UNIVERSITATEA "POLITEHNICA" DIN BUCUREŞTI
Catedra de Masini, Materiale, Actionări electrice
FACULTATEA DE INGINERIE ELECTRICĂ

PoNaDIP
Polymer Nanocomposite Dielectrics with Insulating Properties

Laboratorul de Materiale Electrotehnice (ELMAT)

Splaiul Independenței 313, Sector 6, 060042 BUCUREŞTI, ROMÂNIA
Tel: (4021) 402 92 85, Fax: (4021) 318.10.16
e-mail: florin@elmat.pub.ro

Project CEEX - PoNaDIP 9411/2006

Methodologies for Development and Characterization of Polymer Nanocomposite Dielectrics with Insulating Properties

Contract ECEE-UPB/AMCSIT nr. 234/20.07.2006

PROJECT SUMMARY

Coordinator:	UPB/ECEE	Project director Prof.dr.ing. Florin CIUPRINA
Partner 1:	ICECHIM	Project responsible, Dr.ing. Denis PANAITESCU
Partner 2:	INCDIE ICPE-CA	Project responsible, Dr.chim. Traian ZAHARESCU
Partner 3:	SC ETN-EE	Project responsible, Ing. Costica HOLBAN

The outcome of the CEEX-PoNaDIP research project comprises methodologies and prototype recipes for manufacturing polymer nanocomposite dielectrics (nanodielectrics), characterization and modeling techniques for a comprehensive and highly accurate analysis of nanodielectrics with insulating properties and final products made of selected nanodielectrics to be used in electronic equipment. More precisely, the main results can be grouped together in:

- Methodologies for the realization of nanodielectrics from thermoplastic polymers (PE, PP and PVC) having either inorganic nanofillers (SiO_2, TiO_2, Al_2O_3) or organic nanofillers (cellulose fibers);
- Methodologies for the realization of nanodielectrics from thermoset polymers (epoxy resin) and inorganic nanofillers (SiO_2, TiO_2, Al_2O_3);
- Methodologies and techniques for the characterization of polymer nanocomposites from the point of view of their electrical, mechanical and thermo-oxidative properties.
- Methodologies for the characterization of the structure of nanodielectrics;
- Models for analyzing the electric field distribution in nanodielectrics;
- Models to explain the interactions between nanoparticles and the polymer matrix inside the nanodielectrics;
- Coil holder for impulse transformers made of selected nanodielectrics.

The project have enlarged the reservoir of studies, models, theories concerning polymer nanodielectrics, and of the new methods and techniques of manufacturing and characterization of polymer nanocomposites with high performances

The main steps of the research were:

1) Designing and manufacturing of plaque type samples of about 1 mm thickness from different polymer-filler combinations, by using either thermoplastic (PE, PP, and PVC) or thermoset (epoxy) resins with fillers as silica (SiO_2), titania (TiO_2), cellulose fibers, layered silicates, etc. The average dimensions of the inorganic nanofillers were 15 - 200 nm, whereas for organic fillers they were between 200 nm and 20 µm. The filler with a concentration between 1 and 10 wt% was homogeneously dispersed in the polymer matrix.
2) Characterization and analysis of polymer nanocomposite specimens concerning both nanostructure (FTIR, DSC, X-ray diffraction, electronic microscopy) and macroscopic behavior (electrical, thermal, mechanical properties and flammability)
3) Correlation of the experimental results from the structure-property relationship aiming the fundamental understanding of interfaces, and

advanced modeling both at nanoscale and at macroscopic scale of the phenomena in the polymer nanocomposites experimentally tested under different stresses (electric field, heat, humidity, radiation, oxygen).

4) Manufacturing of final products based on some nanocomposites selected during the previous analysis and characterization of these products from the point of view of mechanical, thermal, electrical properties and flammability aiming the establishing of their possible industrial applications.

The complex project proposed had scientific, technical, economic and social objectives, all of them in accordance with the objectives of the European platform PT4 – EuMaT and of the related platforms SusChem, ENIAC and Manufuture, of the national program CEEX, as well as with the strategies of the European research frame programs, the national strategy in the domain of the partners involved. The research made in common by the consortium constituted for this project has contributed to combining the theoretical and experimental techniques of the partners, aiming the creation of a **pole for research of excellence in the domain of polymer nanocomposite dielectrics**. We have to note that the diversity of the specializations of the researchers involved in the project (electrical engineering, chemistry, computer science, informatics, physics and mathematics) is in accordance with the diversity of the approached domain. In this way, another benefit of such a pole will be the collection of modern techniques for designing, manufacturing and characterization of new materials from the point of view of nanostructure and of the macroscopic properties. This gives excellent opportunities for transfer of knowledge and mutual stimulation of new research.

Besides the high level scientific results, the proposed research project has aimed to attract and train young PhD Romanian students in the domain of the development of new nanometric dielectrics. In this respect, even from the first stage of the project activities aiming the attraction and training of young graduates have been conceived. These activities included workshops attended by numerous PhD students. Some of them were part of the research teams constituted even from the project proposal stage, whereas two Ph.D. students (Ing. Ilona Plesa – UPB/ELMAT and Ing. Adriana Ciucu – ICECHIM) joined the project during its course. They enrolled to the PhD choosing as topic the domain of polymeric nanocomposites and they were hired in the frame of CEEX-PoNaDIP. A part of the scientific results obtained were disseminated by 16 scientific communications at prestigious international and national conferences, as well as by the publishing of 3 articles in ISI indexed journals, thus contributing to the increase of the visibility of the partners of the CEEX-PoNaDIP consortium, both nationally and internationally.

The contribution to the project of each partner can be summarized as follows:

UPB/ELMAT coordinated the whole activity of the complex project, characterized the samples from the point of view of electric properties (absorption resorption currents, resistivity, permittivity, loss factor, dielectric strength, dielectric spectroscopy), developed models for the analysis of the electric field distribution in nanodielectrics and for the computation of the equivalent permittivity, facilitated the access to high performance equipments (own and of European partners) and has elaborated methodologies and techniques for the characterization of the nanodielectrics regarding their electrical properties.

ICECHIM manufactured samples at laboratory level (as plaques or pallets) of nanocomposites with thermoplastic and thermoset polymer matrices, by using themo-mechanical and chemical-mechanical processes as well as non-conventional techniques for the treatment of organic and inorganic nanofillings. has offered its complementary expertise to the characterization of materials by revealing the nanostructure of the composite material (DSC, X ray diffraction and electronic microscopy), as well as mechanical characterization of the new manufactured nanocomposites and has elaborated methodologies for the realization of the nanodielctrics and methodologies for the characterization of the nanodielectrics regarding their structure and mechanical properties.

ICPE-CA offered its complementary expertise for the characterization of the oxidation state of nanocomposites stability under thermal and gamma radiation stresses and has elaborated methodologies for the characterization of the nanodielectrics regarding their resistance against radiation and their thermo-oxidative properties.

ETN-EE realized and has characterized prototypes of finite products (coil holder for impulse transformers) based on selected polymeric nanocomposites, and has played an essential role in the valorification of the research results.

All the partners used the experimental results obtained on the samples of polymer nanocomposites tested in the frame of this project, by correlating the information related to the structure with the properties of the new materials and making proposals of new models to explain the structure-properties relationships, as well as to the dissemination of the results.