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Proposal for a new COST Action

COST 539

“ELENA”
"Electroceramics from Nanopowders Produced by Innovative Methods"

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DRAFT

Memorandum of Understanding

For the implementtion if a European Concerted Research Action
designed as

COST 539

"ELENA"

" Electroceramics from Nanopowders Produced by Innovative Methods"

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the Technical Annex to the Memorandum of Understanding, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/94 "Rules and Procedures for Implementing COST Actions", the contents of which are fully aware of.

2. The main Objective of COST Action is to improve the physical and electronic properties of advanced electroceramics and thick films produced by chemical, physical and mechanical synthesis techniques focusing on the polymeric precursors, sol-gel, spray pyrolysis, microemulsion, ultrasonic and freeze-drying methods.

3. The economic dimension of the activities carried out under Action has been estimated, on the basis of information available during the planning of the Action, at Euro 11.5 million in 2004 prices.

4. The Memorandum of Understanding will take effect when being signed by at least five Signatories.

5. The Memorandum of Understanding will be in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

COST 539

»Electroceramics from Nanopowders Produced by Innovative Methods«

A. Background

The use of ceramics in electronic components is growing rapidly as a result of their superior physical properties and new technology development. The markets and material technologies for ceramics used as insulators, substrates and packages, capacitors, resistors, semiconductors, piezoelectric devices, and superconductors have shown an outstanding growth during the last 2 decades. For each type of material market factor, segmentation and trends are strongly connected with technology developments. The electronic ceramics industry is a highly technological industry characterised by rapid innovation and technological changes. Working with a wide variety of functionally different materials, the electronic ceramic industry is still in the process of a strong expansion and redirection. It interfaces directly with the electronic industry through the widespread use of ceramic components as an integral part of electronic devices and packages. Several of the electronic ceramic market segments have matured but are still growing steadily.

Current size and future growth of the markets estimated for the period 1990 to 2000 is shown in Figure 1.

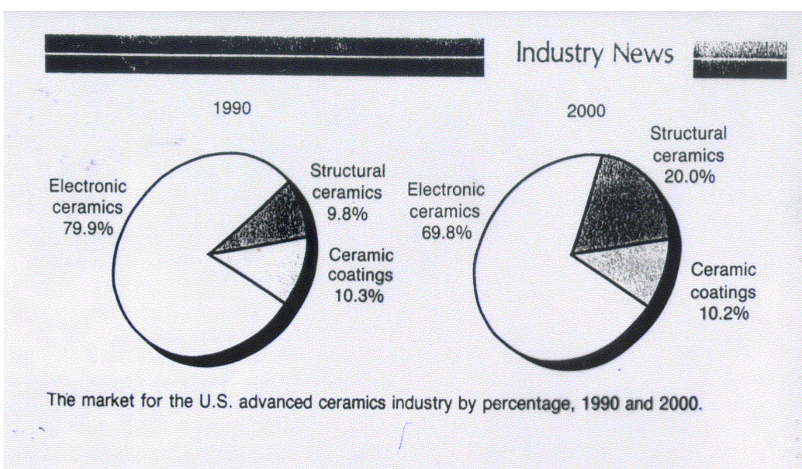

Figure 1: The market for the U.S. advanced ceramics industry for 1990 and 2000.

Electronic ceramics provide basic components as a support of a variety of electronic products including computers, industrial controllers, consumer automotive devices and digital switches. They can be used as active components, such as semiconductors to control voltage and electrical currents, in passive components, such as capacitors and resistors to control electrical currents or voltages, or in mechanical applications, such as ferrite magnets or piezoelectric devices.

Nowadays the significance of electroceramic materials can be pointed out with respect to the electroceramics world market and future prediction. The shortest and most striking way to show the importance can be presented by investment in this field per year. The investment in electroceramics in 2001, expressed in millions US $, was: in Europe – 1940, in USA – 3900, in Japan – 5350, in rest of world – 1535, i.e. in total 12 725 millions US $. The investment in advanced ceramics market is presented in Figure 2.

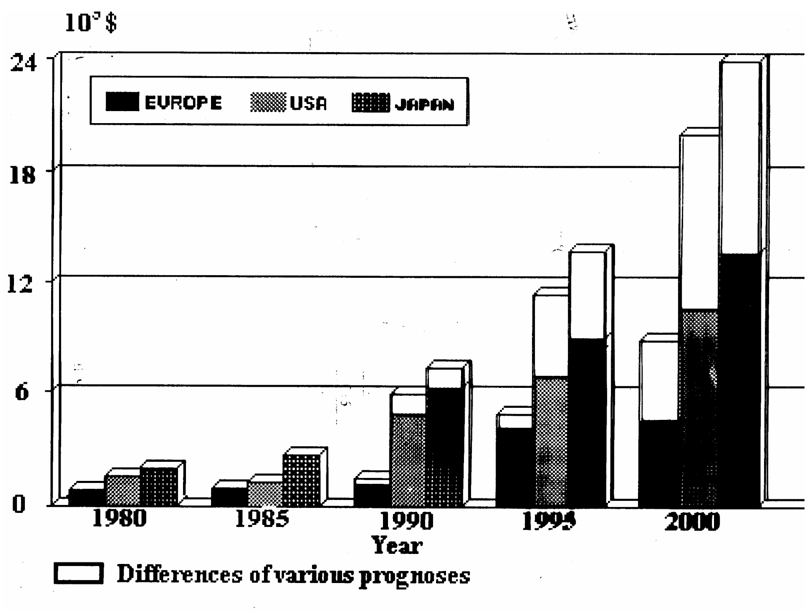

Figure 2: Investment in advanced ceramics market

Bearing in mind the necessity to guarantee Europe's strong positions in emerging nanotechnology markets, the Action is twofold oriented: to develop new functional nanostructured materials, and to promote new technologies for preparation of nano-structured functional materials. Research and development on the nanometer-scale engineering technique will mainly be focused on creating functional materials and components with potentially superior characteristics by strictly controlling their composition and nanostructure. Interdisciplinary and integrated approaches to research and development of nanomaterials and processing would be pursued among others through the promotion of strong research/industry interactions technologies which could easily be implanted in already existing industry capacities.

The research activities will also be focused on development of nanostructured materials and components for clean and safe production, non-polluting, sustainable waste management, hazard reduction in production and manufacturing, enhancing company responsibility in environmental protection and waste management, and on studying all needful interactions. There is much concern on the handling of nanosized powder with respect to their impact on health and safety. By keeping nanopowders in suspension most airborne particle problems with respect to inhalation can thus be avoided. Once sintered or thermally treated the nanostructure may be conserved but no airborne particles are produced.

The introduction of new concepts of advanced electroceramic materials and their potential applications has sparked off a new focus on novel synthetic techniques and processing advances for their preparation. As a consequence, the preparation of innovative materials such as complex functional electroceramic materials, especially ferroelectrics, using novel synthetic routes is a growing technological area. Nowadays, the synthesis technique for the fabrication of nanostructured electroceramic powders has generated considerable interest mainly focusing on improving the physical and electronic properties of the final ceramic products.

These novel process routes make possible the following:

-synthesis of a broad spectrum of materials,

-ability to co-synthesis two or more materials simultaneously,

-production of extremely homogeneous ceramics or composites,

-synthesis of ultra-high purity materials,

-very accurate tailoring of the composition,

-control of the microstructure and nanostructure of the final products and,

-precise control of the physical, mechanical, and chemical properties of the final products.

Innovative synthesis technique for the preparation of the nanostructured electroceramic materials can be basically divided onto the chemical, mechanical and physical methods. Chemical techniques starting from atomic or molecular precursors are mainly focused on the *chemical precipitation, sol-gel technique, polymeric precursors method from organometallic complex, microemulsion processing, hydrothermal synthesis;* physico-chemical methods are mainly focused on *spray pyrolysis, gas condensation, freeze-drying and ultrasonic methods,* which can have significant importance in the preparation of nanostructured ceramic materials. Mechanical methods based on mechanical attrition grinding and milling lead to the formation of highly phase-dispersed materials typical for metal powders or oxide based materials (*mechanical activation*) or the formation of new products because of a solid-state reaction (*mechanochemical synthesis*).

The properties and applications of advanced electroceramic materials depend to a large extent on the stoichiometry and microstructure. The most prominent advantage of innovative methods is the excellent control over the stoichiometry they offer. Because the material composition can readily be tuned by adjusting the composition of the precursor solution, a large number of tailored materials with specific properties can be prepared leading to a diverse family of electroceramic materials for numerous applications. The versatility of this technique has already lead to high quality materials with various properties.

A.1.State of the Art

Today, there are a number of issues facing innovative technologies, which must be addressed. Despite the versatility and obvious benefits of innovative techniques, the integration of such processes (and hence such novel electroceramic materials) into microelectronic, optoelectronic and microsystems devices and components has come up against many difficulties. Control over grain size is often essential to maintain good optical and electrical quality. In addition, the optimisation of the precursors and crystallisation scheme must be addressed in order to attain the texture and microstructure, which satisfy the requirements of the application. Bulk ceramics, thick film quality and reliability issues will be investigated in order to apply in real products and production processes.

To guarantee sufficient device yields, the increasing density of electroceramics and reduction of the defect density (defects in various forms: pores, pinholes, cracks, impurities, or poor stoichiometry) are also an important concern. Chemical purity and particle cleanliness of nanopowders for paste or ink preparation are essential. While high quality thick films can be achieved by multiple coating using a few conventional methods, a single step deposition route would enhance manufacturability and quality of thick films drastically by reducing costs and increasing yields. One acceptable possibility is using screen-printing technique.

This Action aims to advance academic research beyond the present state-of-the-art frontiers. At the same time, it aims to push such frontiers in a direction that is useful to industry. In this manner the research will establish new European technical leading edge technologies while providing the European industries with applications for current operating requirements.

B. OBJECTIVES AND BENEFITS

B1: Scientific Objectives and Benefits

The proposed COST Action ELENA aims to improve the knowledge of tailored innovative procedures for the synthesis of electroceramic nanopowders and materials and to improve their quality for specific electronic sector application.

The main Objective of COST Action ELENA is to improve the physical and electronic properties of advanced electroceramics and thick films produced by chemical, physical and mechanical synthesis techniques focusing on the polymeric precursors, sol-gel, spray pyrolysis, microemulsion, ultrasonic and freeze-drying methods. Knowledge of the precursor chemistry, physical and chemical mechanisms, as well as knowledge of the mechanically activated processes, sintering, co-strain and co-fired sintering, microstructure and nanostructure should increase and tailor to the requirements of industries. To achieve this goal it will be necessary to co-ordinate the basic and applied research efforts of European scientists and industries working in this field.

Secondary objectives and benefits are to:

-develop chemical organometallic precursors, inorganic materials and emulsions to obtain the nanosized electroceramic powders needed for the preparation of bulk ceramics and thick films,

-develop novel and improved procedures for the synthesis and characterisations of nanostructured electroceramic materials,

-reduce nonhomogeneity and irregularity of the microstructure and nanostructure and the number of structural defects (pores, pinholes, cracks, impurities, and poor stoichiometry), trough better control over the grain size and grain shape,

-produce electronic grade dielectrics, semiconductors and ferroelectrics by chemical, physical, mechanical innovative techniques and methods,

-increase the tailorability of electroceramic materials for industrial applications, and

-improve the environmental compatibility of innovative processes and techniques to meet environment, safety, and health requirements.

B2: Industrial and Social Benefits

The ultimate goal of this COST Action is to bridge the gap between the fundamental research in the field of electroceramics and their final technological application in electronics and electronic systems. The Action will ensure the innovation of new generation products in these industrial sectors. The involvement of industrial participants is essential to pinpoint innovative applications of advanced electroceramics.

Bringing together the specialists in the innovative methods for the synthesis, processing and characterisation of advanced electroceramic material, it will be possible to gain a significantly better understanding of these materials and their manufacture. This COST Action will develop new miniaturised products and devices prepared by novel processes applicable in the industrial sectors of environment, health, transportation and communication. Fabrication of ectroceramics and thick films for electronic application will reduce the production cost of the final device and improve its performance due to the well control of stoichiometry of the electroceramics and thick films.

Furthermore, the development of equipment and processes for the production of advanced nanostructured electroceramics is at a relatively early stage of development for certain techniques. Thus, it is imperative that equipment manufacturers and research groups throughout Europe maintain close contact in order to develop this industry to its full capacity. The Provisional List of COST participants shows the interest and enthusiasm for research co-operation and co-ordination in this domain. 18 countries are willing to participate in COST Action ELENA at present. It is recognised, by the technical experts in these countries, that an integrated approach towards novel technologies and special analysis and equipment for the characterisation is required for multicultural applications in order to improve the industrial exploitation of these advanced nanostructured electroceramic materials in Europe. The proposed Action aims to achieve this goal of tailoring powders, ceramics and thick films to the application, thereby improving the material quality and dissemination of the scientific results to industry.

ELENA will be realised by research groups across Western, Central and Eastern European countries integrating Balkan countries teams into the European effort in this field.

COST Action ELENA will provide a platform for:

-*c*ontribution to the co-ordination of scientific policies,

-work in European, international and multi-disciplinary teams developing synergy in nonstructured powders and advanced electroceramic material research activities,

-avoiding the duplication of work,

-dissemination of information through the establishment of a network,

-contributing to the elaboration of a bottom-up strategy for European actions in the area of fundamental research in processing technologies,

-optimisation of inter-European mobility schemes including the exchange and training of graduate students and postdoctoral fellows,

The mobility of researchers within Europe encourages successful inter- and multi-disciplinary collaborations, enhances training and facilitates the development of core expertise within the sciences. It helps to bridge the frontiers of national practices and strengthens the cohesion of Europe. With the knowledge of processing and properties of advanced electroceramic materials and the constraints around those properties, the production process can be fine tuned for enhanced product quality and consistence as well as a reduction in quality variation, to meet European Industrial expectations and requirements. The goal of ELENA is to maintain and further enhance the important role the European science community in this rapidly developing field of strongly correlated electron systems and to ensure that European research groups remain competitive with the USA and Japan.

C. SCIENTIFIC PROGRAMME

The proposed ELENA COST Action would bring together European research and technical specialists and industrialists working on the common theme related to electroceramics and films prepared from nanostructure powders. It is designed to encourage research and technological exchanges and present real co-operation opportunities involving scientists from various fields including theoreticians, material science specialists, material chemists, solid state physicists, electrician and powder metallurgy engineers, and additionally needs the involvement of large scale facilities.

At present, the Action intends, in terms of this proposal, to conduct research towards:

C.1. Synthesis and characterisation of nanostructured powders
C.2. Processing and characterisation of electroceramics and thick films
C.3. Functional characterisation of electroceramic materials and films.

The scientific program can be structured in the **Working Groups** working together in the above named area C. The Working Groups will form the scientific framework of the Action.

The structure of this Action is flexible enough to accommodate projects with either a material or an application focus. Projects will address the objectives of the Action as outlined in section B.

The scheme for the realisation of COST Action ELENA is presented in Figure 3.

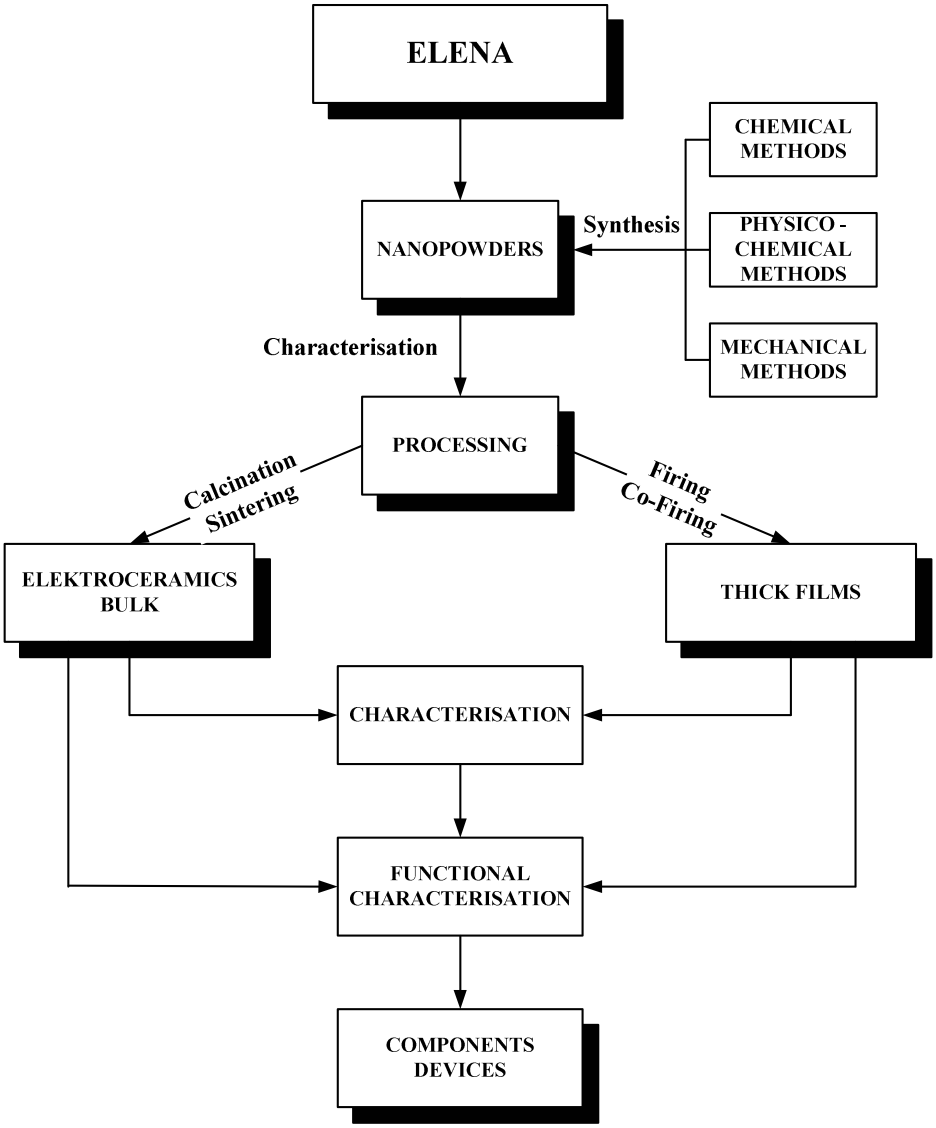

Figure 3. The realisation of COST Action ELENA

C.1. Synthesis and characterisation of nanostructured powders

C.1.1.*Chemical methods*

The Working Groups will address the generic themes of precursor chemistry and processing, micro- and nano-structure and finally the physics of the nanopowders and electroceramics characterisation of their properties and modelling. Interactions are expected between the Working Groups since specialists will be able to offer support with particular techniques to groups working with other materials and processes. The Working Groups will address emerging applications areas for these materials within key industries.

To a large extent, processing is responsible for the structures of the ceramics and films, and these micro- and nano-structures have strong effects on their physical properties and characteristics and on the device performance into which they are incorporated. The themes are chosen bearing obvious and strong relations between (a) precursor chemistry and processing; (b) micro- and nano-structure; and (c) physics/metrology and modelling. These will be expressed in the following priority themes:

-The *chemistry of the organic solutions* will be studied in order to develop improved precursors, tailor the ceramics and films and their crystal, nano- and microstructure. The environmental compatibility of chemicals and processes will be examined.

-The *thermal treatment and processes* (thermal treatment from solutions or sol to powders or gel, temperature and regime of firing and annealing) will be investigated.

-The *physics of sintering* processes including mechanisms of solid-state reaction, reactive sintering, co-strain sintering, and co-fired sintering will be examined.

-The *physics and engineering of the devices* must be taken into consideration, e.g. in the production of electronic grade dielectrics, ferroelectrics or semiconductors.

-*Research to improve the compatibility of precursor chemistry with industrial production,* addressing issues such as larger quantities of produced nanostructure ceramic powders and larger process flows. The aim will be to produce high quality powders for the preparation of dielectric, ferroelectric and semiconducting electroceramics and corresponding thick films with homogeneous micro-and nano-structure, reducing defects and render them suitable for specific applications in microelectronics, optoelectronics, microsystems and nanotechnology.

C.1.1.1.Precursor chemistry and processing:

C.1.1.1.1. *Polymeric Precursor Method from Organometallic Complex –**PPM***

PPM methods make it possible to produce the high purity materials, very accurate tailoring of the composition (the synthesis is actually performed on an atomic level), precise control of the microstructure of the final products and precise control of the physical, mechanical, and chemical properties of the final products. The electroceramics (dielectrics and ferroelectrics) with specific properties used in devices: electrooptic devices, wave-guides, infrared sensors, modulators, caustic wave-guides, electromechanical dispositives, (piezoelectric), ferroelectric memories (FRAM) could be produced by PPM with the quality required for the microelectronics, optoelectronics, and microsystems industries.

The polymeric precursor method starts from the rather known Pechini process having some advantages and disadvantages. The advantages are low costs of precursors, low synthesis temperature; limitable reactivity, ionic homogeneity at molecular level and the possibility to work in aqueous solutions. Besides, the process of preparation and thermal treatment is simple, and it is possible to prepare films with larger areas. The disadvantage is the relatively long preparation time. During preparation by PPM the parameters to be controlled are: stoichiometry, type and concentration of dopants, viscosity and ionic concentration, temperature, time and atmosphere of thermal treatment, temperature, time and number of calcination steps, sintering regime (temperature, time, atmosphere, heating and cooling rate) and annealing, if it is necessary. After sintering of ceramics bulk or active functional component, as a principal part of the thick films, it is very important to control microstructure, grain size, appearance of cracks and density of ceramics or films of electroceramic materials obtained by PPM. To guarantee sufficient device yields the increase in the material density and the reduction of the defect density is an important concern. Homogeneity, stoichiometry and defects need to be strongly controlled. Because of that, the control of chemical purity and all steps of the PPM process during precursors, viscous solutions and resin preparations are essential for the Working Groups attaining nanosized electroceramic powders.

Nowadays the dielectric and ferroelectric ceramic materials for various applications (optical wave-guides, dielectrics, electrooptic shutters, relaxors, capacitors, sensors, etc) are possible to produce by the PPM process. COST Action ELENA will be focused on the electroceramic materials which possess lead such as PLZT, PZT and PCT or on electroceramics without lead such as materials based on titanates: $BaTiO_3$ and $Bi_4Ti_3O_{12}$ or niobates: $LiNbO_3$ and KNO_3.

These may be expressed in the following priority themes:

-Research aiming to *improve the quality and compatibility of chemical solutions*, especially focusing on starting raw materials (metal-citrates, ethylene glycol), cleaning of supports for thick films, ionic concentration and viscosity of solutions, regime for paste preparation and deposition, and temperature-time-atmosphere conditions for sintering, co-sintering or annealing. The aim will be to produce high quality electroceramics and films reducing defects (pores, pinholes, cracks, impurities, poor stoichiometry and poor transparency) and render them suitable for specific applications in microelectronics, optoelectronics, microsystems and nanotechnology.

-The *chemistry of the solutions* will be studied in order to improve organometal precursors, tailor the electroceramic materials and their nano- and microstructure. The environmental compatibility of chemicals and processes will be examined.

-The *physics of sintering*, as well as the physics and *engineering of devices* must be taken into consideration, starting from characterisation of electroceramics and films. Thus, it is necessary to consider and to understand the *origin of the stresses and strains* occurring during processing and thermal treatments (sintering and annealing) and to reduce them.

C.1.1.1.2. Precursor Method using Metal Alkoxides ***–Sol-gel*** *Processing*

This theme is focused on fundamental development of future generation precursors for improved material processing. It targets the discovery and exploitation of basic research to enhance expansion into technology-driven areas. Fabrication of complex structures from simple molecular species is the cornerstone of much modern materials synthesis. Applications in high and medium technology rely on synthetic chemistry during one or more steps in the manufacturing process. Molecular precursors can be broadly defined as molecules whose reaction or decomposition, in isolation or in the presence of other compounds, leads to the formation of a solid-state material. The use of metal alkoxide precursors for the electroceramic materials must meet a series of chemical and material processing requirements in addition to economic considerations. Synthetic chemistry has made significant advances in all of these areas, for example, improved precursor purity and lower toxicity precursors. However, the ability to control structure, composition, and spatial arrangement are important advantages to material growth attained by the application of precursor chemistry and will be investigated within the course of this Action. The chemical structure of the precursor solution and its thermal decomposition behaviour can have a large influence on the microstructure and i.e. on the physical properties of materials. Changes in the precursor chemistry (molecular structure, cross-linking, ligands) can have a drastic influence on film structure and modifications to the precursor preparation method are often key to improving properties.

Therefore the Working Groups operating within this theme during the Action will be involved in the synthesis and processing of:

-*Precursors (alkoxides*) formed by a wide variety of metallic and half-metallic oxides,

-*Organic groups of the precursor molecules* that strongly influence reactivity as well as gel structure, microstructure and physical properties. These organic groups can be modified by synthetic methods. The *solution properties* relevant for film deposition will be modified (chemical stability, kinematics properties, possible additives and modifiers),

-*Thermal processing* which will be investigated as an important influence on the final properties.

C.1.1.2. *Hydrothermal synthesis*

The synthesis of nanomaterials with uniform and sharp particle size distribution is a subject of intensive research in the recent time because of their fundamental scientific interest as well as for the technological importance. The obtained nanomaterials exhibit very interesting electrical, optical, magnetic and chemical properties, which could not be achieved by their bulk counterparts.

Hydrothermal synthesis is well known as an environmentally safe and simple process for producing metal oxides, since it does not require any organic and additional processing such as commination or calcination. Typically, the synthesis has been carried out with an autoclave. A starting solution has to be heated to 373-573 K slowly and then aged for several hours or days. During the heat-up and cooling-down time, hydrothermal reaction takes place to produce nuclei and crystals grow. Exact control of this non-steady-state period promises further development of hydrothermal methods.

Recently, a continuous hydrothermal synthesis method with a flow-through apparatus has been proposed for rapid change of temperature in reaction environment within a few seconds. Mixing with preheated or cooling water in mixing tee can change reaction temperature. The time for the change depends on inner diameter of the tees and solutions feed lines and flow-rate of solutions.

Hydrothermal synthesis is sometimes called a "soft solution chemical processing" because the middle reaction conditions under which the products are achieved (low temperature and short reaction times), leading to controlled particle size and morphology. These characteristics decrease the sintering temperatures and, consequently, low price products can be obtained.

The Working Group involved in the hydrothermal synthesis will use this method for the preparation of nanosized powders of electroceramic materials. Recently, nanopowders, besides various simple electroceramic materials, from lead-zinc-niobate and lead-magnesium-niobate with nice morphology and dielectric properties were successfully prepared that support the idea about the importance of hydrothermal synthesis research efforts in the ELENA Action.

The synthesised nanoparticles will be characterised with detailed (nano) structural characterisation using X-ray powder diffractometry and different electron-microscopic techniques. The sintering samples will be characterised using impedance spectroscopy to investigate grain boundary phenomena.

C.1.1.3. Microemulsion processing

The microemulsion techniques will be used for the preparation of nanoparticles. Water–in-oil microemulsions are used for particle synthesis. A microemulsion can be defined as a thermodynamically stable dispersion of two immiscible liquids stabilised by an interfacial film of surface-active molecules. The microemulsion's stability region depends on various parameters, for example, on the temperature, the concentration of solubilised ions, and the pH of the solution. In water-in-oil microemulsions the aqueous phase is dispersed as micro-droplets surrounded by a monolayer of surfactant molecules in the continuous hydrocarbon phase.

If a soluble metal salt is incorporated in the aqueous phase of the microemulsion it will reside within the aqueous droplets surrounded by the oil. If two identical microemulsions are produced with the reactants A and B dissolved in the aqueous core of the droplets, the exchange of the educts results in the formation of dispersed solid particles AB, which will be contained entirely within the aqueous cores of the microemulsion. The growth of these particles in the microemulsion most probably involves inter-droplet exchange and nuclei aggregation. The dispersion will either be stable or a solid may precipitate.

The synthesis of the nanoparticles with precipitation is a two-step process. In the first step, the constituent-ion hydroxides are precipitated followed by calcination in the second step. Alternatively to calcination, the mixture of hydroxides can be hydrothermally treated in the second step to obtain the final product. The second step can be omitted when particles are obtained *in situ* during the coalescence of reverse micelles of two different microemulsions.

A second type of microemulsion process yields much higher solid content. This process is a combination of usual sol-gel technique and microemulsion synthesis.

In this case, precursors that are rapidly hydrolysed like alkoxides are mixed with a water-in-oil microemulsion. The water of the droplets is used as one of the reactants. The resulting particles may aggregate and precipitate or form dispersion. The dispersions can be broken for precipitation of the solid or can be directly used for coating processes. The materials may be amorphous or crystalline. Crystallite is usually obtained by subsequent calcination.

The synthesised nanoparticles will be characterised using basic electro-magnetic measurements and detailed (nano) structural characterisation using X-ray powder diffractometry, different electron-microscopic techniques and determination of surface area (BET).

C.1.2.Physico-chemical methods

C.1.2.1. Ultrasonic methods

Ultrasonic (sonochemical) methods apply powerful ultrasound radiation (20 kHz – 10 MHz) to obtain a chemical reaction. A number of theories have been developed to explain how ultrasonic irradiation can break chemical bonds, but all of them agree that the main event in sonochemistry is the acoustic cavitation: creation, growth and implosive collapse of gas bubbles formed in a liquid. Extreme conditions are obtained during the collapse: temperatures up to 5000 K, pressures of about 500 bar and cooling rates greater than 10^9 K/s. Because of this unique reaction effect, the ultrasonic method has a rapid reaction rate, controllable reaction conditions, ability to form nanoparticles with uniform shapes, narrow size distributions and high purity. The high cooling rate hinders the organisation and crystallisation of the products. For this reason, in all cases dealing with volatile precursors where gas phase reactions are predominant, amorphous products are obtained. If, on the other hand, the precursor is a non-volatile compound, the sonochemical reaction occurs in the liquid phase. The obtained products are sometimes amorphous and sometimes nanocrystalline.

Many methods have been developed to produce nanoparticles. However, there are some topics related to materials science and nanotechnology in which sonochemical methods proved to be superior to other techniques:

- Preparation of amorphous products: when sonochemistry is applied for the synthesis of amorphous metal oxides or chalcogenides, there is no need to add glass formers to obtain amorphous product in nanometer size
- Insertion of nanomaterials into mesoporous materials
- Deposition of nanoparticles on ceramic and polymeric surfaces
- Formation of proteinaceous micro- and nanospheres

The sonochemical method allows the production of high purity materials with a comparably simple method, avoiding the use of gaseous or toxic precursors, and precise control of the microstructure of the final product.

Research work of the Working Group in this area will include the following themes:

-Sonochemical synthesis of metal chalcogenides: these compounds are among the most popular in recent years due to their excellent semiconductive properties, which make them useful as optic detectors, solar cells and optical storage media,

-Sonochemical preparation of metallic and alloyed nanoparticles

-Sonochemical synthesis of nanophased oxides.

C.1.2.2. Freeze-drying processing

Freeze-drying, starting in 1968, can be defined as a process where a frozen material is dried under vacuum by sublimation of the solvent. The freeze-drying method includes all advantages of powder synthesis from solutions escaping some problems typical for co-precipitation method or sol-gel process (expensive starting materials, long-time processes or contamination with solvents during precipitation).

It is applied on a large scale in food technology. In ceramic powder processing it has been investigated on a smaller scale in order to obtain a homogeneous mixture of different compounds and to suppress agglomerate formation during the drying process. Due to homogeneous distribution of the different constituents, solid oxide reactions occur at lower temperatures in comparison with oxide mixtures that have been prepared by conventional procedures.

The method of freeze-dried powders consists essentially in rapid freezing without separation of a liquid solution of metallic elements. The solid thus obtained is then freeze-dried to eliminate the solvent. This sublimation occurs without any variation in bulk volume, as the particles maintain their shape and dimensions, and remain intact. The solid product thus obtained is then treated for conversion into a finely divided ceramic product. It is important to note that the salts selected must be able to decompose without melting or volatilisation during the subsequent thermochemical treatment. *The essential condition is to gain sufficient solubility of the overall cations considered*. When the solvent is water, it is necessary to consider the existence of very fine ice crystals. As long as these ice crystals are not sublimed, the product must not exceed the cryohydrate temperature. It is also necessary to eliminate the different waters of hydration of the examined solid, each one featuring a range existence as a function of temperature and time, which have to be followed during freeze-drying processes.

An outstanding result of freeze-drying process is that the calcination and sintering temperature may be lower, the porosity lower and the homogeneity higher if during the overall thermochemical treatment of powders a careful control is taken to avoid any sublimation of one element which may locally change the composition. This phenomenon occurs for example for Pb in PLZT or Li and Zn in ferrite. Furthermore, some oxides as ferrites or Cr_2O_3 exhibit an important variation of partial pressure of oxygen and firing temperature must always follow the equilibrium law relative to the material.

C.1.2.3. Spray-pyrolysis

The proposed scientific and technological objectives of this part of COST Action aim to develop *in situ* synthesis of functional nanocrystalline powders and nanocomposites using chemical reactions in aerosols (spray pyrolysis). The principle of the proposed synthesis is based on single-step high temperature aerosol decomposition ultrasonically generated from various precursor solutions. Since the stages of solid-phase precipitation, decomposition and sintering occur in a dispersion phase at the level of several micrometer sized droplets, the advantages of this process relate to the careful control over the particle size,

morphology, chemical and phase composition by adjusting the solution and process parameters. In addition, a high droplet/particle heating rate and high surface reaction result in the formation of fine, spherical, homogeneous polycrystalline particles with a nanoscale composite structure. Aerosol synthesis also enables retaining of the solution stoichiometry and mixing level in the resulting powders reflecting on the homogeneity and properties of selected functional materials in a remarkable way.

In order to improve the powder properties as well as to give the scientific background for the synthesis of functional nanocrystalline powders and nanocomposites, the mechanisms of aerosol droplet formation, intraparticle transport, solute nucleation and growth, chemical reactions and heat and mass transfer at elevated temperatures will be analysed. Also, the chemistry of the precursor solution, determining the mechanisms of particle formation through either surface or volume precipitation at the droplet level will be specially analysed.

Nanophase particles can be generated in accordance with this method by properly controlling the initial aerosol droplet size, the mechanisms of nucleation, growth and aggregation of primary particles and droplet collision and coalescence. As a result, it is possible to obtain either nanoparticles directly from nano-sized droplets ubmicronic sized particles that offer a composite nanoparticle structure. The choice of precursors with regards to the thermal and decomposition behaviour, play an important role in nanoscaled particle synthesis, as well. Because of that, new precursors based on metal-organic complexes will be specially synthesised. The Working Group research on nanocrystalline powder and nanocomposite synthesis will include the investigations of precursor chemical reactions, mechanisms of particle formation, individual grain/particle structure, interaction on the contact area and formation of a required composite structure.

Synthesis of functional nanocrystalline powders and nanocomposites will be realised through completion of aerosol generation of ultrafine non-agglomerated nanophased powders and nanocomposites based on either pure or Pt (Ru)-doped ZnO as well as ZnO-MeO (MeO=Cr^{3+}) suitable for electronic application (sensors). This part of COST Action ELENA will be realised through the following tasks:

-Powder generation will be realised using precursor solutions based on inorganic and/or metal organic compounds and noble and other metal complexes. Formed precursor solutions containing metal ions will be dispersed ultrasonically into fine droplets by an aerosol generator. Consequently, the aerosol will be introduced into a high-temperature tubular flow reactor by means of a carrier gas (air, nitrogen). The carrier gas flow rates, temperature as well as droplet/particle residence time in the decomposition zone has to be controlled in order to determine the correlation between particle morphology, phase content and crystal structure with process parameters. The conditions for nanophase formation will be specially analysed.

-Characterisation of the precursors by means of electronic absorption, infrared spectra and X-ray diffraction analysis. Determination of physico-chemical and thermal properties of selected precursors (solubility, decomposition behaviour) and precursor solutions (surface tension, viscosity, density, concentration), enabling droplet precipitation control, either simultaneous or sequential.

-Characterisation of the resulting particles for their phase content, particle shape, size and particle size distribution and morphology.

-Optimisation of process parameters and correlation with powder properties with the purpose of achieving a high performance nanoscaled composite powder.

The beneficial impacts of these investigations are both scientific and technical. They are scientific in relevance to a better understanding of the mechanisms of the formation of nanophased powders and nanocomposites regarding interfaces evolution, and the particle nucleation, growth and collision. The technical impact of these investigations is in relevance to novel technologies and novel functional materials.

C.1.3. Mechanical methods

The scientific and technological Objective of this part of the COST Action is relating to solid-solid reactions initiated by intensive milling in high-energy ball mills. An important criterion for intensive milling is (a) formation of new products because of solid-state reaction (mechanochemical synthesis) or (b) formation of highly dispersed materials typical for metal powders or oxide based magnetic materials (mechanical activation). A characteristic feature of all solid-state reactions is that they involve the formation of product phase(s) at the interfaces of the reactants. Furthermore, growth of the product phase involves diffusion of atoms of the reactant phases through the product phase, which constitutes a barrier layer preventing further reaction. Intensive milling increases the area of contact between the reactant powder particles due to reduction in particle size and allows fresh surfaces to come into contact. This allows the reduction to proceed without the necessity for diffusion through the product layer. As a consequence, solid-state reactions that normally require high temperatures will occur at lower temperatures during mechanochemical synthesis without any externally applied heat. In addition, the high defect densities induced by intensive milling in high-energy mills accelerate the diffusion process. Alternatively, the particle refinement and consequent reduction in diffusion distances (due to microstructural refinement) can at least reduce the reaction temperatures significantly, even if they do not occur at room temperature. Mechanical treatment of ceramic powders can reduce particle size and enable us to obtain f nano-structured powders, which are of the main interest in the current trend of miniaturisation and integration of electronic components.

Ceramic materials fabricated from nanocrystalline powders can achieve extremely homogeneous microstructures and almost theoretical densities. More recently, it was applied to prepare a few ceramic powders, including oxides and non-oxides. Until now mechanochemical synthesis was successfully used to synthesise materials, such as nano-crystalline oxide powders, solid solutions, nano-particles of superconductor, various functional materials, such as perovskite ferroelectrics: lead-zirconium-titanate (PZT), lead-magnesium-niobate (PMN), lead titanate (PT), lead-zinc-niobate (PZN), barium titanate (BT), lantanas manganat (LM), etc. Named materials are extremely important for electronic purpose, because of their various applicable properties as capacitors, multilayer capacitors, piezo generators, piezo motors, piezo and electrostrictive actuators, relaxors, PTC, IR, gas and humidity sensors, eletrooptic shutters, electrooptic displays, non-volatile memories, buffer layers, integrated optics, AR coating, etc.

A recent breakthrough was also made in the synthesis of spinal structured functional materials, as it is soft ferrite materials that are widely used in electronic applications such as transformers, choke coils, noise filters, and others because of their high magnetic permeability and low losses. Although ferroelectric and ferromagnetic materials are well-established ceramic materials and have been the subject of intensive investigation in the past because of their technical importance, they still remain the focus of esearch activities because they require careful optimisation of many parameters during conventional route for their preparation. The possibility to synthesise some materials at room temperature increased interest of many researchers, especially when the conventional synthesis of some materials involves gaseous products and mass loss at high temperatures that increase the environmental and waste hazard problems. A typical example is the fabrication of Pb-based ferroelectric ceramics. Mechanochemical synthesis of these materials can prevent PbO loss during preparation by skipping multiple steps of calcination at elevated temperatures and subsequent milling and enables maintaining of desired stoichiometry. This method could also be useful in preparing Bi-containing materials because high-temperature synthesis can result in loss of Bi_2O_3. Besides these obvious applications, mechanochemical synthesis could be applied in preparation of other ferroelectric and ferromagnetic materials, because of its simplicity, low costs for the production of larger quantities of powders, reduced energy consumption, and easy control of the stoichiometry of the final products.

The main lines of this part of COST Action will seek to obtain:

-Electroceramic powders through solid-state reaction by mechanically assisted synthesis,

-Electroceramic components /devices based on nanostructured powders such as dielectrics and ferroelectrics with perovskite structure, as lead-magnesium-niobate (PMN), lead-zirconium-titanate (PZT), lead-lanthanum-zirconium-titanate (PLZT), and other important electronic materials, such as barium titanate (BT), lanthanum manganate (LM), or materials with spinel structure as zinc-chromate-$ZnCr_2O_3$,

-Electroceramic thick films based on the powders obtained through mechanically assisted synthesis

The Working Group research will be focused on:

-Solid-state synthesis (through mechanochemical reaction) of nanostructured ceramic powders with perovskite structure based on lead, such as PZT, PMN, PT, PLZT, etc.

-Solid-state synthesis (through mechanochemical reaction) of nanostructured ceramic powders with perovskite structure without lead, such as BT, LM, and BIT, etc.

-Optimisation of powder processing based on the mechanical activation process or mechanically assisted synthesis with special attention on the problems related to powder agglomeration and chemical homogeneity

-Optimisation of powder processing with respect to the scaling up of powder production for industrial applications

-Optimisation of processes to obtain electronic components in the form of bulk ceramics or films from further processed powders.

C.2. Processing and characterisation of electroceramics and thick films

C.2.1. Importance of texture in electroceramics

Many properties of polycrystalline electroceramics fall far below the figures of merit for single crystals. One way of approaching these hugely promising properties is by introducing texture and crystallographic orientation into polycrystalline ceramics. Although textured ceramics produced via template grain growth still fall well short of the factor of 10 for certain single crystal materials, these first research results show the promise of improving properties of up to 3 times that of non-textured ceramics. Texture may be achieved by producing anisotropy materials during both particle synthesis and processing.

Both the chemical and mechanical methods to synthesise powders are possible routes where anisotropy particles can be produced. Precipitation with the use of crystal growth additives (or even seeding) to produce plates or needles is a real possibility. With attrition milling, in the correct solvent and with additives that adsorb onto specific surfaces, plate-like powders can also result. The use of tape casting methods or other high shear forming methods can then be used to align particles during the processing steps. The addition of certain dopants can also strongly influence grain shape and microstructural anisotropy during the sintering stage – even sintering with applied loads could be envisaged to modify ceramic microstructural texture. All these possibilities linked with the fine control of grain boundary composition and at the nanoscale level should enhance electroceramic properties.

C.2.2. Phase composition, Microstructure and Nanostructure

As for most materials of technological interest, the microstructure and nanostructure of electroceramic materials are key for understanding their physical and chemical properties, predicting performance, and developing methods to engineer electroceramics with desired and controllable properties. In order for transfer of the developed technology into industrial applications with a view to the development of industrial scale synthesis, characterisation of the microstructure/nanostructure of electroceramics is essential. The Objective of this research will be to develop a more comprehensive understanding of the influence of microstructure and nanostructure on the physical, chemical and mechanical properties.

Understanding a material begins with comprehending its nanostructure and this activity will be an important factor in this theme. The nanoscale structure will be probed using mass atomic spectroscopy (MAS), NMR, Ca X-ray absorption (XAS), Raman and infrared (IR) spectroscopy, EXAFS and XANES analysis. In addition, small angle scattering techniques and electron microscopy studies will complement spectroscopic data. The properties of electronic ceramics, as of most materials, are to a large degree determined by their defect content. Some examples are: crystal defects such as oxygen vacancies, which are thought to be responsible for poor endurance of PZT capacitors, grain boundaries which lead to increase scattering in waveguide material and second phases lead to resistance degradation and early breakdown. Because in film growth the structure and defect content is often dependent on the properties of the growth surface, one approach to influence microstructure development is by introducing seed layers that promote nucleation.

The x-ray powder diffraction method will be also used for identification and quantification of crystal phases in powders obtained through spray pyrolysis and freeze- drying methods. In addition, line broadening will be analysed in order to obtain microstructure parameters. The crystallisation kinetics of nanophased powders and nanocomposites and the mechanisms of the nucleation-growth process will be analysed by combining transmission electron microscopy and nonisothermal differential scanning calorimetry.

Investigations will be performed using different heating rates in order to determine the kinetic parameters for grain growth. The semi-automatic analysis and scanning probe image processor (SPIP) will be performed in determination of the particle stereological and surface parameters.

Advances in understanding microstructures and microstructure-property relationships require this integrated research program involving the use of a wide range of modern analytical tools capable of probing thin films. Methods will include but will not be limited to high resolution and analytical TEM, STM/AFM, EPMA, XRD, SEM and other spatially resolved imaging and elemental mapping techniques.

C.3. Functional characterisation and application

C.3.1.Physics/Metrology and Modelling

Micro- and nano-structures strongly influence physical properties. More precisely, stresses and strains can give rise to dislocations, defects and inhomogeneities which affect, to a large extent, the dielectric properties (for capacitors in microelectronic applications for instance), optical transmission (for optoelectronic applications), and mechanical specifications (for microsystems applications). It is important to understand the origin of these stresses and strains (i.e. in which step of the process they appear), and to derive some ideas about how to monitor them. It is known that during mechanical activation and mechanically assisted synthesis the stresses and strains are involved in changing the crystal lattice parameters. To this purpose, it is necessary to measure them (by X-rays or spectroscopy such as infrared, Raman, Brillioiun, EPR, etc.), and to build models which could predict their impact on physical properties. Spectroscopic techniques give detailed information on excitations and local fields in the materials studied. These techniques are very sensitive to all of the aforementioned imperfections. Comparison with bulk materials and films obtained by various techniques will allow us to sensitively position the electroceramic materials quality between structural limits.

C.3.1.1.Microelectronics:

The integration of novel materials into microelectronic devices has come up against many difficulties that must be addressed with a multi-disciplinary approach. The problems of compatibility of new or at improved property electroceramic materials with microelectronic processes will require imaginative solutions from chemists, equipment manufacturers and material scientists.

The use of barium titanate based materials as BST in DRAM; integration of complex oxide films is still in a research or early development stage. Indeed, integration of these films with silicon circuitry requires not only growth of a film with the desired characteristics, but also film patterning, as well as ensuring that the film retains the target properties during the remainder of the process sequence. Because many of the materials under consideration are known to act as contaminants for silicon devices, diffusion barriers and special cleaning steps must be developed to prevent diffusion of heavy metals to regions where they can interfere with device performance.

In addition, the development of new techniques is essential in advanced applications.

C.3.1.2.Optoelectronics:

Silicon-based optoelectronics is a diversified technology that has grown steadily over the past decade with thin film integrated optics also becoming more and more important in optical-communications technology. At present, optoelectronics suffers from limited capabilities in on-chip integration, whilst the high cost of hybrid packaging limits the scope of applications. Ferroelectric materials have strong potential for application in optical waveguide devices, with large electro-optic effects observed in many transparent ferroelectric materials. The key challenge for the Working Groups research, besides miniaturisation of electroceramics, is to grow high quality films of the required thickness with low densities of grain boundaries, which lead to scattering losses. In addition, integration of non-standard materials with microelectronic circuits will necessitate special precautions to prevent cross-contamination discussed above.

***C.3.1.3.Microsystems**:*

Microsystems are intelligent miniaturised systems comprising sensing, processing and/or actuating functions. Miniaturised, integrated sensors and actuators are a rapidly growing field with great future potential. Nowadays, most integrated microsystems make use of relatively standard microelectronic materials. Electroceramics with piezo- and pyroelectric properties could lead to enhanced sensitivity and functionality because of their higher figures of merit and the possibility for actuation in MEMS devices. Sensor and actuator elements are commonly placed on top of the metallization, which relaxes concerns of cross contamination in back-end processing. Magneto-optical and electro-optical effects in materials provide for a large variety of device applications. Realisation of the potential of these materials has thus far been impeded by inadequate control of crystalline and chemical perfection during their production. Chemical, physical and mechanical technologies provide methods of compositional and microstructural control for optimising strain energy density for applications in active structures.

Within these themes, researchers from a wide range of scientific disciplines in the Working Groups will work with different industrial partners. The innovative application of non-conventional and innovative techniques will be promoted by means of an annual research-industry group workshop. It is envisaged that this workshop will modify the priority themes for research for the following year.

D.ORGANISATION, MANAGEMENT AND RESPONSIBILITIES

This Action will operate for four years.

Management Committee:A Management Committee (MC) of this Action will be organised and operate according to COST/400/94 "Rules and Procedures". The MC will be installed and will take responsibility for the Action. The Management Committee will meet, at least, once per year. Decisions will also be made by circulating documents via e-mails and other electronic communication services. The MC will set-up and regularly update the web-site, which will consist of a precise description of each group, the experimental equipment and availability, as well as computing capacities. Each participating group is obliged to provide information to the MC.

The MC will invite leading academic and industrial colleagues in several subjects to give plenary talks during the workshop meetings. At the same time attendance of these workshops will enable a participant to exchange ideas with other industrial representatives and to sense the technological prospective of the COST Action members in the areas of interest. This will be an effective and economical approach to maintaining a current understanding of the status of industrial and academic efforts in this field. A mid term review is planned for the end of second year. At this review there will be a formal evaluation of the project and assessment of the most appropriate direction for the COST Action.

Working Groups and Activities

The 3 principal Working Groups-WGs will realise, in principle, the present proposal. The WGs will consist of eight sub-groups working in six main Projects. The flow of information between Working Groups and projects will be stimulated by the interactive nature of the membership of the Working Groups. The each Working Group will elect a Chairperson to co-ordinate the work within the sub-groups and represent it within the MC.

***Working Groups*:**

WG 1: Synthesis *and characterisation of nanopowders prepared by non-conventional techniques and innovative methods*
WG 2*: Processing and structure characterisation of functional electroceramics and films*
WG 3: Functional *characterisation of electroceramics and films*

Working Groups will co-operate with other Working groups engaged in COST Action 528 and European network program POLECER from FP5. The flow of information between working groups will be stimulated by the interactive nature of the membership of the Working groups in COST Action 528 and POLECER programmes.

Promotion of scientific and technical co-operation between researchers and producers from the Community and third countries will contribute to sustainable economic, social and scientific developments. Particularly, research, development and production will join researchers, producers and users from the Central and Eastern Europe Countries, from Balkan and from countries outside Europe such as Brazil and Japan. According to combined and multidisciplinary skills, activities in Working Groups of COST Action ELENA will include research and technological development, innovation related activities, plus readiness and availability of the scientific and technological excellence in Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new production processes and devices.

One larger Workshop or Conference will be held during the ELENA period. One or two smaller scale Workshops or Conferences (Seminars) will be held annually during the COST Action period. Substantial participation in regular international Conferences will be supported.

Working Group meetings

Working Group meetings will be held, at least, two times a year. The specific Working Group meeting should be composed of an appropriate number of scientists of the specific Working Group area as well as additional researchers from complementary groups (e.g. experimental and theory).

Joint meetings among various Working Groups in this COST Action and with relevant Working Groups from other relevant COST Actions will be organised at least once a year in such a way as to best promote interdisciplinary communication.

Besides meetings among various groups, the main emphasis will be put on short-term fellowships primarily awarded to younger researchers

Mini-workshop and Short Term Scientific Missions-STSM

The exchange of ideas in smaller research groups discussing in specific issue will be organised. The exchange ideas in smaller groups from Universities, Institutes and Companies, milling equipment producers, ceramic processing industries and electronic equipment companies from several European countries and from countries outside Europe will be welcome in terms of mini-workshops.

The primary instrument within the Action will be short-term scientific mission. STSM will allow younger researchers to improve skills and competence from research stays in partner laboratories, to solve specific scientific problem, to use methods, procedures and equipment available within the partner institutions of COST Action ELENA.

E. TIMETABLE

The total duration of the Action is four years.

The COST Action ELENA will be generated with the specific skills of each Working Group and participant countries and institutions.

In terms of the Action Organisation, there are two important aspects:

1.Each sub-WG will be focused on specific innovative methods related to nanopowder preparation as well as to various families of electronic ceramics. This will be following by (a) theoretical approach to problem, (b) synthesis of nanopowders, (c) synthesis (preparation/fabrication) of ceramics or thick films (d) microstructure and nanostructure characterisation, (e) electric characterisation and characterisation of functional properties important for further application.

2.Principal WGs will be focused on outstanding goal of the ELENA. Main emphasis will be directed to join the results of sub-WGs through the following tasks:

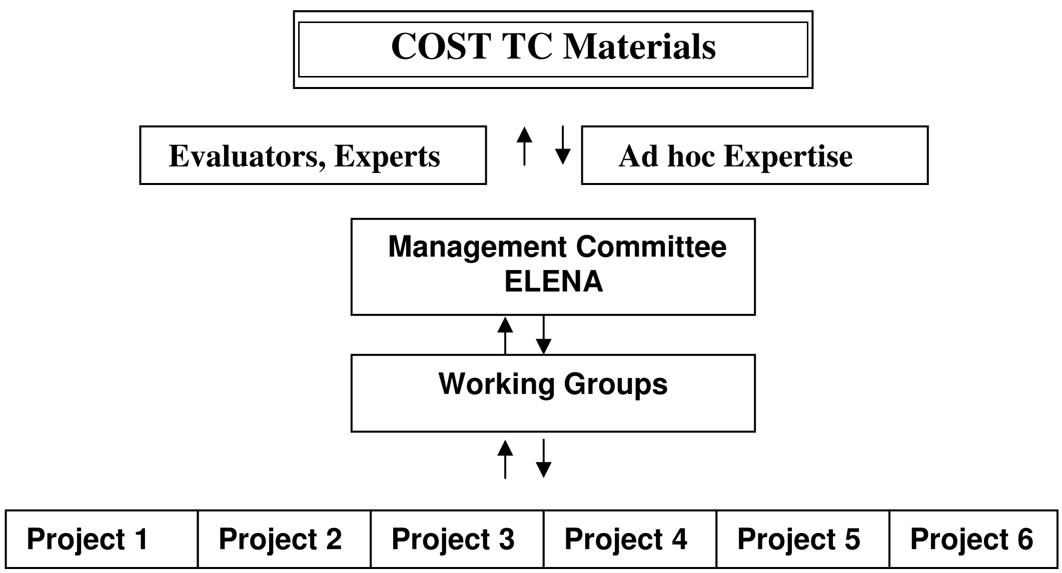

Figure 4. COST Action ELENA illustrated by Organisation and Projects.

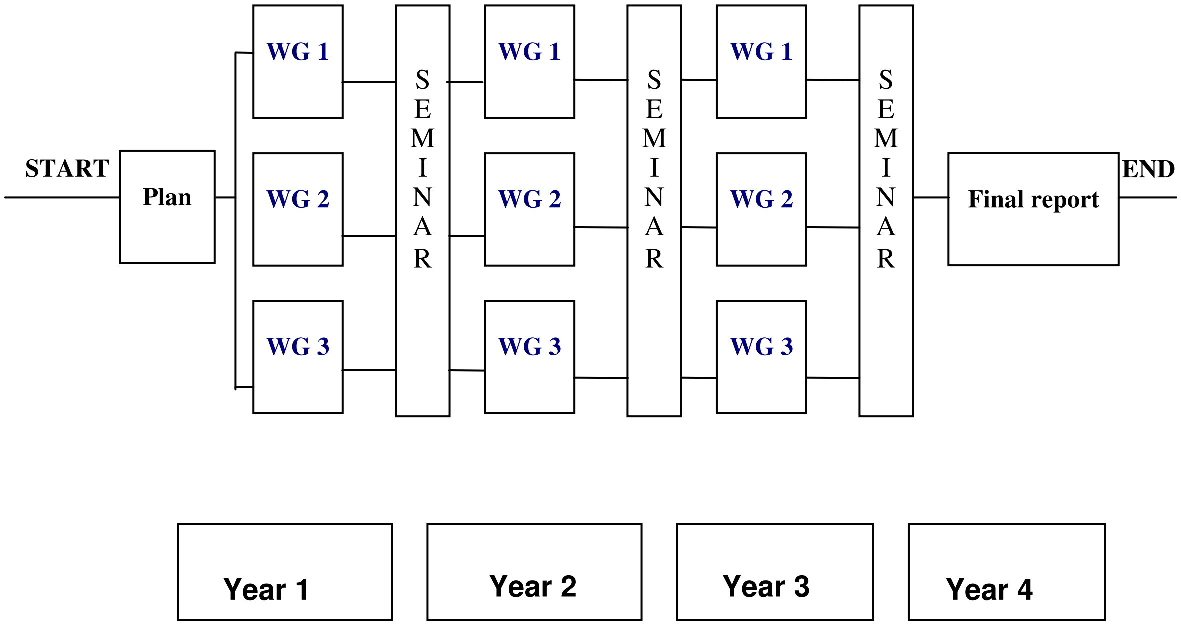

Figure 5: Timetable of COST Action illustrated by meeting of Working Groups

Year 1	Year 2	Year 3	Year 4
Start			
Formation of projects			
Workshop of WGs leaders, Mini-Workshops, Conferences,Seminars			
Overview available; start meetings; continue meetings on sub-topics			
	Start exploration of wider participation		
	Intermediate Progress Report available		
		Start evaluation of results	
		Concluding Symposium	
			Final Report

Figure 6. Timetable of COST Action ELENA.

Projects:

Project 1 ***Chemical methods for nanopowder synthesis and characterisation of powders***
Project 2 ***Physical methods for nanopowders synthesis and characterisation of powders.***
Project 3 ***Mechanical methods for nanopowders synthesis and characterisation of powders.***
Project 4 ***Processing and functional characterisation of electroceramics and films prepared from nanopowders.***
Project 5 ***Theoretical approach to mechanisms and kinetics of the nanopowders formation using innovative methods.***
Project 6 ***Theoretical approach from basic sciences to technology of advanced electroceramics and thick films prepared from nanopowders(physics of sintering, modelling, metrology)***

F. Economic dimension

The economic dimension is estimated by the demands of the scientists and countries participating in the proposal of COST Action ELENA. The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest:

List of the relevant countries:

1. Slovenia, 2. Italy; 3. Spain; 4. France ; 5. Portugal; 6. Belgium ; 7. Germany
8. Czech Republic ; 9. Poland ; 10. Hungary; 11. Slovakia; 12. Switzerland
13. United Kingdom 14. Serbia and Montenegro; 15. Romania; 16. Bulgaria;
17. Lithuania; 18.Denmark

Non-COST:

1.Russia; 2. Brazil; 2. Japan

On the basis of national estimates provided by representatives of these countries, the economic dimension of the Activities to be carried out under the Action has been estimated, in 2004 prices, approximately **Euro 11.5 millions**. This estimate includes all listed countries, COST and non COST, either.

For non COST countries this estimate is Euro 2.5 millions (Japan, approximately Euro 1.5 millions and Brazil approximately Euro 1.0 million).

This estimate is valid under assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

G. Dissemination plan

The dissemination of the results of the ELENA COST Action is targeted to the contributing members of the COST Action, as well as to the other researchers in the field, other research frameworks and Institutes and Academia and, if appropriate, industrial companies.

In order to distribute this information, the dissemination will be realised in standard publication in well established peer-reviewed journals, at national and international conferences and symposia and at workshops, seminars and conferences organised by the MC. Electronic possibilities such as web-sites and web-data bases as well as an electronically distributed newsletter are envisaged. The web-site will be constituted by a ”confidential” part, where partners at the COST Action ELENA can exchange their results and a public part, where relevant results will be available for a general audience, presented in a popular manner.

Further channels of dissemination of knowledge are associated with the mobility of young researchers (due to a larger number of short time scientific mission) and workshops at different scale.

The progress of the Action as well the results of its evaluation will be taken into consideration in updating the dissemination plan during the course of the Action.

H. Industry supplies

It is very important to bring out that industry participants will support ELENA COST Action. Other industrial partners will be additionally chosen from:

Manufacturers and suppliers of advanced electroceramic raw materials.

- Manufacturers and suppliers of advanced ceramic nanopowders.
- Companies involved in the development and manufacture of advanced electroceramic components.
- Manufacturers of integrated circuits, piezoelectric elements, capacitors and other electroceramic devices.
- Suppliers of electronic ceramic components.
- Ceramic companies interested in diversification.

COST 539

‘ELENA’

"ELECTROCERAMICS FROM NANOPOWDERS PRODUCED BY INNOVATIVE METHODS"

ADDITIONAL INFORMATION
NOT PART OF THE MOU

The main purpose of providing “Additional Information” is to facilitate the assessment of the proposal and highlight known interest in it.

The majority of participants of the COST Action ELENA have been involved in a previous programme founded by FP5, FP6 and ESF, which were successfully carried out from 1998 up to now. This programme, which assisted the co-operation between scientists from 18 different European countries and 2 non-COST (Brazil and Japan), is considered as one of the important reason that European researchers are leading the field of electroceramic materials prepared from nanopowders obtained by innovative methods. Due to of expantion in the field of electronic materials, e.g. advanced ceramics for electronic application as well as various methods for the ceramic powder preparation and the growing importance of nanosize powders, a common structured European research is strongly needed.

a) Expecting benefits

The proposed programme intends to improve the knowledge in the field of electroceramic materials, which are expected to posses new or improve properties for the application in electronic devices. Along with the expanding field of integrated and miniaturised electronic devices, importance of nanostrucure powders for the preparation of the electroceramic materials future generation also increases. Action additionally helps to integrate scientists from Eastern European and Balkan countries, enabling extensive transfer of knowledge, expertise, competence and skills to the formerly underfavoured regions. COST Action ELENA will give the possibility for the education and training of European graduates and postdoctoral students. Synergetic effects are expected, since scientists from many different fields co-operate in the proposed programme.

b) Synergy of new COST Action with existing European programmes

The proposed COST Action is an important programme for the implementation of European co-operation in the domain of advanced electrocermics and new technologies. In the long term, development of the proposed technologies will improve novel technologies in European companies giving a competitive advantage in the markets where Europe can be a strong competitor for the US and Japan. The COST Action ELENA provides the best means for harmonising national research activities in this field in many countries including Central and Eastern Europe and Balkan countries, where significant basic research expertise already exists.

The Objective of COST is also to improve the knowledge of research groups in the field of electroceramics from nanopowders produced by innovative methods. This network will foster creative ideas, which may develop into new proposals with defined aims, and work programs specifically tailored for key applications relevant to EU industrial or social needs. Besides, the advantage of the COST approach lies in a relatively rapid exchange of information between scientists and technical experts.

c) Complementarily of this proposed COST Action and COST 523, 525 and 528

The main Objective of COST 523 (Nanostructured Materials, starting on 1997, stop running on February 2004) was the development of nanostructured materials with new and unique structural and functional properties.

The main Objective of COST 525 (Advanced Electroceramics: Grain Boundary Engineering, starting on 2001, end 2005) is to develop and to apply numerical optimisation methodologies for automatic materials process design, based on quantified product quality, relating to process targets and constraints, including economic aspects.

The main Objective of COST 528 (Chemical Solution Deposition of Thin Films, starting on June 2000, end on June 2005), although complementary to COST 525, is focused on thin films, covers a much broader range of advanced material thin films, the properties of the final devices. COST 528 action promotes co-operation between academia and industry, taking into account the needs of the microelectronics, optoelectronics and micro-systems industries and by strengthening the integration of European infrastructures in this domain and related sciences.

ELENA COST Action although complementary to COST 523, 525 and 528 is focused on electroceramic materials in bulk and a thick film form and covers a broad range of advanced non-conventional processing and materials with improved or novel properties for various applications in electronics. ELENA Action will promote co-operation between various research institutions, academic staffs, industrial sector in Central and Eastern Europe and Balkan countries strengthening the integration of European infrastructures in this domain and related sciences.

d) The applicants of ELENA

***The representatives from 18 COST- countries and more than 45 Institutions will participate in COST Action ELENA*.**

The following list gives an overview on Institutions who have been expressed interest to participate in the proposed COST Action ELENA. From each Institution will participate the groups consist of a number of researchers, actively working in the field correlated to Objective of Action. The institutions are shown in following list:

Belgium (1)*	*LUC, Lindbergh*
Bulgaria (2)	*University of Chem. Tech. Metall., Sofia*
Czech Republic (1)	*Institute for Physics of CAS, Prague*
Denmark (1)	*Ins. Fors. Radet*
France (6)	*Caen University, Lab.Crist.Sci.Materiaux, Caen, Un.Belford, CNRS UMR, Un. Bourgogne, LRRS UMR, Un.Limoges, ECP, Ecole Central, Paris*

Germany (3)	*FZJ, Juelich, Zoz Gmb Com. Weden, NanDOx*
Hungary (1)	*Research Institute for Solid State Physics and Optics, Budapest*
Italy (2)	*ISTEC, Faenza, University of Genoa*
Lithuania (1)	*Vilnius University,Vinius*
Poland (1)	*PUT, Poznan*
Portugal (1)	*University of Aveiro, Aveiro*
Romania (2)	*Ins.Physics , Bucharest, National Ins.Materials Physics, Bucharest*
Serbia&Monten.(8)	*CMS Un.Bgd, HF Un.Bgd, In.Phys.,Bgd, TF Un.N.S., EF Un.Nis, ITNS SASA, IRITEL dd., EI Nis*
Slovakia (1)	*Institute of Materials Research, Slovak Academy of Sciences, Kosice*
Slovenia (4)	*IJS, Ljubljana, Univer.Maribor, HIPOT,Lj., Politehnika, Nova Gorica*
Spain (2)	*Un.Carlos III,Leganes, LCMM CSIC, Madrid*
Switzerland (2)	*EPF, Laousanne*
United Kingdom(3)	*University of Manchester,London South Bank University, University of Sheffield*
Russia (1)	*Inst.Solid State Chem.and Mechanochemistry, Novosibirsk*
Brazil (1)	*Instituto de Quimica-Unesp, Araraquara*
Japan (2)	*Keio University, Yokohama, Nara Machinery, Tokyo*

*-Number of involved institutions

List of Experts (contacts' detail will be supplied later by the proposer)

Experts who have been consulted during the drafting of the proposal and have already expressed interest in the Action

1. **Biljana Stojanović** (C.Jovalekic,Z.Marinkovic,V.Vukotic, CMS University of Belgrade, Serbia and Montenegro)

2. **Marija Kosec** (IJS, Ljubljana, Slovenia)
3. **Nava Setter** (EPFL, Lausanne, Switzerland)
4. **Barbara Malič**(IJS, Ljubljana, Slovenia)
5. **Mihail Drofenik** (University of Maribor, Slovenia)
6. **Vladimir Srdić**(TF University of Novi Sad, Serbia and Montenegro)
7. **Lorena Pardo**(LCMM CSIC, Madrid, Spain)
8. **Paula Vilarinho** (University of Aveiro, Aveiro, Portugal)
9. **Jose Manuel Torralba** (Universidad Carlos III, Leganes, Spain)
10. **Hongming Ren** (Zoz Gmb Company, Weden, Germany)
11. **Heinrich Zoz** (Zoz Gmb Company, Weden, Germany)
12. **Mamoru Senna** (Keio University, Yokohama, Japan)
13. **Eric Gaffet** (University of Belford, CNRS UMR, Belford, France)

14. **Frederic Bernard** (University of Bourgogne, LRRS UMR, Bourgogne, France)
15. **Cristian Pithan** (FZJ, Juelich, Germany)
16. **Philip Gaucher** (ECP, Ecole Central, Paris, France)
17. **Nebojsa Romcevic** (Institute for Physics, Belgrade, Serbia and Montenegro)
18. **Maria Aparecida Zaghete** (Instituto de Quimica-UNESP, Araraquara, Brazil)
19. **Jose Arana Varela (**UNESP-CMDMC, Araraquara, Brazil
20. **Jean Pierre Mercurio** (University of Limoges, Limoges, France)
21. **Daniel Chateigner** (Caen University, Lab.Crist. Sci. Materiaux, Caen, France)
22. **Jan Petzelt** (Institute for Physics of CAS, Prague, Czech Republic)
23. **Maria Zaharescu** (Institute for Physics, Bucharest, Romania)
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The proposed Action intends to affiliate at least one scientist of each participating country. The following persons have agreed to participate in MC:

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Curriculum vitae : Professor Biljana D.Stojanovic

B.Stojanovic is full time professor at the University of Belgrade and scientific advisor in the Centre of Multidisciplinary Studies. Main research area is in the materials science field with special attention on the materials for electronic applications and nanostructured powders. She is full member of the Academy of Engineering Sciences, full member of the International Institute of Science of Sintering, member of the Department for Physics of the Serbia Academy of Sciences and Arts and member of various national and international scientific associations. She is the leader or chairperson of numerous national and international projects and scientific co-operations on bilateral or multilevel. B.Stojanovic has been the visiting professor at Universities in France, Spain, Italy, Brazil, Argentina and Japan. She has been published about 600 articles and technical disclosures, more than 60 are recent publications relevant to the ELENA field.