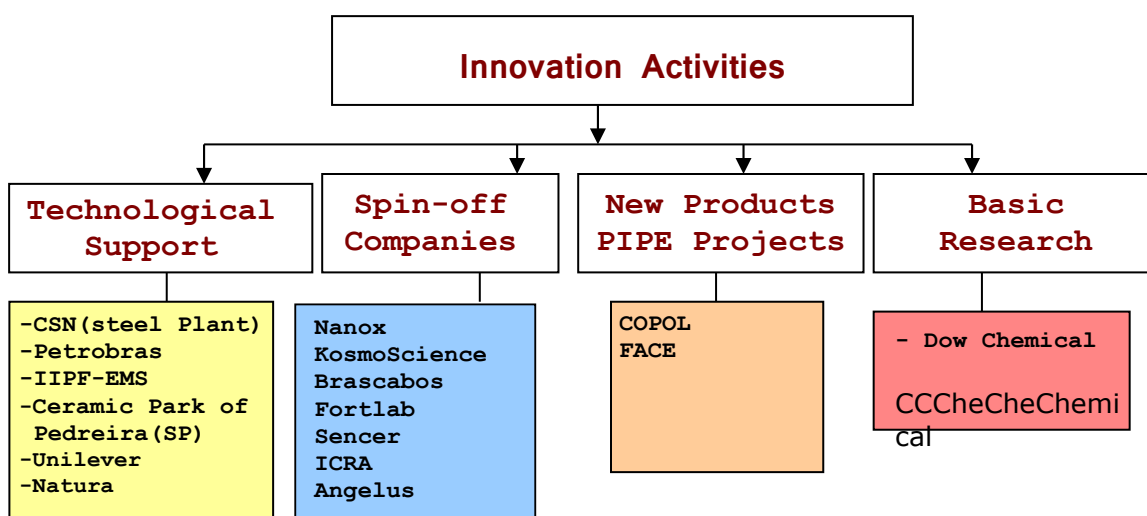


Figure 2 – Innovation Activities developed in our Center.

2.1 – Technological Support

The projects developed in the metallurgical sector with the CSN Company, comprised advanced refractories. They have to be used in order to assure high metal quality under both of the economical and ecological aspects. During services, refractories must not only tolerate high temperature but also withstand stress (thermal and / or mechanical) as well as resistance to combined attacks by liquids such as molten metals, slags and fluxes.

In 2009, we obtained a new contract from PETROBRAS S.A., with the goal of developing basic research related to the use of ceramics nanobelts and nanorods,

mainly SnO₂ and SnO, for gas sensor. The basic idea is to use this nanostructured material to detect average low concentration of gases (ppb) such as H₂S and CH₄.

2.2 - “Spin-off Companies”

In the past 6 years, our students have created two small companies, based on research developed in our Center. The first one was the Kosmo Science. This company's main purpose is to develop analytical procedures in order to characterize cosmetics products, and to find the interaction between the cosmetic, the hair and the skin. Our collaboration with the Kosmo Science consists mainly of providing them with the facilities (spectroscopy and microscopy instruments).

Our students also founded the Nanox. Its goal of is to develop nanostructured coating with functional properties such as: anti-bactericide and hard coatings.

2.3 - Basic Research

This new group of projects started last year and the main goal is to obtain financial support from private companies for basic research. The first project was developed with the Dow Chemical and is related to the development of nanocomposite materials, as described last year. More recently, our group obtained three new projects for basic research in material related to nano-sensors and self-healing materials. Those projects are supported by Petrobras. The first one is related to the use of nanomaterials for the development of gas sensors, particularly for the detection of H₂S in a sub-ppm level. The second one is related to the development of self-healing materials based on magnetic nanocrystals and its applications in metallic materials. Finally, the third project is related to the development of Mo-nanolayers deposited in gamma alumina and its application as catalytic material.

2.4 - Nanomaterials and Nanostructures for Alternative Energy Devices

An in-depth understanding of the processes involved in the operation of electrochemical cells is crucial in the development of new methods for the design of more efficient electrochemical cells destined specifically for energy conversion and storage. An indispensable aspect of this body of knowledge is a thorough grasp of the synthesis and design of functional electrodes and electrolytes with unusual and

valuable properties, which, today, are provided, to a large extent by the nanosize effect of these cells' functional components. Indeed, future developments in this field will necessarily depend on nanoscience and nanotechnology as has been done by the MCDCM.

Therefore, this research area's main focus is to develop new strategies that exploit nanoscale architectures to enhance the efficiency of alternative energy conversion and storage devices and on the basic principles of electrochemistry governing the effects of nanoscale on electrodes and electrolytes. In addition, the MCDCM introduces basic principles of nanotechnology to guide the reader through this incipient interdisciplinary boundary. The scope of ensembles of nanosized objects and products that have been and can be created is truly remarkable. Moreover, the potential impact of these products on basic science and applications is so great that the subject is inexhaustible, particularly in view of the enormous diversity of nanosized objects. Therefore, this area of research must be limited to objects and systems that already show real promise for a variety of applications.

The electrochemical manufacture of small objects ranks high in the design of new materials and systems with special properties. However, although the mechanism of formation or removal of small individual portions of solids plays a decisive role in the field of electrochemical nanotechnology, the use of electrochemistry as a tool for the preparation of nanostructures for electrode and electronic applications lies outside the scope of this chapter. In other words, the absence of this and other related topics clearly indicates, from the start, that no attempt will be made to cover the field comprehensively here.

2.5 - Presently the artistic and chinaware ceramics are the most competitive in the international market.

An extended contract project with the Pedreira Ceramic Park's (SP)²⁹ industries was signed in order to improve the regional competitive conditions. The project focused on two main lines of actions: 1) development of batch formulation; 2) establishment of a conceptual base as the design trademark for the ceramic ware produced in Pedreira. The new batch formulation, using a new set of raw materials,

allowed a cost reduction with raw materials as well as an improvement of the properties of the final products. It can be emphasized that the water absorption was reduced from 32% to 11% in the ceramic ware. The design project consisted in modifying the geometry of ceramic articles, the design of ceramic products as well as to propose the idea of that the segmentation of the product lines in small industries bring advantages in terms of production and commercialization of the ceramic ware.

CONTINUOUS EDUCATION AND DISSEMINATION DIVISION

In 2010, we kept on developing our continuous education and scientific dissemination activities in order to involve more students in basic science and ceramic materials concepts.

In continuous education, it is crucial to have a reduced number of students in the classroom. Thus, the short-course is taught in more than one day. This way, students receive a direct support from the teacher (a MCDCM searcher), which in turn allows a better understanding of the new concepts associated with ceramic material.

This year, we also freely disseminated videos and enabled a free access to the nanotechnology network. In fact, the MCDCM recorded a total of 215,000 accesses to the different videos produced in 2010.

The Nanoscience and nanotechnology project: "time to be nanoart" that began before 2010 was further developed with two new videos produced. Nanoart is the art and nanotechnology's intersection. The Nanoart videos were very successful and reached approximately 35,000 views in 2010. Moreover, more than one hundred copies were distributed to artists, researchers, professionals and teachers from eleven Brazilian states.

The 2010 activities can be summarized as follows:

I - Nanoscience and nanotechnology: "time to be nanoart"

The INCTMN / CMDMC and other research centers house large collections of images which have been compiled through 30 years of materials research. These nanometric images often remind items that one can encounter in daily life. For

example, an aluminum oxide nano-network resembles a beehive's honeycomb. Nature constantly produces images from the world around us. Modern technology has placed nature on the artist's stage and gave birth to an artwork formed by various morphologies of materials. One can easily imagine nature personified, painting images with a tiny atomic or molecular brush.

With nano-art, nature freely creates its own morphology and consistently presents itself in a unique way with the ever evolving free-spiritedness of an abstract artist. This image contrasts to the macro scale where a sculpture is carved from tangible material such as wood, stone or metal by chisel and sweat--a process during which it either takes an aesthetically appealing predefined shape or it is not considered art.

The video **NANOART 5 - Nanotechnology – Nanotecnologia** can be seen:

<http://www.youtube.com/watch?v=3UIRFXB1qX0>

Last year, we kept on developing the continuous education and scientific dissemination activities in order to involve more students in basic science and ceramic materials concepts. For example, the short-course about Nanotechnology and Glass Materials was respectively taught for 639 and 438 students in 2010. This number was around three times higher than in 2009.

In continuous education, it is crucial to have a reduced number of students in the classroom. In this case the short-course is taught in more than one day. Thus, students receive a direct support from the teacher (a MCDPCM researcher), which allows a better understanding of ceramic material new concepts.

1. Project “One Day as a College Student ”

In this project, students from high schools (15-17 years old), could choose to participate to different activities such as physics experiments, visit to the university library to the the research group Growth of Crystals and Ceramic Materials (CCMC)laboratories with an MCDMC. In 2010, the following schools visited the research group Growth of Crystals and Ceramic Materials (CCMC)laboratories:

Activities	School name and city	Day/Month/ year	Students presen t
Lectures and physics experiments demonstration at Institute of Physics of S. Carlos, USP	E.E. Chanceler Raul Fernandes Rio Claro	23/04	45
	E.E. Dr. Alberto Alves Rollo Américo Brasiliense	21/05	53
	Centro Educacional Zequinha de Abreu Santa Rita do Passa Quatro	26/05	80
	E. E. Prof. Mario Florence Novo Horizonte	28/05	46
	E. E. Marciano de Toledo Piza Rio Claro	18/06	45

II – Short-course: Nanotechnology and glass materials

In 2010 school year, we decided to focus on the Nanotechnology and glass materials themes. The short-course was taught to 15-17 years-old students. The evaluation's results revealed that the students do not have an organized knowledge about these themes, although they acknowledged their importance in our life. In Sao Carlos' school the number of students who attended the course and the course's dates were:

Nanotechnology:

School name	Students	Day/month
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	24/05
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	25/05
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	26/05
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	27/05
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	28/05
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	01/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	30	02/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	30	07/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	30	08/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	09/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	32	10/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	32	11/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	32	14/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	15/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	16/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	33	17/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	18/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	22/06
Escola Estadual "Profº. Gabriel Felix do Amaral"	35	23/06

Glass materials

School name	Students	Day/month
Escola Estadual "Profº. José Juliano Neto"	25	11/10
Escola Estadual "Profº. José Juliano Neto"	25	12/10
Escola Estadual "Profº. José Juliano Neto"	25	13/10
Escola Estadual "Profº. José Juliano Neto"	25	14/10
Escola Estadual "Profº. José Juliano Neto"	28	25/10
Escola Estadual "Profº. José Juliano Neto"	28	26/10
Escola Estadual "Profº. José Juliano Neto"	28	27/10

Escola Estadual "Profº. José Juliano Neto"	28	28/10
Escola Estadual "Profº. José Juliano Neto"	28	29/10
Escola Estadual "Profº. José Juliano Neto"	28	22/11
Escola Estadual "Profº. José Juliano Neto"	30	23/11
Escola Estadual "Profº. José Juliano Neto"	30	24/11
Escola Estadual "Profº. José Juliano Neto"	30	25/11
Escola Estadual "Sebastião de Oliveira Rocha"	20	06/12
Escola Estadual "Sebastião de Oliveira Rocha"	20	07/12
Escola Estadual "Sebastião de Oliveira Rocha"	20	08/12
Escola Estadual "Sebastião de Oliveira Rocha"	20	09/12

III – Materials Physics Summer School - FisMat

In 2010, we organized for the second time a Materials Physics Summer School (Escola de Verão em Física dos Materiais - FisMat). This activity was performed in partnership with the Institute of Physics of São Carlos (IFSC), University of São Paulo (USP).

The objective was to disseminate advanced concepts in materials science for undergraduate students and post-graduate who are taking the first courses in physics, or chemistry or materials engineering.

A total of 250 students from different Brazilian regions (Rio Grande do Sul, Santa Catarina, Paraná, Rio de Janeiro, Sergipe, Goiás, Mato Grosso do Sul, São Paulo e Minas Gerais) signed up on our homepage (www.fismat.ifsc.usp.br). From these, only the best 40 students were selected after looking at their Curriculum Vitae. The Summer School involved courses, invited lectures and a posters section.

IV – Scientific Research Activity (SRA) for 15-17 years old students (Iniciação Científica Jr)

This project is very different from the other projects conducted by the MCDKM. For this project, the students must develop a research project during twelve consecutive months, but off class periods.

The SRA's objective is to develop a materials science research with high school students, so that they can learn the scientific method and understand the knowledge

construction process. Thus, students weekly attend our research group in order to conduct studies, experiments, results' analysis, reports' preparation and lectures. At the end of each project, students give lectures at the Institute of Physics of São Carlos and at its school.

In 2010, the SRA concluded was:

Student	School	Project	Period
Natali Soler Matubaro de Santi	Colégio Objetivo	Supercondutividade	Out./2009 a Dez./2010

V- Cooperation project in the educational area

Title: Development and evaluation of strategies to stimulate the inflow of high school students in the career of physics: a study in São Carlos (SP, Brazil) and Santiago de Cuba.

Coordinators: Prof. Dr. Antonio Carlos Hernandez (Brasil) and Prof. Dr. Juan Julián Guillarón Láser (Cuba).

Financial support: CAPES/MES-Cuba

Period: January 2011 to 2012.

VI – Diffusion in Media

It is important to point out the MCDPCM interface with the media. In this period, Ceramic Materials information was disseminated through written press, radio and TV. São Carlos' Newspapers (Primeira Página, A Folha and Araraquara (Imparcial) have covered news about MCDPCM achievements in the Innovation Projects, emphasizing the materials's development realized in partnership with different industries. O Diário Oficial (Imprensa Oficial) and O Estado de São Paulo (a national coverage

newspaper) also reported MCDCM achievements and emphasized the benefits gained by MCDCM's industrial partners due to the fruitful collaboration

The technical developments obtained in Materials Science (photoluminescence, nanoparticles, and nanostructure) have benefited the whole region, which shows how important the University-Industry is. Consequently, EPTV, the Central Region's main TV Company produced a series of reports covering the activities of MCDCM and TV Globo and Record (TVs of national coverage).