PROJECT TITLE: High Accuracy Photopyroelectric Calorimetry for Magnetic Nanofluids
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Progress Report 3

General Objective: PPE calorimetry for thermal effusivity investigation of magnetic nanofluids.

1. Selection of the detection configuration, draw up of the theoretical equations and setup of experimental parameters for the measurement of the thermal effusivity.

In order to investigate the thermal effusivity of the magnetic nanofluids, the front detection configuration was selected. Two types of detection cells have been considered: (i) a 2-layers detection cell together with the frequency scanning procedure and (ii) a 4-layers detection cell together with the coupling fluidõs thickness scanning. The information was collected always from the phase of the FPPE signal. Restrictions of thermally thin and optically opaque regime for the sensor were imposed. In order to correlate the theory with experiment 215 µm and 100 µm thick $LiTaO_3$ pyroelectric sensors have been used, the frequency scanning range being 0.2Hz - 5Hz in the case of thickness scanning procedure and 0.1Hz - 50Hz in the case of frequency scanning procedure.

2. Increase of the performances of the PPE calorimetry for thermal effusivity investigations.

An experimental set-up based on the thickness scanning procedure (TWRC method) with a minimum scanning step of 30 nm was designed. This approach eliminates the errors of the exact measurement of the sampleõs thickness. The information is collected from the phase of the BPPE signal (and not from the amplitude). The type of the coupling fluid can be selected in order to assure the best accuracy of the measurement. The best method for data processing was a fitting procedure with two fitting parameters: the exact value of the coupling liquidõs thickness and the value of the sampleõs thermal effusivity. The final sensitivity and accuracy of the results depend on the difference between the thermal effusivities of the sample and coupling fluid and, this is why water and ethylene glycol have been selected as best coupling fluids in our investigations.

From experimental point of view, a special detection cell was designed for sampleõs accommodation; it prevents any leakage and evaporation of the sample. The thickness scanning procedure was performed with a special picomotor involving loop control. Special computer programs, based on LW software, were made both for data processing and acquisition.

Present stage of the research (stages 1+2+3)

As one can see from the indexes of performance (papers published in ISI journals or presented at international conferences) counted on EVOC platform, during the first 3 stages of this research we focused our attention on the selection of the best photothermal technique and on the optimization of its performances for thermal characterization of magnetic nanofluids. We approached all the PT techniques available in our group: the photopyroelectric calorimetry (paper 4/2012; conf. 1/2011, conf. 2, 3, 4/2012) and photothermoelectric calorimetry (conf. 1, 3, 7/2012), photothermal radiometry (paper 3/2012; paper 2/2013) and thermography (paper 3/2013; conf. 5/2013), using sometimes combined techniques (paper 1/2011; paper 1/2012; conf. 1/2012; conf. 6, 8, 9/2013). The research concerning the optimization of the previously mentioned techniques concerned liquid materials (paper

3/2012; paper 2/2013) but also solid materials, inserted sometimes as layers in the detection configuration (FPPE as example) (paper 2/2012; paper 1/2013; conf. 4/2013). Finally, having in mind the experience of the group, we selected as most suitable the PPE technique, and optimized it for thermal characterization of magnetic nanofluids. At this stage we are able to investigate both thermal diffusivity and effusivity of liquids with high enough accuracy.

Concerning the application to nanofluids there are already some preliminary investigations both on magnetic and non-magnetic nanofluids (paper 4/2013, conf. 5, 6/2012; conf. 2, 10, 11/2013).

Indexes of performance (stages 1+2+3)

ISI journals

1. Self-consistent measurement of all thermal parameters of a liquid by FPPE-TWRC technique, D. Dadarlat and M. N. Pop, AIP Conf. Proc. 1425, 13 (2012)

2. Contact and non-contact photothermal calorimetry for investigation of condensed matter. Trends and recent developments, D. Dadarlat, J. Therm. Analysis Calor. 110, 27-35 (2012)

3. Self-consistent Photopyroelectric Calorimetry for Liquids , D. Dadarlat, M. N. Pop, Int. J. Thermal Sciences, 56, 19-22 (2012)

4. Photothermal Calorimetric Techniques Applied to Condensed Matter Materials, D. Dadarlat, Proc SPIE, 8411, 84110T 1-10 (2012)

5. Photopyroelectric (PPE) Calorimetry of Composite Materials. , D. Dadarlat, M. N. Pop, O. Onija, M. Streza, M. M. Pop, S. Longuemart, M. Depriester, A. H. Sahraoui, V. Simon, J. Therm. Analysis Calor. 111, 1129-1132 (2013)

6. Improved methods for measuring thermal parameters of liquid samples using photothermal infrared radiometry, M. Kuriakose, M. Depriester, D. Dadarlat and A. Hadj Sahraoui, Meas. Sci. Technol. 24 025603 (2013)

7. Photopyroelectric Calorimetry of Magnetic Nanofluids. Effect of Type of Surfactant and Magnetic Field. , D. Dadarlat S. Longuemart , R. Turcu , M. Streza , L. Vekas , A. Hadj Sahraoui, Int. Jour. Thermophys., 2013- accepted

International conferences

1. Frequency versus thickness scanning as self-consistent procedures in the photopyroelectric calorimetry, D. Dadarlat , 41th Winter School on Wave and Quantum Acoustics, Szczyrk, Poland, 27 Feb-03 March, 2012

2. Recent Developments in the Photopyroelectric Calorimetry of Condensed Matter, D. Dadarlat , Second Mediterranean International Workshop on Photoacoustic and Photothermal Phenomena, Erice, Italy,19-26 April 2012 ï invited

3. Basic aspects of the Photopyroelectric Method, D. Dadarlat , Second Mediterranean International Workshop on Photoacoustic and Photothermal Phenomena, Erice, Italy, 19- 26 April 2012 - invited

4. Photothermal Calorimetric Techniques Applied to Condensed Matter Materials D. Dadarlat, Advanced Topics on Optoelectronics Microelectronics and Nanotechnologies, Constanta, 23-26 august, 2012- invited

5. Functionalized polymer based magnetic nanostructures with controlled properties for magnetic drug targetingò, R. Turcu, I. Craciunescu, A. Nan, C. Daia, R. Tietze, J. Liebscher, C. Alexiou, L. Vekas , Conference ĂColloids and Nanomedicine 2012ò, Amsterdam, 15-17 iulie 2012

6. Hybrid particles based on nanosized magnetite encapsulated into polymers/copolymers R.Turcu, A. Nan, I. Craciunescu, L. Vekas , 10th Conference on Colloid Chemistry, Budapesta, 29-31 August 2012

7. A New Photothermal Calorimetry: the Photothermoelectric (PTE) Technique D. Dadarlat M. Streza, M. Kuriakose, M. Depriester, A. Hadj Sahraoui , 42th Winter School on Wave and Quantum Acoustics, Szczyrk, Poland, 25 Feb-01 March, 2013

8. Photopyroelectric Calorimetry of Magnetic Nanofluids. Effect of Type of Surfactant and Magnetic Field , D. Dadarlat S. Longuemart , R. Turcu , M. Streza , L. Vekas , A. Hadj Sahraoui , 42th Winter School on Wave and Quantum Acoustics, Szczyrk, Poland, 25 Feb-01 March, 2013

9. Photothermoelectric (PTE) versus photopyroelectric (PPE) calorimetry for thermal characterization of solids, D. Dadarlat, Central and Eastern European Conference for Thermal Analysis and Calorimetry (CEEC-TAC2), Vilnius, Lithuania, 27 ï 30 Aug. 2013.

10. Complementary photothermal techniques for complete thermal inspection of solids**,** D. Dadarlat , M. Streza, O. Onija, K. Strzalkowski, C. Prejmerean, D. Prodan, L. Silaghi-Dumitrescu, N. Cobirzan, Conference on Photoacoustic and Photothermal Theory and Applications (CPPTA), Varsovia, Polonia, 25-27 Sept. 2013.

11. Measurement of the thermal parameters of selected II-VI crystals by means of photopyroelectric methods and infrared lock-in thermography, K. Strzağkowski, D. Dadarlat, M. Streza, A. Marasek, Conference on Photoacoustic and Photothermal Theory and Applications (CPPTA), Varsovia, Polonia, 25-27 Sept. 2013.

13. Alternative contact photothermal techniques for thermal inspection of solids, D. Dadarlat, Processes in Isotopes and Molecules, Cluj-Napoca, 25-27 sept 2013

14. Thermophysical analysis of II-VI semiconductors by PPE calorimetry and lock-in thermography, K. Strzalkowski, D. Dadarlat, M. Streza, Processes in Isotopes and Molecules, Cluj-Napoca, 25-27 sept 2013

15. Polymer coated magnetic nanoparticle clusters, R. Turcu, I. Craciunescu, A. Petran, V. Socoliuc, C. Daia, O. Marinica, C. Leostean, L. Vekas, Processes in Isotopes and Molecules, Cluj-Napoca, 25-27 sept 2013

16. Stimuli responsive magnetic nanogels for different biomedical applications, I. Craciunescu, A. Petran, C. Daia, O. Marinica, L. Vekas, R. Turcu, Processes in Isotopes and Molecules, Cluj-Napoca, 25-27 sept 2013

Detailed results of this stage can be found in Research Report 3 (Romanian) and in the above mentioned disseminated papers.