Project no. **INCO-CT-2006-026283-OPSA**

Project acronym: **OPSA**

Project title:

Centre of Excellence for Optical Spectroscopy Applications in Physics, Material Science and Environmental Protection

Instrument: **SSA**

Thematic Priority:

Nanotechnologies and nanosciences;
Long-term interdisciplinary research into understanding phenomena, mastering processes and developing research tools

Final Activity Report

Period covered: from 01/07/2006 to 30/06/2009 Date of preparation: 31/07/2009

Start date of project: 01/07/2006 Duration: 36 months

Project coordinator name: **Zoran V. Popović**
Project coordinator organisation name: **Institute of Physics - Belgrade**

Version: final

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Project summary

The aim of this project is to improve the level of scientific and technological research in the Centre for Solid State Physics and New Materials (Institute of Physics) in order to become the ***Centre of Excellence for Optical Spectroscopy Applications (OPSA) in Physics, Material Science and Environmental Protection.*** This project has to improve the current experimental techniques concerning their performances and possibilities (spectral range, sensitivity, resolution, low and/or high- temperature, pressure and magnetic field abilities), thus bringing these equipment to European level. Besides, through the education and training of young researchers in European laboratories, special courses in OPSA and using modern equipment in research, we expect to expand the front of excellence to the West Balkan countries, keeping the experts in the region and broadening perspectives for high level education, research and ability of employment of the young people.

1. Project objectives and major achievements during the reporting period

The overall *objective* of OPSA is:

- **(O_1)** to promote long term research into understanding phenomena, mastering processes and developing research tools in the field of Nanoscience and Nanotechnologies through an upgrade and renew of our experimental techniques (Raman and infrared systems),
- **(O_2)** to develop human potential through educational and training activities,
- **(O_3)** to promote cooperative research and technological and educational activities between research centers, universities and industry in the field of Micro and Nano-technologies and Microsystems.

Achievements of Objective O_1: *Upgrade and renew of our experimental techniques.* In the first year of the OPSA project, we obtained new triple stage TriVista 557 spectrometer system equipped with CCD detector, confocal microscope and appropriate microscope cryostat (WP1; Tasks 1.1, 1.2 and 1.3). Within the WP1 of the OPSA project in the second year we tested all parts of new Raman spectrometer as well as the complete system. We also prepared detailed instructions for use of the whole set-up (Task WP.1.6). In the third period of the OPSA project we organized training courses for our students (Task WP 1.7). **Fourier transform infrared spectroscopy (FTIR)** system (Bomem DA-8), was up-graded during the first and second year of the project with adequate light sources, beamsplitters and detectors for near IR and visible region, an IR microscope and a closed cycle cryostat. All above mentioned components are mounted and tested, as foreseen for the second year of duration of the OPSA project (Task WP 2.5). We also prepared manuals for use of IR microscope and whole system (Task WP2.6). In the third period we organized training courses for our students (Task WP 2.8).

Achievements of Objective O_2: *Educational and training activities.* Training of our collaborators in other Centers of excellence for optical spectroscopy in Europe was also foreseen within this project. In the first and second year of the project our co-workers had the opportunity to have experience in use of heating microscope stage at University of Valencia (Spain) and high pressure diamond anvil cell at National technical University of Athens (Greece) for Raman scattering measurements on nanocristalline materials, as well as to improve and transmit their knowledge to other colleagues who are working on the OPSA project. In the third year of the OPSA Project we did practice in use of DAC at NTU-Athens and we also realized strong collaboration with several Italian Universities, like the University of Bari and the University of L'Aquilla, where measurements and training in use of x-ray photoluminescence spectroscopy (XPS) for nano-sized materials characterization were realized.

Achievements of Objective O_3: *To promote cooperative research.* Thanks to the increase of our capabilities during the first and second year of OPSA project we took part in existing CoMePhS

517039 (STREP project –FP6 Programme) and Nanocharm (Cooperation project within FP7 Programme) European projects. We also established good collaboration with several research institutions in the field of nanoscience and nanotechnologies.

Project Management: Significant progress has also been realized regarding the administrative part of the OPSA project. Necessary managerial and financial actions concerning the equipment ordering, custom clearance and theirs storage and installation at Institute of Physics in Belgrade have been completed in the first year of duration of the project. In the second year we promoted and targeted our project results towards industry, SME, education and research and development sector through a calendar for year 2007. In the third period of OPSA project we have organized the Symposium A: Raman scattering in material science within European material research society fall meeting (EMRS-2008), held in Warsaw, September 15-19th, Poland. A booklet about our potentials and strategy is also realized in this period.

Detailed workpackages progress of the OPSA follows in the next pages.

2. Workpackage progress during the whole duration of the OPSA project

We present below the deliverables and milestones list which were expected at the end of the OPSA project. Most of them are reports and, as explained below, have been accomplished.

Table 1: Deliverables list (total duration of the OPSA project)

Del. no.	Deliverable title	Delivery date	Workpack. no.
D1	Project progress intermediate reports (scientific and economic reports).	Month 12	WP0
D2	Final project report (scientific and economic reports).	Month 36	WP0
D3	Report on the project dissemination activities	Month 36	WP6
D4	Web site	Month 6	WP6
D5	Raman system with CCD detector	Month 24	WP1
D6	Micro-Raman set-up	Month 24	WP1
D7	Cryostat for confocal microscope	Month 24	WP1
D8	FT-spectrometer for near-IR and visible range and an IR microscope	Month 24	WP2
D9	A closed cycle optical cryostat for FTIR	Month 24	WP2
D10	μ- Raman and μ- photoluminescence spectroscopy characterization	Month 36	WP3, WP4
D11	FT-reflectivity characterization	Month 36	WP5
D12	Brochures	Month 36	WP6
D13	Network of centres of excellence	Month 36	WP7
D14	Manual instruction	Month 24	WP1, WP2

Deliverables D1 – D14 are all submitted.

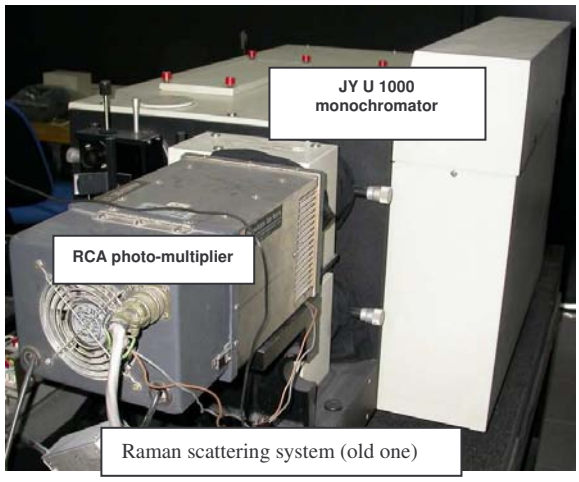
Table 2. Milestones (total duration of the OPSA project).

Mil. no.	Milestones	Work-package no.	Actual/Forecast delivery date
M1	Complete system for micro-Raman and micro - photoluminescence spectroscopy equipped with microscope and microscope cryostat for low temperature measurements.	WP1	Month 12/12
M2	FT - spectrometer for 30 cm^{-1}-25.000 cm^{-1} spectral range, equipped with an IR microscope and an appropriate cryostat for low temperature measurements.	WP2	Month 12/18
M3	Complete skillfulness for optical characterization of different nano-materials and structures at low temperatures.	WP3	Month 36/36
M4	Improving skills using the high pressure Raman and photoluminescence spectroscopies for the investigations of phase transitions in nano-sized materials.	WP4	Month 36/36
M5	More complete insight into vibrational properties, band gap nature as well as the nature of the surface bonds and reactions occurring at the nanoparticle surface.	WP5	Month 36/36
M6	Promotion of OPSA Center of Excellence raising its scientific level to the European ones expecting that OPSA will become the world-widely recognized and attractive for young scientists, academic and industry research.	WP6	Month 36/36
M7	OPSA should become a node within Centres of excellence of European research society.	WP7	Month 36/36

2.1. WP1: Upgrade of the Raman system with a multichanel detector, confocal microscope with a motorized x,y,z stage and a microscope cryostat.

2.1.1. WP1 Objectives and starting point of work at the beginning of the reporting period

The existing Raman scattering system, see right figure (the same set-up is using for PL spectroscopy measurements) is equipped with double grating U 1000 Jobin Yvon spectrometer, Ar, Kr, He-Cd, He-Ne, ion lasers, and classical RCA photomultiplier (PMT) as a detection system. The system contains a macro-Raman optical facility, and allows the measurements in the temperature range between 10 and 400 K by using an appropriate cryostat. This Raman system was set up in late eighties and amortized long ago.



Raman scattering system (old one)

Our Raman set-up did not have enough sensitivity

to study micro and nano-sized materials. Therefore, within this project, we proposed an upgrade of our system with: Digital Spectroscopy CCD System with Camera controller (Task WP1.1.); Confocal Raman Microscope with Motorized X-Y-Z Stage (Task WP1.2.) and Low temperature Cryostat for Microscope (Task WP1.3.).

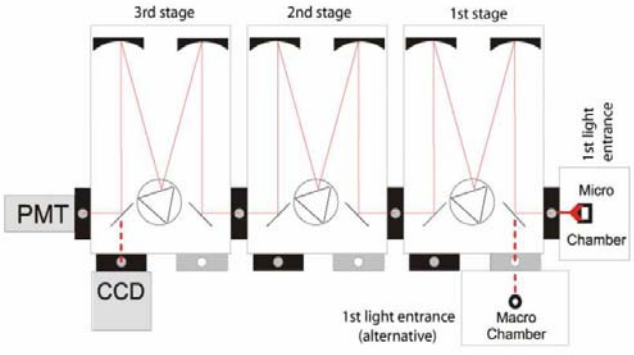
The photomultiplier as a detector was replaced by CCD camera in the modern Raman system about two decades ago. The use of CCD detector enables acquiring of Raman and PL signals in a very short time. Besides CCD detector, the modern Raman systems are supplied with confocal microscope and microscope cryostat for low temperature micro Raman and micro-PL measurements.

Simple replacement of photomultiplier (PMT) with CCD detector in existing U1000 Raman spectrometer was not possible without substantial modifications. Namely, a set of changes should be necessarily done, like changing of internal slits, removing exit slit, development of opto-mechanical coupling at the entrance slit for microscope set-up, etc. At the end, we will have double monochromator (M) with CCD (desired sensitivity level) and microscope, but with worse stray light rejection, the condition which is very important for Raman spectrometers. This problem is usually solved by adding one more stage (fore-monochromator - FM). Adding of FM would lead to additional reconstruction of our U1000 monochromator, which includes optical and mechanical coupling between M and FM, development of new software, etc. Finally, as a result of such improvement, we will alter the performances of existing system and realize new system, but its performances will be far from modern micro Raman spectroscopy set-ups.

2.1.2. WP1 Progress towards objectives – tasks worked on and achievements made with reference to planned objectives

Analysing the Raman scattering equipment market we decided to buy TriVista 557 triple stage system, equipped with CCD detector and confocal microscope (WP1; Tasks 1.1, and 1.2). The TriVista 557 (S&I GmbH) is a triple spectrograph which offers the highest spectral resolution and extreme stray light rejection required for the Raman and photoluminescence measurements in UV, VIS, and NIR spectral ranges. Its unique optical design (patent pending) allows an easy switching between additive and subtractive modes and it can be easily reconfigured to work as a double or a single spectrometer.

TriVista 557 system (S&I GmbH)



Triple Raman Spectrometer in additive or subtractive mode with Macro- or Micro-Chamber and PTM and CCD detectors.

TriVista consists of the Acton Research Corporation spectrometers. They are known for superb resolution, stray light rejection, excellent imaging and ruggedness. The TriVista can operate from 185 nm to 2.2µm. The spectral resolution can reach 4 picometers in the VIS spectral range (500 nm). The extreme stray light rejection allows Raman spectra to be measured as close as 5 wave numbers from the Rayleigh line.

The TriVista is the most flexible system for scientific use on the market. Nine gratings (three in each stage) with different numbers of grooves per mm (from 300 to 2400 grooves/mm) ensure the collecting of the Raman spectra in different ranges and with different resolutions just by applying software commands. The TriVista 557 model has 500 nm focal length in the first and the second stages and 750 mm in the third stage. It can be used in single, double and triple configurations. A single configuration means all three stages can be used simultaneously and independently for three different experiments to be run at once. Most often the TriVista is utilized as a double or triple system. In these cases, the light beam sequentially passes through 2 or 3 stages and the gratings of the involved stages coherently move together with very high precision. Two most common reasons for using a double or a triple system instead of a single spectrometer are a high spectral resolution and a high stray light rejection. These two effects can be achieved in different modes of the TriVista operation:

1. The Additive mode gives a high spectral resolution and high linear dispersion.
2. The Subtractive mode gives a high stray light rejection.

The TriVista software offers an easy way to switch between additive and subtractive modes just by mouse-clicking. The physical mechanism behind this switch is changing the direction of the grating rotation. In the additive mode both gratings in the first and the second stages synchronously rotate clockwise adding dispersion to each other. In the subtractive mode the grating in the first stage rotates clockwise but the grating in the second stage synchronously rotates counter- clockwise precisely cancelling dispersive action of the grating in the first stage.

As it can be seen from the figure above, in triple configuration the Double monochromator stage is used together with the last stage as a Triple system for Raman spectroscopy. However, it can be also used as an excitation stage for Fluorescence and Photoluminescence and the emission can be detected by the last stage of the system.

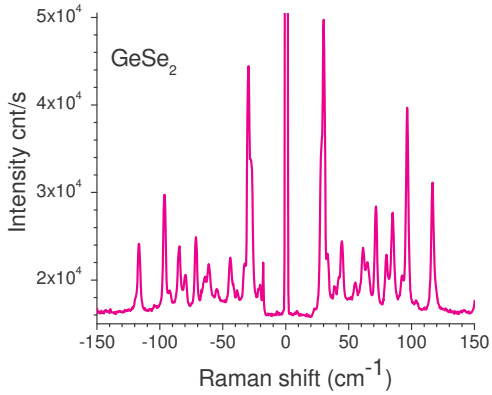
The S&I software was written to obtain an optimized access to all three stages of the TriVista. It is programmed in "Visual Basic" and runs in co-operation with the Princeton Instruments' WinSpec software package, which is designed to operate a multitude of CCD detector and allow access to exclusive detector functions. The S&I software controls spectrometer functions whereas the WinSpec is used as a DLL and provides data acquisition and setup functions for multi-channel detectors.

Spec-10: 256E CCD Detector

Quantum efficinecy of Spec-10: 256E

The TriVista spectrometer is equipped with the Princeton Instruments Spec-10: 256 detector, which is a fully integrated spectroscopic CCD system. A choice of industry standard, spectroscopic-format E2V sensors are offered. The Spec-10: 256E incorporates an open electrode sensor which offers a broadband response over a wide spectral region - from 200 to 1050 nm, as can be seen from the quantum efficiency curve, see above. The liquid nitrogen cooling of the CCD effectively eliminates dark noise, even for long exposures.

To simultaneously obtain Stokes and Anti-Stokes Raman spectra, the TriVista system is equipped by a laser mask, which can be installed on 1st, 2nd, or on both intermediate slits. The laser mask is a very thin metal bar positioned precisely in the middle of the slit which mechanically blocks the laser light. For more versatility, the laser stop mask has 4 options - three bars of different width (150, 300, -600 μm) and the open space to allow the Raman signal to pass unblocked through the intermediate slit. The laser stop mask is set on a sliding strip for changing between 4 options and a precise positioning.

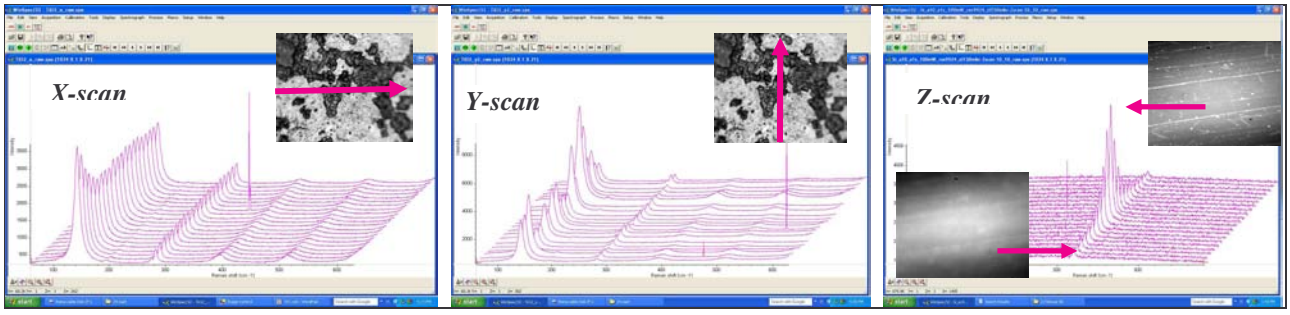


Stokes and Anti-Stokes Raman spectra of $GeSe_2$

Sliding Strip with Laser Stop Mask

The Micro-Raman assembly is based on the upright microscope BX51 from Olympus and the Confocal Micro-Raman Interface (CMRI) as an extension for the BX51 to allow for the Micro-Raman Spectroscopy. CMRI is designed to allow direct coupling and fibre coupling for transmission of a laser beam and a Raman signal. Polarisation dependent measurements are possible for both direct coupled and fibre coupled laser beams. The confocal Raman microscope has a spatial resolution on a micron scale.

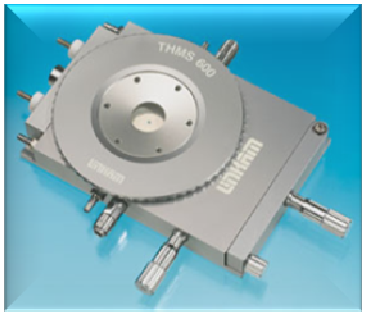
The TriVista system is equipped with a CCD detector, a confocal microscope, whereas the software-driven XYZ stage makes possible an automated 3D mapping with an auto focus option. For variable temperature measurements under microscope we have supplied Linkam THMSG600 heating/freezing stage which works in temperature range -196° to 600°C, up to 130°C/min heating and temperature stability <0.1°C.



X-scan and Y-scan: Raman spectra of the TiO_2 at various positions on the sample along x-and y-axes
Z-scan: Raman spectra of the Si thin film at various positions on the sample along z-axis;

The heating/cooling microscope stage (WP1; Task 1.3)
(LINKAM THMS600 - System description)

The THMS600 is one of the most popular heating and freezing stages used in many applications where high heating/freezing rates and 0.1°C accuracy and stability are needed. The LINKAM THMS600 heating/cooling stage is equipped with a CI94 temperature controller and a LNP94 Liquid Nitrogen Pump.



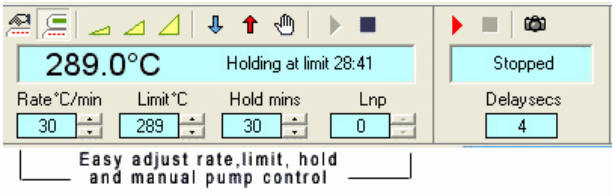
LINKAM THMS 600 heating/ cooling stage

CI94 temperature controller

LNP94 Liquid Nitrogen Pump

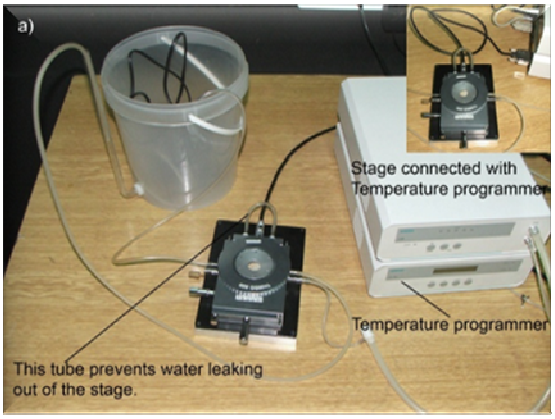
Technical data:

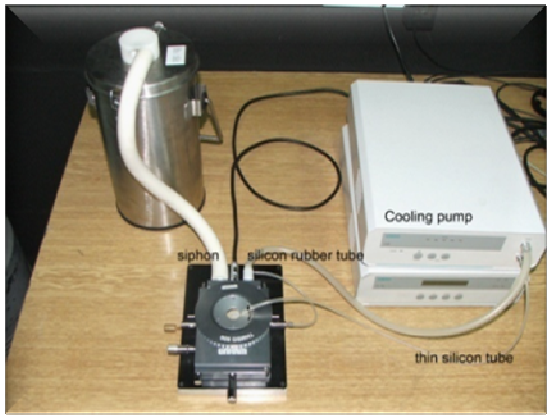
- Temperature range -196° to 600°C.
- Up to 130°C/min heating.
- Temperature stability <0.1°C.
- 16 mm X,Y sample manipulation.
- Sample area 22 mm diameter.
- 100 Ω platinum resistor sensor.
- Light aperture - 2.4mm Ø.
- Silver heating block for high thermal conductivity.
- Direct injection of the coolant into the silver block.
- Single ultra thin lid window - 0.17mm.
- Objective lens working distance - 0.1mm to 4.5mm.
- Water cooled stage body for high temperature work (>300°C).
- Sample side loading without removing the stage lid.
- Can be used with all microscope techniques
- Controlled heating rates of 0.01°C to 130°C/min.
- Controlled cooling rates of 0.01°C to 100°C/min
- Displays Temperature to 0.01°C
- Hold time 0 - 9999 mins.
- RS232 interface to allow programming by Linksys software.
- A cooling system consists of the 2 Litre dewar and a control unit housing the pump which can be controlled by selecting one of 5 manual pump speeds.
- Recycled dry nitrogen gas is used to purge the sample chamber and upper lid window surface of condensation.
- The precise control of liquid nitrogen flow allows for specific stages controlled cooling rates as fast as 130^{O}C/min or as slow as 0.1^{O}C/min.



The Linksys 32 software displays the live temperature, active ramp information and allows for the user to have full control of the rate of heating, limit and hold time

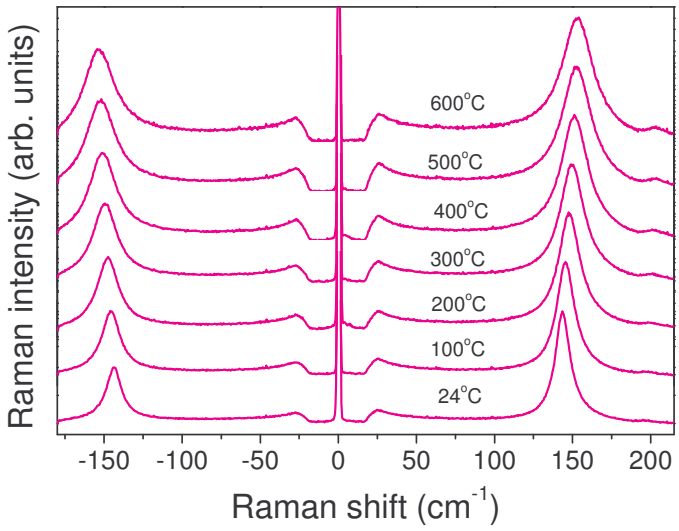
Heating / Cooling Procedure





Heating Procedure
The container with a pump inside should be approximately 2/3 filled with water. The heating is provided using Linksys32 software.

Cooling Procedure
The container should be 2/3 filled with liquid nitrogen. The lid must be placed so that the thin capillary tube is pointing upward. The thin silicon tube carries exhaust nitrogen gas and is used to prevent the blurring of the top of the window on the stage lid.



Stokes and anti-Stokes Raman spectra of TiO_2 measured with TriVista 557 spectrometer using Linkam stage in the 24 – 600 °C temperature range.

For helium temperature micro Raman measurements (the temperature range from 4 to 300 K) we have obtained the ***Cryovac Konti cooling cryostat.*** (WP1, Task 1.3).

Installation (WP1, Task 1.4), testing (WP1, Task 1.5) and writing of manual instruction (WP1, Task 1.6), were realized in the second year of duration of the OPSA project. In appendix A we have shown manual instruction for use of TriVista 557 spectrometer system.

Last activity within WP1 is Task 1.7, Training. We have organized training courses for our students and others young researcers in use of Raman and Photoluminescence methods for characterization of nanomaterials. Programme of the training course is as follows.

Programme of the training course for μ - Raman and μ - PL measurements at TriVista spectrometer system

This course, aimed at postgraduate and PhD students from academic institutions, as well as the researchers from laboratories for physics and material science, provides training for μ - Raman and μ - PL measurements at TriVista spectrometer system. It is forseen to last five working days.

<table>
<tr><td>Day one</td><td>During the training course the attendants will be introduced into the main parts, configurations and research potential of the TriVista 557 spectrometer system.

The course starts with training in the S&I software, which controls spectrometer functions, and WinSpec software, which is used as a DLL and provides data acquisition and setup functions for multi-channel detectors. Apart from these two software packages, a brief overview of three more programs are also included in this course: QED software for running and control of the optical camera, Stage Control software for the control of XYZ motorized Stage, and Linkam software for the control of heating and cooling in Linkam microchamber.
The following topics[1] will be covered during the first day of training:
A. Software Settings
• Starting S&I software
• General hardware settings of the TriVista 557 system
• Generating different configurations of the TriVista 557 spectrometer
- Setting the main properties of TriVista configurations (mode, method for detection – CCD or PMT, and choice of the gratings)
- Stage settings (gratings and order)
- Slits
- Offsets
B. Measurements
• Starting measurements
- Running WinSpec software
- Cooling the detector
- Running mixed Ar^+/Kr^+ laser (turning the laser cooling, feeding and laser beam on; choice of laser line wavelength; turning the laser off)
- Adjusting the sample position (microscope, XYZ microscope stage)
- Focusing of laser beam on a sample</td></tr>
<tr><td>Day two</td><td>During the second day of training, the attendants will be educated for autonomous measurements of the Raman spectra of reference samples (crystal Si and $GeSe_2$) at room temperature. The following topics will be covered:
• Data Acquisition
- Global settings and commands
- Data format and illustration
- CCD detector and WinSpec
- Measurement parameters in WinSpec
- Conversion of the collected spectra to ASCII format</td></tr>
<tr><td>Day three</td><td>During the third day of training, the attendants will be instructed how to use some additional features of TriVista system. The following topics will be covered:
• Collecting Raman and PL spectra in wider range – Step&Glue mod
• Running the Stage Control software for the control of XYZ motorized</td></tr>
</table>

[1] For more information about particular topics, review to TriVista System Manuel, WinSpec Manual, as well as the Manual written in our Center, within the OPSA Project, see www.solid.phy.bg.ac.rs/OPSA

	stage - Use of x, y and z scan function - Autofocusing • Simultaneous measurements of Stokes and anti-Stokes Raman signal • Measurements of low frequency Raman spectra
Day four	The fourth day of training will be dedicated to variable temperature Raman measurements. The attendants will be teached how to use the Linkam THMS600 heating/freezing stage. The following topics will be covered: • Use of main parts of Linkam heating/freezing system - Mounting Linkam microchamber at XYZ stage - CI94 temperature controller - LNP94 liquid nitrogen pump • Running the Linkam software for the control of heating and cooling in Linkam microchamber • Heating procedure • Cooling procedure • Raman measurements at different temperatures
Day five	The measurements during the first four days of the training course are performed using adjusted spectrometer. However, the last day of the course will be dedicated to readjustment of the TriVista spectrometer, which is necessary after replacement one laser by another, or any change of the laser beam path outside the system. The following topics will be covered: • Optical path adjustment - Alignment of the laser beam path outside the TriVista system - Alignment of the beam path inside the Confocal Micro-Raman Interface - Adjustment of the beam path at the entrance of the first stage of TriVista spectrometer • Matching the stages in TriVista spectrometer - Access to general "Offset Table" in "Monochromator Settings" - Stage settings within the "System Settings " window - Matching - through "Advanced Slit Commands "

This training course has been organized twice for young PhD students from the Center for Solid State Physics and New Materials. We are planning to organize such courses at least twice a year for PhD students and scientists from the other scientific institutions from Serbia and abroad. Report from the first training course is given in appendix B.

WP1. Summary. By instalment of TriVista 557 Raman spectroscopy system equipped with CCD detector (Task WP1.1), confocal microscope (Task WP1.2) and heating/freezing stage (Task WP1.3), which took place in June 2007, we fulfilled Tasks of the WP1 foreseen for the first year of OPSA project (milestone M1 - *Complete system for micro-Raman and micro-photoluminescence spectroscopy equipped with microscope and microscope cryostat for low temperature measurements*). Within the WP1 of the OPSA project in the second year we tested all parts of new Raman spectrometer as well as the complete system. (Task WP 1.5). We also prepared detailed instructions for use of whole system (Task WP.1.6). In such a way we realized deliverables D5, D6 and D7, foreseen for 24th month of duration of the OPSA project. In the third year of the OPSA project we organized training courses (Task WP 1.7) for our students. The manual instruction (D14) for use of TriVista Raman system and training report for use of the same system are given in appendixes A and B, respectively.

WP2. Fourier transform (FT) spectroscopy in the near-infrared and visible range at low temperatures.

2.2.1 WP2 objectives and starting point of work at the beginning of the reporting period

Our Fourier Transform Infrared (FTIR) spectroscopy system (Bomem DA8) enables the reflectance and transmittance measurements of solid samples in a spectral range from 30 to 5000 cm^{-1}. It was necessary to upgrade this system providing adequate light sources, beam-splitters and detectors for near IR and visible region. Beside these improvements, in order to perform measurements at liquid helium temperature it was necessary to purchase a low-vibration closed cycle cryostat since there is no helium liquefier in Serbia. For reflectivity measurements of micro sized sample we proposed obtaining of an infrared microscope.

2.2.2 WP2 progress towards objectives – tasks worked on and achievements made with reference to planned objectives.

Bomem DA8 is a research grade Fourier-transform spectrometer for the range 4 to 50 000 cm^{-1}. The term 'research grade' refers to an instrument operating under the vacuum, having high resolution, high scanning stability and an access to several input-output ports for different experiments. It has a vertical conventional Michelson interferometer with a patented dynamical alignment system keeping the exact alignment of the mirrors during each scan. The average angular deviations from an optimal alignment is less than 10^{-6} radians in normal laboratory environments and about 10^{-5} radians under severe vibration conditions. Special advantage of the instrument is a unique far infrared hypersplitter that covers a broad spectral range from 40 to 700 cm^{-1}.

Bomem DA8 spectrometer with its accessories

The configuration of the instrument is given in Figure above. It consists of three sections: the upper one containing the source and beamsplitter compartment, the middle section with the beam switching compartment, the sample compartment and the detector modules, and the lower part containing the vacuum leads, the power supplies and the data processing and control electronics. Depending of the moving mirror travel, the resolution ranges from 0.06 to 0.0026 cm^{-1}. The instrument has two focused output beams in a sample compartment and three parallel output beams.

Upgrade of existing BOMEM DA8 Fourier Transform Infrared (FTIR) spectroscopy system with adequate light sources, beam-splitters and detectors for near IR and visible region was main objective of WP2 for the first year of the OPSA Project. We have obtained (Task, 2.1 and 2.2, 2.4):

1. **Silicon photo-diode detector (IPH56) for the optical range 8500-50000 cm^{-1} (300K).**
2. **InSb detector (IPH50) for the optical range 1800-8500 cm^{-1} (77K).**
3. **Quartz beamsplitter (IMB21) coated with TiO_2 for the range 4000-25000 cm^{-1}.**
4. **DA8 internal PC frame (IMK35)**
5. **Bomem GRAMS/AI 7.0**
6. **IR-Plan advance analytical microscope dedicated to DA8 spectrometer**

All above mentioned components are mounted and tested, as foreseen for the second year of duration of OPSA project (Task WP 2.5 and WP2.6). We also prepared manuals for use of IR microscope and whole system (Task WP2.7).

Due to problems with LHe in Belgrade, we ordered the low-vibration closed-cycle ARS DMX 20 cryostat. Although DA8 can withstand some level of vibrations due to its sophisticated dynamical alignment system mentioned before, the standard closed cycle systems far from being adequate for DA8 spectrometer. Therefore we decided to buy one of low-vibration closed cycle cryostats that appeared recently on the market. Closed cycle cryostat **CS204SE-X20(OM)**) model from Advanced Research Systems, consists from Displex Cryocooler - CS-204SE, and Low vibration Interface, Model DMX-20; helium compressor ARS-4HW; VPS vacuum system. This configuration is suitable for many vibration sensitive applications (vibration levels of 3 to 5 nanometers at sample).

BOMEM DA8 with new InSb and Si detectors as well as Spectra-tech IR-PLAN advanced analytical microscope

The new Quartz beamsplitter for the range 4000 - 25000 cm^{-1}

During the third year of the OPSA project we organized training courses in infrared spectroscopy and characterization of nanocrystalline materials. Different dielectric function models like three and four parameter model, Kramers-Kronig analysis and effective medium theories were used to

interpret the infrared spectra of nanostructured materials. The courses were organized for PhD students and potential industry users.

Syllabus for the course in Infrared spectroscopy and characterization

The course of Infrared spectroscopy (IR) is dedicated to the PhD students, young researchers and potential industry partners as an introduction in using infrared spectroscopy for characterizing, identifying or determining a substance. The students (attendants) will be instructed about design of spectrometers, about the sample preparation, diverse methods of measurements, modelling and interpretation of the spectra. The course was dedicated presumably to the application of IR spectroscopy to nanostructured systems.

Lecture 1	**Introduction to the spectroscopy, classification of methods and common types of spectroscopy** Lecture covers: Brief introduction to the spectroscopy, definition of the most common types of spectroscopy and measurement processes.
Lecture 2	**Background and theory of infrared spectroscopy** Lecture covers: The definition of the infrared spectroscopy, basic theory, types of infrared measurements (transmission and reflectance). Introduction to the Fourier transform infrared spectroscopy.
Lecture 3	**Infrared instrumentation** Lecture covers: basic components of spectrometer, radiation sources, infrared detectors, dispersive spectrometers and diffraction gratings. Basic principles of Michelson interferometer and its advantages over dispersive ones.
Lecture 4	**Fourier transform infrared spectroscopy** Lecture covers: Important structural parts of FT spectrometers. Introducing with BOMEM DA-8 instrument, its capabilities and introducing with PCDA program for collecting the IR spectra.
Lecture 5	**Dielectric properties: classical treatment** Lecture covers: Definition of reflectivity, transmission , absorption and optical constants. Beer's law. Examples of the reflectivity and transmission spectra. Evaluation of dielectric constant from Kramers-Kronig analysis.
Lecture 6	**Determination of ε (ω) from experimental data** Lecture covers: Modelling of the observed reflectivity (three and four parameter models). Lyddane-Sachs-Teller relation. Analyzing of the reflection spectra using KK analysis and four parameter model.
Lecture 7	**Standard accessories for transmission and reflection sample techniques** Lecture covers: types of the cells, holders for solid samples (pellets, films), microcells with condensers for a very small amount of sample, reflection methods, measurement of external reflection, attenuated and diffuse reflectance
Lecture 8	**Reflection sample technique** Lecture covers: Preparation of the samples for reflection measurements, reflection measurements at room and low temperature in FAR, MID and NIR-IR region.
Lecture 9	**Transmission sample technique** Lecture covers: Transmission measurements at room and low temperature in FAR, MID and NIR-IR region.
Lecture 10	**Infrared characterization and introduction to infrared spectroscopy of nanostructured systems** Lecture covers: band gap absorption, relaxation effects to the dielectric function, coupled LO phonon-plasmon modes interactions, use of effective-medium theories of dielectric functions; Bruggeman and Maxwell-Garnet

	theory. Examples for TiO_2, CeO_2, SiC and Si/C/N nanostructured materials.
Lecture 11	Introduction to the main parts of IR microscope. Adjustment of the optical path in transmission and reflection operating mode. Performing transmission and reflection measurements in MID region.

WP2. Summary. After upgrade of existing BOMEM DA8 Fourier Transform Infrared (FTIR) spectroscopy system with adequate light sources, beam-splitters and detectors for near IR and visible region we are able to measure the reflectance and transmittance of solid samples in a spectral range from 30 to 25000 cm^{-1} (Task WP2.1 and WP2.2). Beside these improvements, in order to perform measurements at liquid helium temperature we obtained a low-vibration closed cycle cryostat (model **CS204SE-X20(OM)** from Advanced Research Systems, Inc, Task WP2.3). Finally, in order to carry out measurements on the micro sized (about 10 microns) materials we obtained IR-Plan microscope (Task WP2.4). All above mentioned components are mounted and tested, as foreseen for the second year of duration of OPSA project (Task WP 2.5 and WP2.6; *Milestone M2: FT - spectrometer for 30 cm^{-1}-25.000 cm^{-1} spectral range, equipped with an IR microscope and an appropriate cryostat for low temperature measurements*). We also prepared manuals for use of IR microscope and whole system (Task WP2.7). During the third year of the OPSA project we organized training courses (Task WP2.8) in infrared spectroscopy and characterization of nanocrystalline materials.
In appendix C we present manual instruction for use of Bomem DA8 FTIR spectrometer and IR-Plan microscope (D14).The training report for use of the BOMEM system is given in appendix B.

WP3. Training in the μ-Raman and μ-PL spectroscopy at low temperatures and high magnetic fields.

We were planning training of some of our co-workers in the field of μ-Raman and μ-PL spectroscopy at low temperatures and high magnetic fields at the Institute of Materials Science of the University of Valencia, because at the University of Valencia there is a similar system for Raman and photoluminescence spectroscopy, as we now have in Belgrade. Particularly, interested for us, at this moment, were the measurements of Raman and photoluminescence spectra at different temperatures using Linkam TS1500 heating microscope stage, which was at disposal at the University of Valencia. One of our co-worker (Z. V. Popovic) spent several weeks in measuring Raman scattering spectra of La and Nd doped TiO_2 and CeO_2 samples in the temperature range 23-900 ^oC using microscope Linkam TS1500 heating stage. At the Institute of materials science, the University of Valencia and at Catholic University of Leuven, Belgium, Laboratory for Solid State Physics and Magnetism we performed Raman and magnetic measurements in high magnetic fields up to 14T of pure cerium dioxide nanopowders and doped with Fe^{2+}(Fe^{3+}) ions. Results of this activity were presented in several scientific papers and conferences and in appendix D.

WP4. Training in high-pressure μ-Raman and μ-PL spectroscopy research

The training in high-pressure μ-Raman spectroscopy took place within a team of researchers from Department of Physics National Technical University of Athens (NTUA), Greece, with whom we have already established a fruitful and long-term cooperation in this field. Z. Dohcevic – Mitrovic spent almost two months in training at NTUA how to perform high pressure Raman scattering spectra using Diamond Anvil Cell. During this period she was introduced with main instrumental and optical parts of the Raman scattering set-up, necessary to perform high pressure measurements and how to prepare the sample for this type of measurements. The high pressure Raman scattering measurements were performed on undoped TiO_2 nanopowders with an average particle size of 7 nm obtained from XRD results. Measuring of the μ-Raman spectra of anatase TiO_2 nanocrystalline

sample at high pressures were performed at Jobin-Yvon T64000 triple spectrometer equipped with a liquid nitrogen cooled CCD and a microscope (magnification 40x) was used for detection. High pressure measurements were achieved with a Merrill–Basset type diamond anvil cell (DAC) fitted under the microscope allowing micro-Raman study in a back scattering geometry. The pressure transmitting medium was a mixture of methanol–ethanol (4:1). Results of this activity was presented in appendix D.

WP5. Training courses in optical characterization of nano-sized structures and materials

Training of our co-workers in the field of optical characterization of nano-sized structures and materials is foreseen in many of European leading institutes and faculties. During the third year of OPSA project we realized strong collaboration with several Italian Universities as University of Bari, University of L'Aquilla and ENEA,Centro Ricerche Cassacia (Roma), where M. Scepanovic was realizing measurements and training in use of spectroscopic techniques such as x-ray photoelectron spectroscopy for nano-sized materials characterization. Training courses in FTIR spectroscopy were performed in the Institute of Physics, Belgrade. Results of this activity were presented at conferences and in appendix E.

WP6. Dissemination of results

Dissemination plan (appendix F) for the OPSA project included:

1. The OPSA web site - http://www.solid.phy.bg.as.rs/opsa
2. A vignette (graphic identity) of the OPSA Project
3. A brochure of the OPSA Project.
4. Publication of papers in scientific journals,
5. Organisation of seminars, (workshops, symposia) for researchers, PhD students and industry representatives.

1. Nowadays, the **worldwide web** is the most effective mechanisms for disseminating materials. For the OPSA project we have made a web site, just at the beginning of duration of the project, which purpose was to present the goals and resources of the Centre for Solid State Physics and New Materials of Institute of Physics as the Centre of Excellence for Optical Spectroscopy Applications in Physics, Material Science and Environmental Protection. The web site is located at web site of our centre, but it is made as a completely independent web site. It is easily accessible at http://www.solid.phy.bg.ac.rs/opsa.

Besides our technical, human and knowledge potentials, the OPSA project Web site includes:

- information about OPSA and its activities including contact details, background information, working papers, events (seminars, workshops, conferences) etc.
- manual instructions of experimental set-ups (the web in this respect acts as a principal mean of publication);
- frequent news and updates to keep the community informed

We have developed a publications programme (image identity, booklet, scientific publications, and calendar) in order to raise awareness about OPSA and its activities and potentials:

2) **Image identity of OPSA Project** is based on dispersion of light through optical prism, from one side and geographical position of Belgrade, which is situated at the point where river Sava flows

into the Danube (see Header), from the other side. A typical logo is designed to cause immediate recognition by the viewer. We believe that OPSA logo fulfills its purpose.

3a) **Booklet about OPSA** (enclosed, appendix G). The OPSA project booklet shortly presents our mission and strategy, current projects, as well as, our resources, abilities and potentials.
3b) **OPSA calendar.** The OPSA calendar for year 2008 was realized. It represented our abilities and some of our results obtained with experimental set-ups, which are on our disposal. The calendar was distributed to about 1000 industry, SME, research, education and development organizations addresses around the world (see appendix K).

4) Papers published in scientific journals.

OPSA encourages its researchers to publish actively in distinguished international journals and to present papers at international meetings. Copies of these publications are given in appendix H.

Papers published in scientific journals within the OPSA project:

1. Z. V. Popović, Z. Dohčević-Mitrović, M. J. Konstantinović, M. Šćepanović
Raman scattering characterization of nano-powders and nano-wires (rods)
Journal of Raman Spectroscopy **38**, 750 (2007).

2. Z.V. Popović, A. Milutinović, N. Romčević
Spin-assisted photoluminescence of polycrystalline α-MnSe
J. Luminescence 128 (2008) 142-146.

3. Z. V. Popović, Z. Dohčević-Mitrović, A. Cros and A. Cantarero
Raman scattering study of the anharmonic effects in CeO_2 nanocrystals
Journal of Physics: Condensed Mater19 (2007) 496209 (9pp)

4. R. Kostić, S. Aškrabić, Z. Dohčević-Mitrović, Z.V. Popović
Low-frequency Raman Scattering from CeO_2 Nanoparticles
Applied Physics A90, 679-83 (2008).

5. Z. Dohčević-Mitrović, M. Radović, M. Šćepanović, M. Grujić-Brojčin, Z. V. Popović, B. Matović and S. Bošković
Temperature-dependent Raman study of $Ce_{0.75}Nd_{0.25}O_{2-\delta}$ nanocrystals
Applied Physics Letters 91 203118 (2007).

6. M. Radović, Z. Dohčević-Mitrović, M. Šćepanović, M. Grujić-Brojčin, B. Matović, S. Bošković, Z. V. Popović,
Raman study of Ba-doped ceria nanopowders
Science of Sintering 39 (2007) 281-286.

7. M. Šćepanović, M. Grujić-Brojčin, Z. Dohčević-Mitrović, K. Vojisavljevic, T Sreckovic, Z. V. Popović
The effects of Nonstoichiometry on optical properties of oxide nanopowders
Acta Physica Polonica A, 112 (2007) 1013.

8. S. Aškrabić, R. Kostić, Z. Dohčević-Mitrović, Z.V. Popović
Raman scattering from low-frequency phonons confined in CeO_2 nanoparticles
Journal of Physics: Conference Series 92 (2007) 012042.

9. Z. Dohčević-Mitrović, Z.V. Popović and M. Šćepanović
Anharmonicity Effects in Nanocrystals Studied by Raman Scattering Spectroscopy
Acta Physica Polonica **A116** (2009) 36

10. M. Grujić-Brojčin, M.J. Šćepanović, Z.D. Dohcević-Mitrović and Z.V. Popović
Use of Phonon Confinement Model in Simulation of Raman Spectra of Nanostructured Materials
Acta Physica Polonica **A116** (2009) 51

11. R. Kostić
Raman Scattering from Acoustic Phonons Confined in Spherical Nanoparticles
Acta Physica Polonica **A116** (2009) 62

12. M. Radović, Z. Dohčević-Mitrović, N. Paunović, M. Šćepanović, B. Matović and Z.V. Popović
Effect of Fe^{2+} (Fe^{3+}) Doping on Structural Properties of CeO_2 Nanocrystals
Acta Physica Polonica **A116** (2009) 84

13. M. Šćepanović, S. Aškrabić, M. Grujić-Brojčin, A. Golubović, Z. Dohčević-Mitrović, A. Kremenović and Z.V. Popović
Low Frequency Raman Spectroscopy of Pure and La Doped TiO_2 Nanopowders Synthesized by Sol Gel Method
Acta Physica Polonica **A116** (2009)99

14. S. Askrabic, Z. D. Dohcevic-Mitrovic, M. Radovic, M. Scepanovic, Z. V. Popovic,
Phonon-phonon interactions in $Ce_{0.85}Gd_{0.15}O_{2-\delta}$ nanocrystals studied by Raman spectroscopy
JOURNAL OF RAMAN SPECTROSCOPY **40** (2009): 650-655

15. M. J. Ščepanovic, M. Grujic-Brojcin, Z. D. Dohcevic-Mitrovic and Z. V. Popovic
Characterization of Anatase TiO2 Nanopowder by Variable-Temperature Raman Spectroscopy
Science of Sintering, 41 (2009) 67-73

16. A. Golubovic, M. Ščepanovic, A. Kremenevic, S. Aškrabic, V. Berec, Z. Dohcevic-Mitrovic, and Z. V. Popovic
Raman study of the variation in anatase structure of TiO2 nanopowders due to changes of sol-gel synthesis conditions
J. Sol-Gel Sci Technol 49 (2009) 311-319

17. M. Šćepanović, S. Aškrabić, V. Berec, A. Golubović, Z. Dohcević-Mitrović, A. Kremenović and Z.V. Popović
Characterization of La-Doped TiO_2 Nanopowders by Raman Spectroscopy
Acta Physica Polonica A 115 (2009) 771.

Papers presented at scientific conferences:

1. B.Matovic, S.Boskovic, J. Dukic, Z.Dohcevic-Mitrovic, M. Radovic, Z. V. Popovic
Raman Study of Ba-doped Ceria Nanopowders
Proc. 10th EcerS Conf.Goller Verlag, Baden-Baden,2007,p1557-59

2. M. Radović, Z. D. Dohčević-Mitrović, M. Šćepanović, M. Grujić-Brojčin, B. Matović, S. Bošković and Z. V. Popović:
Raman study of Ba-doped ceria nanopowders
Physics and Technology of Materials – FITEM07, Session 1, August 2007, Čačak, Serbia

3. Z. D. Dohčević-Mitrović, Z. V. Popović, M. J. Šćepanović, M. U. Grujić-Brojčin, S. B. Bošković, B. M. Matović, and M. Radović:
Raman study of anharmonicity and phase separation in $Ce_{0.85}Gd_{0.15}O_{2-y}$ nanopowder
International Conference on Structural Analysis of Advanced Materials – ISCAM 2007, Book of abstracts 103, September 2007, Patras, Greece

4. S. Aškrabić, Z. Dohčević-Mitrović, M. Radović, M. Šćepanović, M. Grujić-Brojčin, B. Matović and Z. V. Popović:
Raman study of oxygen vacancy behaviour in ceria nanopowders doped with Nd, Y and Gd
1st International conference from Nanoparticles & Nanomaterials to Nanodevices & Nanosystems – IC4N, Book of abstracts 83, June 2008, Halkidiki, Greece.

5. Z. Dohčević-Mitrović, N. Lazarević, S. Aškrabić, M. Mirić, M. Radović, M. Šćepanović, Z. V. Popović:
Raman and spectroscopic ellipsometry study of defect states in $Ce_{0.85}Gd_{0.15}(Y)O_{2-\delta}$ nanocrystals
Proc. Nanotec 2009.it, March 2009, Rome, Italy.p.114-115

6. N. Paunovic, M. Radovic, Z. Dohčević-Mitrović, B. Matović, and Z. V. Popović:

Room temperature feromagnetism in pure and Fe2+(Fe3+) doped nanocristalline CeO2,
Proc. Int. Conf. on material science and engineering (BRAMAT), p.KN6.02, Brasov, Romania, 2009.

7. M. Šćepanović, V. Berec, S. Aškrabić, A. Golubović, Z. Dohčević-Mitrović, A. Kremenović and Z. V. Popović
Raman spectroscopy of anatase TiO_2 nanopowders doped with varioius contents of La^{3+}
15th Central European Workshop on Quantum Optics CEWQO 2008, June 2008, Belgrade, Serbia, Book of abstracts, p. 90.

8. S. Aškrabić, M. Šćepanović, A. Golubović, Z. Dohčević-Mitrović and Z. V. Popović
Photoluminescence properties of titanium dioxide nanopowders synthesized by sol-gel technology
XIII International Symposium on Luminescence Spectrometry, September 2008, Bologna, Italy, Final program and abstracts book, PO087.

9. M. J. Šćepanović, M.U Grujić'Brojčin, Z. D. Dohčević-Mitrović, S. Aškrabić, R. Kostić and Z. V. Popović
Raman spectroscopz method for determination of particle siye distribution in anatase TiO_2 nanopowders
YUCOMAT (2007), book of abstracts 54, 10-14 September, Herceg Novi, Montenegro

10. Zoran. V. Popovic, Zorana Dohčević-Mitrović
Raman study of ceria based nanomaterials for solid oxide fuel cells
EuroNanoForum 2007 Nanotechnology in Industrial Applications European and International Forum on Nanotechnology Düsseldorf (Germany), book of abstracts 347, 19-21 June 2007

11. Z. D. Dohčević-Mitrović, Z.V. Popović, M.J. Šćepanović, M.U. Grujić-Brojčin, S.B. Bošković, B. M. Matović and M. Radović
Raman study of anharmonicity and phase separation in $Ce_{0.85}Gd_{0.15}O_{2-\delta}$
ICSAM-2007, International conferece on structural analysis of advanced materials, Book of abstracts, 103, Patras 2007, Greece.

12. Z. V. Popović, Z. D. Dohčević-Mitrović and M. J .Šćepanović
Anharmonicity effects in nanocrystals studied by Raman scattering spectroscopy
Invited lecture, Condensed Matter Physics Conference of Balkan Countries, CMPC-BC 2008, book of abstracts 13, 26-28 May, 2008, Mugla, Turkey

Theses realized within the OPSA project:

1. Marko Radovic "Structural and vibrational properties of $Ce_{1-x}A_xO_{2-y}$ (A=Nd, Gd, Ba) nanocrystals"
M.Sc. thesis, Faculty of Physics, Univeristy of Belgrade, Serbia, 2008

2. Mirjana Grujic-Brojcin: "Optical spectroscopy of oxide nanopowders"
PhD thesis, Faculty of Electrical Engineering, University of Belgrade, Serbia, 2008

5. International conference, workshops, seminars were organised by the OPSA project to raise awareness about OPSA activities, resources, etc. Most important for us was the organization of Symposium A: **Raman scattering in material science**, within EMRS-2008 Fall Meeting, which was in Warsaw on September 15-19th, 2008, see appendix I. The OPSA project coordinator (Prof. Dr Zoran V. Popovic) was chairman of the Symposium, and Dr Zorana Dohcevic-Mitrovic, scientific secretary. OPSA project was one of sponsors. This Symposium summarized actual knowledge in the field of Raman spectroscopy in material science and was the best way to show our abilities as a Centre of Excellence, as well as, obtained results in nano-material characterization.

Summary WP6. We have realized all proposed dissemination plan objectives. Booklet about the OPSA Center of excellence contains 48 pages. We have published 17 papers in scientific journals

and 12 papers were presented at scientific conferences as the results of the OPSA project. It is worth mentioning the organization of the Symposium A: Raman scattering in material science, within EMRS-2008 Fall Meeting, which was held in Warsaw on September 15-19th , 2008. The project coordinator (Prof. Dr Zoran V. Popovic) was chairman of the Symposium, and Dr Zorana Dohcevic-Mitrovic, scientific secretary. OPSA project was one of sponsors, see www.e-mrs.org/meetings/fall2008/A.html. This Symposium summarised actual knowledge in the field of Raman spectroscopy in material science and was the best way to show our possibilities as a European Centre of Excellence, as well as obtained results in nano-material characterization.

WP7. Networking

The networking of OPSA programmes with research institutions and universities run according to the expected plan in order to bring together researchers and research projects with a similar interest. Up to now this activity resulted in two additional European community scientific projects (STREP **CoMePhS** project within FP6 programme and **Nanocharm** project within FP7 programme) and the presence in **COST P16** Programme. The third European **NIM_NIL** project No. 228637 within FP7 programme is under negotiations.

Our activity in the field of networking was specially emphasized and fruitful during the third year of OPSA project. We took part in several networking events like **EUROPOLES, European Networking Event, Paris, June 2nd 2009,** where we had a presentation titled: **Multifunctional nanostructured oxidic films and nanopowders based on high k dielectric pure and doped CeO_2** (see appendix J). After this event we made contacts with several research institutions and potential industrial partners from Germany and Spain:

1. **IDM**, **Institute for Thin Film and Microsensoric Technology**, Teltow, Berlin, Germany (www.idm-teltow.eu)
2. **IHP – Innovations for High Performance Microelectronics** (www.ihp-microelectronics.com), Leibniz, Germany
3. Dr Laura Martinez, from **ADEuropa Foundation** (Spain),

in the field of materials for micro and nano-electronics putting emphasis on the research of new class of high-k dielectrics for future applications in MIM capacitors, memories and transistors as well as for epitaxy mediation for high quality epitaxial semiconductor layers (silicon-insulator-silicon stacks).
We also made a contact with Dr Lang Thilo from the Brandenburg Economic Development Board, i.e. agency which maintains a very good contact to innovative companies and research providers in a number of high tech sectors in the Capital Region of Germany.

Another networking event, where Prof. Zoran V. Popovic and Dr Zorana Dohcevic-Mitrovic took part, was **ICPC-NanoNet workshop** held in Prague on June 1st 2009. The ICPCNanoNet is a project funded by the European Commission under the 7th Framework Programme and aims to provide wider access to published Nanoscience and Nanotechnology research and opportunities for

collaboration between organisations and scientists in the EU and International Cooperation Partner Countries (ICPC). At the site **www.icpc-nanonet.org**, our Center for Solid State Physics and new Materials, Institute of Physics, is completely recognizable as one of the leading research institutions in Balkan region-Serbia in a field of nanoscience and nanomaterials (see parts of their site).

Meanwhile, Prof. Zoran V. Popovic became a member of the Programme committee "NMP" within FP7 Programme, as well as a member of the High Level Group of EU Member States and FP7 Associated States on Nanoscience and Nanotechnologies, and Dr Zorana Dohcevic-Mitrovic became a national contact point (NCP) in the Ministry of science and technological development in the field of Nanosciences, Nanotechnologies, Materials and new Production Technologies (NMP).
Dr Zorana Dohcevic-Mitrovic made as well, a very good collaboration with Dr. Marine Melkonyan from A.V. Shubnikov Institute of Crystallography of RAS, Moscow, Russia, who is NCP for NMP in Russia and this collaboration will enable our group to take part in the Russian programmes aimed to nanoscience and nanotechnologies.

During 2009 we established good collaboration with several research institutions in the field of potential materials for solid oxide fuel cells (SOFCs).
The list of our new partners is:

1. Dr. Alessandra Sanson
Materials and Processing for Energy Applications Group
Institute of Science and Technology for Ceramics (ISTEC)-CNR, Faenza, Italy

2. Dr Stefano di Stasio
University of Naples, Italy

3. Dr Daniel Zanetti, CECS, Brasil

Through the general agreement between Serbian Academy of Science and Art (SASA) and Romanian Academy of Science (RAS) during a three years period (2008-2011), a project **"Ionic conductor with perovskite structure in the Sr, Mg- doped $LaGaO_3$ system for SOFC-intermediate temperature"** will be realized between Center for Solid State Physics and new Materials, Institute of Physics Belgrade, Serbia and Institute of Physical Chemistry of Romanian Academy**.**

Thanks to the OPSA project and having all above in mind, we believe that our Center is becoming a node in Networking of centres of excellence for nanoscience and nanotechnologies in Europe.