

COST Action MP1106

Smart and green interfaces - from single bubbles and drops to industrial, environmental and biomedical applications (SGI)

FINAL ACHIEVEMENT REPORT (11/05/2012 – 10/05/2016)

This report on the full lifetime of the Action is submitted by the MC Chair on behalf of the Management Committee.

Confidentiality: This report, other than section II.D, is non-confidential. Section II.D is confidential to the Management Committee and the COST Association (including the Committee of Senior Officials, Scientific Committee and Administration).

Executive summary of the Achievement Report:

The diversity of gas/liquid, liquid/liquid and gas/liquid/solid interfaces in industrial environmental and biomedical applications but also in everyday life demands a well concerted effort and complementary work by scientists in different fields. Smart interfaces are those that can accomplish a technological task with high efficiency, adaptability and selectivity. Green interfaces are those that are eco-friendly (biodegradable, reusable, more durable, less energy consuming to produce). The scientific objective of the MP1106 COST Action was to identify and implement best strategies and means to tailor Smart & Green interfaces and accurately control their performance by concerted action of the most active European research institutes and companies in the field. A further objective of the Action was to organize a Europe-wide interdisciplinary cooperation platform directed towards scientific added value and improvement of industrial/environmental/medical applications concerning smart and green interfaces. To meet these challenges the Action brought together science and technology teams from Europe (and beyond) to reinforce academia-industry interaction. The Action was structured in four Working Groups (Fundamentals, Materials, Diagnostics, Industrial Technology) covering different aspects of the topic. The aim of the Working Groups was (a) to improve the fundamental understanding of interface structure and its evolution by combining theoretical development, numerical techniques and novel experimental techniques, (b) Develop new materials relevant to creation of Smart and Green interfaces e.g. surfactants, macromolecules, structured solid surfaces etc, (c) Develop novel and improve existing diagnostic techniques referring to properties of single or multiple interfaces and to general real/life applications, and (d) Develop or improve marketed industrial technologies spanning from consumer end-products to classical industrial processes and to computational tools for design and optimization. The approach of the Action was to combine small scale phenomena and large scale applications with research across the disciplines and through the scales. The scope was to identify current knowledge gaps and suggest ways to overcome them. The Action has organized nine combined WG1-4 meetings



which were ideal forums for the exchange of results and information across the WGs. The Action has organized six Training Schools which constituted an excellent opportunity for Early Stage Researchers to get first hand knowledge on modern experimental techniques and theoretical analyses whereas TS was on cultivating their entrepreneurship skills. There were four Annual Workshops which were all jointly organized with the annual international conference on Smart and Green Interfaces. The latter was a great opportunity to disseminate the outcomes of the Action activities to a broader scientific community. In addition, there were six MC meetings and a Core Group meeting. From the 54 STSMs, 41 were conducted by ESRs (22 by females). STSMs resulted in advancement of the fellows careers and led to common publications. Sixteen Inclusiveness Target Countries participated in the Action (32 in total). More than 230 scientific articles have been published with acknowledgement to the Action and 9 Patents have been filed. The MP1106 Action acted as a springboard for collaborative funding applications: several joint applications have been submitted both to EU and national programs.

Summary assessment of outcomes and impacts by Action Rapporteur:

(max.500 words) (to be transferred by COST Association from Action Rapporteur report)

SO enters Action Rapporteur 500 word summary here.

Action Rapporteur

Name

Institution

Country

Validation by Scientific Committee

This report was validated by the Scientific Committee on: <COST insert date of SC validation

I. Achievement Report

I.A. COST Action Profile

Objective/ Aim

The main objective of the Action is to organize a European interdisciplinary cooperation platform directed towards scientific added value and improvement of industrial, environmental and medical applications concerning interfaces, bubbles and drops.

Details

MoU:	4181/11	Start of Action:	11/05/2012
CSO approval date:	01/12/2011	End of Action:	10/05/2016

COST Member Countries and Cooperating State having accepted the MoU

Parties							
Country	Date	Country	Date	Country	Date	Country	Date
Austria	30/01/2012	Belgium	09/02/2012	Bosnia and Herzegovina	26/06/2014	Bulgaria	20/01/2012
Croatia	11/01/2012	Czech Republic	10/02/2012	Denmark	29/03/2012	Estonia	11/04/2012
Finland	03/05/2012	France	23/03/2012	Germany	18/01/2012	Greece	23/01/2012
Hungary	05/03/2012	Ireland	16/01/2012	Israel	27/12/2011	Italy	13/01/2012
Latvia	07/11/2012	Lithuania	23/05/2013	Luxembourg	27/04/2012	Netherlands	17/01/2012
Norway	02/02/2012	Poland	18/01/2012	Portugal	06/01/2012	Romania	15/03/2012
Serbia	24/02/2012	Slovakia	23/03/2012	Slovenia	05/01/2012	Spain	04/01/2012
Sweden	09/08/2013	Switzerland	14/12/2012	Turkey	15/03/2012	United Kingdom	09/12/2011

Total: 32

Intentions to Accept the MoU

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Other participants:

Institution Name	Country
University of Alberta	Canada
Lafayette College	USA
Ian Wark Research Institute	Australia
University of Auckland	New Zealand
NC PHEP Belarusian State University	Belarus

Contacts

Chair/ Vice Chair

Position	Name	Contact details	Country	Date of PhD	Gender
Chair:	Professor Thodoris D Karapantsios	Aristotle University of Thessaloniki School of Chemistry, Univ. Tel. +302310997772	Greece	1994	M

		Fax +302310997759 karapant@chem.auth.gr Box 116 54124 Thessaloniki Greece			
Vice Chair:	Dr Libero Liggieri	Istituto per l'Energetica e le Interfasi, Consiglio Nazionale delle Ricerche via De Marini, 6 16149 Genova Italy Tel. +390106475722 Fax +390106475700 l.liggieri@ge.ieni.cnr.it	Italy		M

Working Group Leaders

WG#	WG Title	WG Leader	Country	Date of PhD	Gender	Number of participants
1	Fundamentals	Victor Starov	UK	1973	M	177
2	Materials	Victoria Dutschk	NL	2000	F	160
3	Diagnostics	Reinhard Miller	DE	1978	M	79
4	Technology	Norman McMillan	IE		M	109

Other positions if applicable (STSM Coordinator, WG Vice Leader, Task Force Leader...)

Position	Name	Country	Date of PhD	Gender
STSM Coordinator	Mustafa Ersoz	TR	1994	M
	Sergio Caserta	IT	2004	M
ESRG Leader	John Lioumbas	GR	2006	M

Action website: <http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml>

I.B. Achievement of MoU objectives and deliverables and additional outputs

MoU objectives

MoU objective	Achieved Yes/ Partially/ No	Evidence of (partial) achievement
The main objective of the Action is to organize a European interdisciplinary cooperation platform directed towards scientific added value and improvement of industrial, environmental and medical applications concerning interfaces, bubbles and drops.	Yes	<p>The Action attained a large visibility in the science community that grew with the years. At the end of the Action there are more than 430 registered members at the 4 WGs of the Action https://docs.google.com/document/d/1zGnV0-9d5VH-MNCyFJRoc1w0ccOwEwV5voffAkm1d-s/edit?pli=1 Members are from both academia and the market (industry, companies etc)</p> <p>The Action has organized a large number of events such as WG meetings, Training Schools, STSMs. More important, the Action has supported a new series of international conferences: Smart and Green Interfaces with the first organized in 2013 and the fourth in 2016 http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml</p> <p>The collaborative work and advancements made in the first 2 years of the Action have been summarized in a Review paper prepared by the officers of the Action in one of the most prominent scientific journal in the field V. Dutschk, T. Karapantsios*, L. Liggieri, N. McMillan, R. Miller and V.M. Starov, "Smart and green interfaces: from single bubbles/drops to industrial environmental and biomedical applications", ACISci., 209, 109-126, 2014, http://dx.doi.org/10.1016/j.cis.2014.02.020 A similar effort as regards an CRC edited volume has been undertaken for the end of the Action and currently feedback and potential contributions is collected from members. This volume will be devoted to a Review of Smart and Green Interface Instrumentation and its Commercialisation</p> <p>In addition, the Action has organised six Thematic Cluster on hot science topics whose members spanned horizontally across the Working Groups of</p>

		<p>the Action Thematic clusters had dedicated sessions in every event of the Action. The six Thematic clusters were:</p> <ol style="list-style-type: none"> 1. Nanomaterials and Nanotechnologies 2. Nanostructured Materials for Water Treatment and Purification 3. Medical Diagnostics and Advanced Therapies, 4. Sustainable Food Science and Technology, 5. Heat and Mass Transfer on a Solid Substrate, 6. Wetting of complex surfaces,
<p>Improvement of the fundamental understanding of the general interface structure and evolution dynamics. This will be achieved by a combination of theoretical development, the implementation of novel numerical techniques for solution of the governing equations and the exploitation of novel experimental techniques concerning both single and multiple interfaces</p>	Yes	<p>This can be seen in the developments reported in publications in peer reviewed journals and presented in various meetings organized by the Action and beyond. In particular, Action meetings included sessions devoted to deal with specific knowledge gaps http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml</p> <p>Indicative highlights:</p> <p>V. Preziosi, G. Tomaiuolo, M. Fenizia, S. Caserta, S. Guido, Confined tube flow of low viscosity emulsions: Effect of matrix elasticity, Journal of Rheology, 60, 419 (2016), DOI: 10.1122/1.4943987.</p> <p>J. Zawala, D. Kosior, T. Dabros, K. Malysa, "Influence of bubble surface fluidity on collision kinetics and attachment to hydrophobic solids", Colloids Surfaces A, (2016) doi:10.1016/j.colsurfa.2015.12.023</p> <p>N. Pagureva, S. Tcholakova, K. Golemanov, N. Denkov, E. Pelan, S. D. Stoyanov, Surface Properties of Adsorption Layers Formed from Triterpenoid and Steroid Saponins. Colloids and Surfaces A, 491 (2016) 18–28</p> <p>M. Lotfi, A. Javadi, S.V. Lylyk, D. Bastani, V.B. Fainerman and R. Miller, Adsorption of proteins at the solution/air interface influenced by added non-ionic surfactants at very low concentrations for both components. 1. Dodecyl dimethyl phosphine oxide, Colloids Surfaces A, 475 (2015) 62–68.</p>

	<p>John S Lioumbas; Evanthia Georgiou; Margaritis Kostoglou and Thodoris D. Karapantsios*, “Foam free drainage and bubbles size for surfactant concentrations below the CMC” Colloids and Surfaces A, 487 (2015) 92-103</p> <p>E. Guzmán, E. Santini, M. Ferrari, L. Liggieri, F. Ravera, Interfacial Properties of Mixed DPPC–Hydrophobic Fumed Silica Nanoparticle Layers. J. Phys. Chem. C, 119 (2015), pp 21024–21034. DOI: 10.1021/acs.jpcc.5b07258.</p> <p>Sotiris P Evgenidis; Thodoris Karapantsios, “Effect of bubble size on void fraction fluctuations in dispersed bubble flows” International Journal of Multiphase Flow, 75, 163-173, 2015.</p> <p>Kramek-Romanowska et al. Dynamic tensiometry studies on interactions of novel therapeutic inhalable powders with model pulmonary surfactant at the air-water interface. Colloids Surfaces A. 480 (2015) 149-158</p> <p>Jeromen, Andrej, Govekar, Edvard. Modelling of resonant droplet detachment in laser metal droplet generation. Physics procedia, 2012, vol. 39, pp. 863-871, doi: 10.1016/j.phpro.2012.10.111</p> <p>Abi Chebel N., Vejražka J., Masbernati O., Risso F.: Shape Oscillations of an Oil Drop Rising in Water: Effect of Surface Contamination. J. Fluid Mech. 702, 533-542 (2012).</p> <p>E. Guzman, E. Santini, L. Liggieri, F. Ravera, G. Loglio J. Krägel, A. Maestro, R.G. Rubio, D. Grigoriev and R. Miller, Particle-surfactant interaction at liquid interfaces, in “Progress in Colloid Interface Science”, Vol. 4, P. Kralchevsky, R. Miller and F. Ravera (Eds.), 2013, Chapter 4, p. 77-109.</p> <p>E.Santini, E. Guzmán, M. Ferrari, L. Liggieri, Emulsions stabilized by the interaction of silica nanoparticles and palmitic acid at the water–hexane</p>
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		<p>interface. Colloids and Surfaces A: Physicochem. Eng. Aspects. 2014 In press. http://dx.doi.org/10.1016/j.colsurfa.2014.02.054</p> <p>Wylock, S. Dehaeck, D.A. Quintans, P. Colinet and B. Haut, "CO₂ absorption in aqueous solutions of N-(2-hydroxyethyl)piperazine: experimental characterization using interferometry and modeling", Chem. Eng. Sci. 100, 249-258 (2013); doi: 10.1016/j.ces.2013.02.068.</p> <p>P Sinha, I Szilágyi, F-J M Ruiz-Cabello, P Maroni, M Borkovec, Attractive forces between charged colloidal particles induced by multivalent ions revealed by confronting aggregation and direct force measurements, Journal of Physical Chemistry Letters 4 (2013) 648.</p> <p>V Dutschk, T Karapantsios, L Liggieri, N McMillan, R Miller, VM Starov, Smart and green interfaces: From single bubble/drops to industrial environmental and biomedical applications, Adv Colloid Interfac 209 (2014) 109-126.</p> <p>L. Lanotte, G. Tomaiuolo, C. Misbah, L. Bureau, S. Guido. "Red blood cell dynamics in polymer brush-coated microcapillaries: A model of endothelia glycocalyx in vitro", Biomicrofluidics, 8, 014104, 2014.</p>
Development of new materials relevant to creation of Smart and Green interfaces. These materials cover the whole span of size range and it can be surfactants, macromolecules, solid surfaces, solid foams, aerosol particles.	Yes	<p>This can be seen in the developments reported during the various meetings organized by the Action http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml</p> <p>Indicative highlights:</p> <p>N. Denkov, S. Tcholakova, I. Lesov, D. Cholakova, S. K. Smoukov. Self-Shaping of Oil Droplets via the Formation of Intermediate Rotator Phases upon Cooling. Nature 528 (2015) 392–395</p> <p>Sami Rtimi, Cesar Pulgarin, Michael Bensimon, John</p>

		<p>Kiwi, Evidence for TiON sputtered surfaces showing accelerated antibacterial activity under solar irradiation, <i>Solar En.</i>, 2013, 93, 55-62.</p> <p>Sosnowski T.R., Kurowska A., Butruk B. Jabłczyńska K. (2013). Spraying of cell colloids in medical atomizers, <i>Chem. Eng. Transact.</i> 32, 2013, 2257-2262. (full paper - DOI: 10.3303/CET332377)</p> <p>S Rtimi, O Baghriche, C Pulgarin, J-C Lavanchy, J Kiwi, Growth of TiO₂/Cu by HIPIMS for accelerated bacterial loss of viability, <i>Surf. & Coat. Technol.</i> 232 (2013) 804-813.</p> <p>Ampatzidis C. D., Varka E-M., Karapantsios* T. D., "Adsorption Behavior Of Non-Conventional Eco-Friendly Tyrosine Glycerol Ether Surfactants" <i>Colloids Surfaces A: Physicochem. Eng. Aspects</i>, 438, 104– 111, 2013, http://dx.doi.org/10.1016/j.colsurfa.2012.12.039.</p> <p>J Kiwi, S Rtimi, C Pulgarin, Chapter 'Cu, Cu/TiO₂ thin films sputtered by up to date methods on non-thermal thin resistant substrates leading to bacterial inactivation' v1, p.74-82, 2013 in: Book: 'Microbial pathogens and strategies for combating them: science, technology and education: Editor: A. Méndez-Vilas Publisher: Formatex Research Center ISBN (13).</p> <p>M Rutkevičius, VN Paunov, GH Mehl, SD Stoyanov, Q Qin, PA Rubini, J Petkov, Sound absorption properties of porous composites fabricated by a hydrogel templating technique", <i>Journal of Materials Research</i> 28/17 (2013) 2409-2414.</p> <p>J Borovička, SD Stoyanov, VN Paunov, Shape and size recognition of microbial cells by colloidal cell imprints, <i>Nanoscale</i> 5 (2013) 8560 - 8568.</p> <p>W Small, SD Stoyanov, VN Paunov, Scaffold Free Fabrication of Linear Multicellular Assemblies by Dielectrophoretic Hydrogel Trapping Technique, <i>Biomaterial Science</i> 1 (2013) 996 – 1002.</p>
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<p>Development of novel and improvement of existing diagnostic techniques employing knowledge emerged from the first two objectives. The term diagnostics refers to the identification of the properties of the interfaces and to general real/life applications (e.g. medical diagnosis) in which interfaces/bubbles/drops intervenes.</p>	Yes	<p>This can be seen in the developments reported during the various meetings organized by the Action http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml</p> <p>Indicative highlights:</p> <p>I.T. Horvath, P. Colinet, M.R. Vetrano, Assessment of the light extinction spectroscopy technique for submicron particle characterization, <i>Powder Technology</i> 291 (2016) 375–382</p> <p>R. D'Apolito, F. Taraballi, S. Minardi, X. Liu, S. Caserta, A. Cevenini, E. Tasciotti, G. Tomaiuolo, S. Guido, Microfluidic interactions between red blood cells and drug carriers by image analysis techniques, <i>Medical Engineering & Physics</i> 38, 1, pp. 17-23, DOI: http://dx.doi.org/10.1016/j.medengphy.2015.10.005</p> <p>Margaritis Kostoglou, Thodoris D. Karapantsios,, “On the identification of liquid surface properties using liquid bridges”, <i>AdvCIS</i>, 222, 436-445, 2015 http://dx.doi.org/10.1016/j.cis.2014.04.007</p>

		<p>John S. Lioumbas, Ariadni Chatzidafni, Thodoris D. Karapantsios, Spatial Considerations on Electrical Resistance Tomography Measurements, Measurement Science and Technology, 25 (5), 055303 (12pp) 2014, doi:10.1088/0957-0233/25/5/055303</p> <p>Margaritis Kostoglou, Thodoris D. Karapantsios, Analysis of bubble-in-liquid bridge configuration as prototype for studying foam dynamics. Zero bond number case. Colloids Surfaces A: Physicochem. Eng. Aspects 460, 386-390, 2014, DOI: 10.1016/j.colsurfa.2013.12.045</p> <p>A. Javadi, J. Krägel, M. Karbaschi, J.Y. Won, A. Dan, A.V. Makievski, G. Loglio, L. Liggieri, F. Ravera, N.M. Kovalchuk, V.I. Kovalchuk and R. Miller, Capillary pressure experiments with single drops, in "Progress in Colloid Interface Science", Vol. 4, P. Kralchevsky, R. Miller and F. Ravera (Eds.), 2013, Chapter 13, p. 271-312.</p> <p>Javadi, N. Mucic, M. Karbaschi, J.Y. Won, M. Lotfi, A. Dan, V. Ulaganathan, G. Gochev, A.V. Makievski, V.I. Kovalchuk, N.M. Kovalchuk, J. Krägel and R. Miller, Characterization methods for liquid interfacial layers, Eur. Phys. J. Special Topics 222 (2013) 7–29.</p> <p>A. Dan, G. Gochev, J. Krägel, E.V. Aksenenko, V.B. Fainerman and R. Miller, Interfacial rheology of mixed layers of food proteins and surfactants, COCIS, 18 (2013) 302–310</p> <p>J. Zawala, E. Malysa, M. Krzan, K. Malysa, "Monitoring of contamination of environmental and coal processing plants waters using the bubble velocity measurements – advantages and limitations", Physicochem. Probl. Miner. Process., 50(1) (2014) 143–157</p> <p>Lioumbas, J.S., Zamanis, A. & Karapantsios, T.D. 2013, "Towards a wicking rapid test for rejection assessment of reused fried oils: Results and analysis for extra virgin olive oil", Journal of Food</p>
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		<p>Engineering, 119, pp. 260-270.</p> <p>A. Pommella, V. Preziosi, S. Caserta, J.M. Cooper, S. Guido, M. Tassieri, "Using Optical Tweezers for the characterization of very low viscoelastic polyelectrolytes solutions", Langmuir, Volume 29, Issue 29, 23 July 2013</p> <p>S. Caserta, S. Campello, G. Tomaiuolo, L. Sabetta, S. Guido, "A methodology to study chemotaxis in 3D collagen gels", AIChE Journal 59(11) pages 4025-4035 2013.</p>
<p>Development or improvement of marketed industrial technologies and end user applications relevant to interfaces, bubbles and drops. The objective covers from consumer products to classical industrial processes and to computational tools for their design and optimization.</p>	Yes	<p>This can be seen in the developments reported by commercial and industrial participants during the various meetings organized by the Action http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml</p> <p>Indicative highlights:</p> <p>Viorel Nastasa, Kostas Samaras, Christos Ampatzidis, Thodoris Karapantsios, PhD; Mario A Trelles, Javier Moreno-Moraga, Adriana Smarandache, Mihail Pascu* "Properties of Polidocanol foam in view of its use in sclerotherapy" International Journal of Pharmaceutics, 478 (2), 588-596, 2015 doi:10.1016/j.ijpharm.2014.11.056</p> <p>John S. Lioumbas and Thodoris D. Karapantsios*, "Effect of Increased Gravitational Acceleration in Potato Deep-Fat Frying", Food Research International 55, 110–118, 2014, doi:10.1016/j.foodres.2013.10.044</p> <p>B Ahmad, S Stoyanov, E Pelan, E Stride, M Edirisinghe, Electrospinning of ethyl cellulose fibres with glass and steel needle configurations, Food Research International, 10.1016/j.foodres.2013.09.021, 2013.</p> <p>SA Hamad, SD Stoyanov, VN Paunov, Triggered Cell Release from Shellac-Cells Composite Microcapsules, MRS Proceedings, 1498, 2013.</p>

	<p>TR Sosnowski, A Kurowska, B Butruk, K Jabłczyńska, Spraying of cell colloids in medical atomizers, Chem. Eng. Transact. 32 (2013) 2257-2262. (full paper - DOI: 10.3303/CET332377</p> <p>M Ferrari, F Ravera, L Liggieri L Navarini, Interfacial Studies of Coffee-Based Beverages: From Flavor Perception to Biofuels, Surfactant Science and Technology: Retrospects and prospects (Taylor & Francis Group).</p> <p>Indicative <u>patents</u>:</p> <p>Karapantsios, T. D., Evgenidis, S. P., Zacharias, K., Karayiannis, G. "Innovative, non-invasive electrical impedance spectroscopy technique for prompt diagnosis of Coronary Artery Disease", Hellenic Industrial Property Organisation, submitted file Feb 2016.</p> <p>Karapantsios, T. D., Kostoglou, M., Evgenidis, S. P., Zamanis A., "A novel method for the determination of two fluids' interfacial tension and the study of liquid/liquid and liquid/gas interface stability", Hellenic Industrial Property Organisation, submitted file April 2016.</p> <p>Karapantsios, T. D., Evgenidis, S. P., Zacharias, K., Mesimeris, T., "Method for the detection and characterization of bubbles in liquids and device therefor, resp. system", European Patent Office, Application Number: EP14188200.1, 2014</p> <p>Lioumbas, J.L., Zamanis, A. and Karapantsios, T.D., "Rapid test for rejection of used oil by employing wicking in porous media", Hellenic Industrial Property Organisation, Patent Number 20140100445/2014</p> <p>AT Ashcroft, J Cao, VM Fawcett, EG Pelan, SD Stoyanov, W. Zhou, HJ Zhou, Liquid composition for cleaning of head surfaces, 2013, WO Patent 2,013,078,949.</p>
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MoU deliverables

MoU deliverable	Delivered Yes/ Partially/ No	Evidence of (partial) delivery
Networking between groups working on different aspects of S&G interfaces	Yes	<p>The Action attained a large visibility in the science community that grew with the years. At the end of the Action there are more than 430 registered members at the 4 WGs of the Action https://docs.google.com/document/d/1zGnV0-9d5VH-MNCyFJRoc1w0ccOwEwV5voffAkm1d-s/edit?pli=1 Members are from both academia and the market (industry, companies etc)</p> <p>The Action has organized a large number of events such as WG meetings, Training Schools, STSMs. More important, the Action has supported a new</p>

through organization of scientific events, training schools and STSMs		<p>series of international conferences: Smart and Green Interfaces with the first organized in 2013 and the fourth in 2016 http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml</p> <p>In addition, the Action has organised six Thematic Cluster on hot science topics whose members spanned horizontally across the Working Groups of the Action. The six Thematic clusters had dedicated sessions in every event of the Action. The six Thematic clusters were:</p> <ol style="list-style-type: none"> 1. Nanomaterials and Nanotechnologies 2. Nanostructured Materials for Water Treatment and Purification 3. Medical Diagnostics and Advanced Therapies, 4. Sustainable Food Science and Technology, 5. Heat and Mass Transfer on a Solid Substrate, 6. Wetting of complex surfaces,
Annual workshops	Yes	<p>The Action has linked its annual workshop to a new series of international conferences: Smart and Green Interfaces with the first organized in 2013 and the fourth in 2016. So annual workshops were organized jointly with SGI conferences, as follows:</p> <ul style="list-style-type: none"> • 1st Annual Workshop (13-14.09.2012, Dublin, Ireland) http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2012/01_Programme_Annual_Workshop_MP1106_2012.pdf • 2nd Annual Workshop "Smart and Green Interfaces (21-22.03.2013, Prague, Czech Republic) http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2013/Minutes_of_MC_meeting_Prague_21_March_2013_v1_.pdf • 3rd Annual Workshop "Smart and Green Interfaces" (22-24.04.14, Marseilles, France) http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2014/Minutes_of_MC_meeting_Marseille_2023%20April%202014_v4.pdf • 4th Annual Workshop "Smart and Green Interfaces", (2015, Belgrade, Serbia) http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2015/FlyerBelgrade.pdf • Annual Workshop "Smart and Green Interfaces" (4-6 May, 2016, Athens, Greece) http://sgic2016.com/

Annual WG meetings	Yes	<ul style="list-style-type: none"> Working Group meeting: Fluid/Fluid Interfaces in Science and Technology (Sofia, Bulgaria) http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml Working Group meeting: Smart and Green Interfaces: Multiphase flows with/without phase change, Zaragoza, Spain http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml Working Group meeting: Wetting of solids: Material and kinetic aspects, Cargese, France http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml Working Group meeting: Heat and Mass Transfer on a Solid Substrate Wetting of complex surfaces, Eindhoven, The Netherlands http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2014.xhtml Working Group meeting: Nanomaterials and Nanotechnologies and "Nanostructured Materials for Water Treatment/Purification, Antalya, Turkey http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2014.xhtml Working Group meeting: Medical Diagnostics and Advanced Therapies Sustainable Food Science and Technology, Napoli, Italy http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2014.xhtml Working Group meeting: Smart and green interfaces - achieving dynamic control and tuning of the nature of a solid surface's interfacial interactions with liquids and with soft matter, Nottingham, UK http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml Working Group meeting jointly with Bubble and drops Interfaces, Golm-Potsdam, Germany http://bd2015.mpikg.mpg.de/ Working Group meeting: Fundamentals and Diagnostics, Sofia, Bulgaria http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2015/Report_on_SGI-FunD_2015.pdf
Annual Training	Yes	<ul style="list-style-type: none"> Training School "A way to Smart Europe" (23–25.04.2013 Twente, Netherlands)

Schools		<p>http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2014.xhtml</p> <ul style="list-style-type: none"> • Cultivating Entrepreneurial Ideas, Thessaloniki, Greece http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml • Particles at Liquid Interfaces: Fundamentals and Applications, Bonassola, Italy http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2014/Announcement-COST Actions MP1106 and CM1101 Joint Training School on Particles at Liquid Interfaces.pdf • International Advanced Course in Liquid Interfaces, Drops and Sprays, Darmstadt, Germany. http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2014/LIDESP_Leaflet.pdf • Winter training school, "Kinetics of wetting/spreading of complex liquids", Loughborough, UK http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml • From Innovation to Entrepreneurship - Joint with cost Action TU1105, Thessaloniki, Greece http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml • Flows Stability and Marangoni effects, Madrid, Spain http://cost-mp1106.lcpe.uni-sofia.bg/files/Workshops/2015/CoWet_COST_MP1106_TS_schedule.pdf <p>A special TS was organized on "Cultivating Entrepreneurial ideas" which covered topics such as:</p> <ul style="list-style-type: none"> ➤ Introduction to Entrepreneurship and Basic issues in Management ➤ Entrepreneurship in new technologies ➤ Innovation, Creativity and Entrepreneurship ➤ Funding and Investment organizations (business angels, venture capital, crowd funding) ➤ Articulation and structure of a Business Plan <p>This TS included lectures, Workshops and computer Lab sessions</p>
STSMs (at least 10 per year & 70% for	Yes	<p>In total 54 STSMs were organized between labs in 19 countries. The total duration of STSMs was 1232 days. The number could have been higher if the budget of the Action had not been reduced in the last year of the Action. About 76% of the STSMs beneficiaries were ESRs. The budget spent for</p>

ESRs)		STSMs was about 10% of the total budget of the Action.
Industrial interface to market new technologies	Partially	In the scientific events many participants were from industries and commercial companies, like Shell, Unilever, TECLIS, Kruss Sinterface, Loufakis chemicals, Euro Heat Pipes etc, . In addition, several STSMs were performed between academic labs and companies http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml . However it proved difficult to maintain the presence of industries in all events through the years as they preferred bilateral collaborations with selected members instead of continuous exposure to the entire Action.

Co-authored publications and FP7/ H2020 proposals

The co-authored publications and FP7/ H2020 proposals/ projects resulting from the Action are listed on the page following the “Additional outputs and achievements” section.

Additional outputs and achievements

Please describe any other outputs and achievements, focusing in particular on those that contribute to the COST mission of “COST enables break-through scientific developments leading to new concepts and products and thereby contributes to strengthen Europe’s research and innovation capacities.”

The Action enabled the creation of collaborations between teams that led (a) to a number of publications that are considered as break-through scientific developments and (b) to a number of FP7 and H2020 project proposals targeting on new concepts and/or products. Especially towards the FP7 and H2020 proposals the Action organized six specific Thematic clusters that were meant to create partner consortium that would submit joint project proposals and also discuss commercialization and IP related matters

The Action organized a large number of events where the exchange of information and discussions among participants on specific knowledge gaps were direct and effective. Well-known scientists from around the globe were invited to give plenary lectures in annual workshops presenting the current state-of-the-art and arguing about future possibilities and trends. On this account, the Action has supported a new series of international conferences: Smart and Green Interfaces with the first organized in 2013 and the fourth in 2016. All annual workshops were jointly organized with these conferences which allowed bringing along also scientists from outside the Action to discuss common problems.

The collaborative work and advancements made in the Action were summarized in a Review paper prepared by the officers of the Action in one of the most prominent scientific journal in the field V. Dutschk, T. Karapantsios*, L. Liggieri, N. McMillan, R. Miller and V.M. Starov, “Smart and green interfaces: from single bubbles/drops to industrial environmental and biomedical applications”, ACISci., 209, 109-126, 2014, <http://dx.doi.org/10.1016/j.cis.2014.02.020> A similar effort as regards an CRC edited volume has been undertaken for the end of the Action and currently feedback and potential contributions is collected from members. This volume will be devoted to a Review of Smart and Green Interface Instrumentation and its Commercialization

Co-authored publications and FP7/ H2020 proposals

Co-authored publications

This table contains the (up to) ten most significant co-authored publications resulting from the Action. All publications are on the topic of the Action, co-authored by at least two Action participants from two different countries participating in the Action.

NO.	Bibliographic data (including: Title, Authors, Title of the periodical or the series, Issue number or volume, Publisher, Year of publication, Relevant pages)	Main author	Number of authors	Action participants listed among the authors (Name, country and role ¹)	WGs involved in publication	Date of submission (must be after Action start date)	Expected date of publication (if not already published)	Persistent link to publicly available version of the paper (if available) or the abstract	Is/Will open access ² provided to this publication?	Is/ will COST be cited/ acknowledged in the publication?	Are/ will COST funds (be) implicated in this publication	Relevance to H2020 Societal Challenges ³ ?	Is it peer-reviewed?	Was the added value of the Action Networking necessary for the publication	Impact Factor (if applicable)
1	V Dutschk, T Karapantsios, L Liggieri, N McMillan, R Miller, VM Starov, Smart and green interfaces: From single bubble/drops to industrial environmental and biomedical applications, Adv Colloid Interfac 209 (2014) 109-126.	T. Karapantsios	6	Dutschk NL MC Member Karapantsios GR MC Member Liggieri IT MC Member N McMillan UK MC Member Starov UK MC Member	1, 2, 3, 4		11.3.2014	http://www.science-direct.com/science/article/pii/S0001868614001080	NO	YES	YES	YES	YES	YES??	7.776
2	Viorel Nastasa, Kostas Samaras, Christos Ampatzidis, Thodoris Karapantsios, PhD; Mario A Trelles, Javier Moreno-Moraga, Adriana Smarandache, Mihail Pascu* "Properties of Polidocanol foam in view of its use in sclerotherapy" International Journal of Pharmaceutics, 478 (2), 588-596, 2015 doi:10.1016/j.ijpharm.2014.11.056	M. Pascu	8	Nastasa RO WG Member Samaras GR Trainee Ampatzidis GR Trainee Karapantsios GR MC Member Pascu RO MC Member	1, 2	7/10/2014	26/11/2014	http://www.science-direct.com/science/article/pii/S0378517314008710	NO	YES	YES	YES	YES	YES??	3.65
3	N. Denkov, S. Tcholakova, I. Lesov, D. Cholakova, S. K. Smoukov. Self-Shaping of Oil Droplets via the Formation of Intermediate Rotator Phases upon Cooling. Nature 528 (2015) 392–395	N. Denkov	5	Denkova BG MC Member Tcholakova BG WG Member Smoukov BG WG Member	2, 3	11/06/2015	09/12/2015	http://www.nature.com/nature/journal/v528/n7582/full/nature16189.html	NO	YES	YES	YES	YES	YES??	42.351
4	S.S. Dukhin, V.I. Kovalchuk, G.G. Gochev, M. Lotfi, M. Krzan, K. Malysa, R. Miller, "Dynamics of Rear Stagnant Cap Formation at the Surface of Spherical Bubbles Rising in Surfactant Solutions at large Reynolds numbers under conditions of Small Marangoni Number and Slow Sorption Kinetics", Advances Coll. Interface Sci., 222 (2015) 260–274	G.G. Gochev	7	Krzan PL WG Member Malysa PL MC Member Miller DE MC Member	1, 2		12/10/2015	http://www.science-direct.com/science/article/pii/S0001868614002656	NO	YES	YES	YES	YES	YES??	7.776
5	Semenov, S., Trybala, A., Rubio, R.G., Kovalchuk, N., Starov, V. & Velarde, M.G. 2014, "Simultaneous spreading and evaporation: Recent developments", Advances in Colloid and Interface Science, vol. 206, pp. 382-398.	Starov, V.	6	Trybala UK WG Member Rubio ES WG Member Starov UK MC Member	1, 2		4.09.2013	http://www.science-direct.com/science/article/pii/S000186861300095X	NO	YES	YES	YES	YES	YES??	7.776
6	Particle laden fluid interfaces: Dynamics and Interfacial rheology A.J. Mendoza, E. Guzmán, F. Martínez-Pedrero, H. Ritacco, R.G. Rubio, F. Ortega, V.M. Starov and R. Miller, Adv. Colloid Interface Sci., 206 (2014) 303–319	E. Guzmán R.G. Rubio Ortega, V.M	8	Rubio ES WG Member Starov UK MC Member Miller DE MC Member	1, 2		19.10.2013	http://www.science-direct.com/science/article/pii/S0001868613001255	NO	YES	YES	YES	YES	YES??	7.776
7	New evidence for TiO ₂ uniform surfaces leading to complete bacterial reduction in the dark, Critical issues, Jelena Nescic, Sami Rtimi, C. Hebert, Cesar Pulgarin, Goran M. Roglic and John Kiwi, Colloids and Surfaces B: Biointerfaces, 2014, 123,	Sami Rtimi Cesar Pulgarin	6	Rtimi FI WG Member Kiwi CH MC Member	1.	31.03.2014	07.10.2014	http://www.science-direct.com/science/article/pii/S0927776514005311	NO	YES	YES		YES	YES??	4.152

¹MC Member/ MC Substitute/ MC Observer/ WG Member/ Training School Trainee/ STSM Recipient/ Other Action Participant

²Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

³ H2020 Societal Challenges are "Health, demographic change and wellbeing"; "Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy"; "Secure, clean and efficient energy"; "Smart, green and integrated transport"; "Climate action, environment, resource efficiency and raw materials"; "Europe in a changing world - inclusive, innovative and reflective societies"; "Secure societies - protecting freedom and security of Europe and its citizens"

	593-599.																
8	Transition from Spherical to Irregular Dispersed Phase in Water/Oil Emulsions Schmitt, M., Limage, S., Grigoriev, D. O., Krägel, J., Dutschk, V., Vincent-Bonnieu, S., Miller, R., Antoni, M., , Langmuir, 30 (2014) , 4599-4604	M. Antoni	7	Dutschk	NL	MC Member	1,2,3	???	03/04/2013	http://pubs.acs.org/doi/abs/10.1021/la404766w	NO	YES	YES	YES	YES	YES??	4.457
				Miller	DE	MC Member								YES			
				Antoni	FR	MC Member											
9	Particle laden fluid interfaces: Dynamics and Interfacial rheology A.J. Mendoza, E. Guzmán, F. Martínez-Pedrero, H. Ritacco, R.G. Rubio, F. Ortega, V.M. Starov and R. Miller, Adv. Colloid Interface Sci., 206 (2014) 303–319	R. Miller	8	Rubio	ES	WG Member	1,2,3	???	19.10.2013	http://www.science-direct.com/science/article/pii/S0001868613001255	NO	YES	YES	YES	YES	YES??	7.776
				Starov	UK	MC Member								YES			
				Miller	DE	MC Member											
10	M. Lotfi, M. Karbaschi, A. Javadi, N. Mucic, J. Krägel, V.I. Kovalchuk, R.G. Rubio, V.B. Fainerman, R. Miller, Dynamics of liquid interfaces under various types of external perturbations, Current Opinion in Colloid & Interface Science, Volume 19, Issue 4, August 2014, Pages 309-319	V.B. Fainerman	9	Lotfi	DE	MC Member		1.2.2014	2.5.2014	http://www.science-direct.com/science/article/pii/S1359029414000442	NO	YES	YES	YES	YES	YES??	5.84
				Karbaschi	DE	MC Member											
				Javadi	DE	MC Member											
				Mucic	DE	MC Member											
				Rubio	ES	MC Member											
				Miller	DE	MC Member											

FP7/ H2020 Proposals and projects

This table contains FP7/ H2020 proposals/ projects spinning off from Action activities and including in the proposing consortium at least three Action participants from at least three different countries participating in the Action.

NO.	Title	Name and country of main proposer	Number of proposers	Action participants listed among the proposers (Name, country, role ³ in the Action)	Funding agency submitted to	Date submitted	Date results expected	Result	Call identifier	Relevance to H2020 Societal Challenges ⁴ ?	Was the added value of the Action Networking necessary for the proposal / project?
Projects											
1	Using the self-organisation of interfacially active agents for the generation of porous solids with physico-chemically well-controlled surface properties.	Wiebke Drenckhan	1	D. Langevin (FR, MC member), D. Weaire (IE, MC member),	ERC	2011	2012	funded	ERC Starting grant	New materials	yes
2	Complex Wetting Phenomena - CoWet	Tatiana Gambaryan-Roisman, DE	16	RG. Rubio (ES, WG member) V. Starov (UK, WG member) R. Miller (DE, MC Member) T.D. Karapantsios (GR, Action Chair)	EC FP7	20/10/2012		Started 01/02/2014	FP7-PEOPLE2013-ITN	yes	yes
Proposals											
	WATERMATTERS	van der Geld, N Julia Degeratu Materials innovation institute (M2i) , The Netherlands	12	Stefano Guido, UNINA, ITALY, Thodoris Karapantsios, AUTH, Greece, Hephaestus Boiler Makers & Engineering, Greece, Cees Van Der Geld, The Netherlands	H2020-NMP-15-2015	6/03/2015	June 2016 first stage result	Rejected at first stage	NMP15-2015 Materials innovations for optimisation of cooling in power plants	yes	yes
	Food4Elder	Antonio Vicente, Portugal			H2020-SFS-2015-2						
	Nanofats	Filiz Altay, Turkey	6	Filiz Altay, Nanotel Uretim Inc. Turkey; Stoyan Smoukov, University of Cambridge UK; Stefano Guido, Università Degli Studi di Napoli Federico II Italy;	H2020-NMP-PILOTS-2015	horizon 2020	26/03/2015		Rejected		
	Nobiocide	Marite Cardenas, Denmark			H2020-MSCA-ITN-2015						
	HEBiT	Alessandro Marroni,			Future and Emerging Technologies						
	UNB				Future and Emerging Technologies						
	COVALENT	Selen Baschieri, Ital			: COST Open Call OC-2015-1.						
	HealthNut	Andre Brodkorb,			COST Open Call						

		Ireland									
	iCON2	Ger Koper, The Netherlands			H2020-NMP-PILOTS-2015						
	StRaSS	Carl Brown, UK			H2020-MSCA-ITN-2015						
	AWARE	Susran Eroglu			H2020-NMP-32						

I.C. Networking

Added value of the Networking

The Action offered for the first time a unique networking environment capable of examining smart and green interfaces from a very broad perspective: from fundamentals and basic principles to applications. A strong point of the Action that has never occurred before and will hardly happen again was to gather to the same forum diverse science and technology experts that by tradition do not speak the same language when it comes to problems and developments in the field of soft interfaces (gas/liquid, liquid/liquid, gas/liquid/solid) e.g., in foams, emulsions, bubbly flows, wetting, coating, spraying, encapsulation, flotation, etc., Apart from linking activities between teams in bilateral and multilateral projects, the Action was extremely useful in avoiding duplication of efforts, in comparison and validation of results and in decreasing costs due to equipment sharing. As such the Action contributed significantly to accelerating scientific and technological progress in Europe. The Action has brought together experimental, theoretical and numerical teams allowing in-depth investigation through the scales and across the disciplines. The presence of many world leading industries was a strong asset of the Action confirming its commitment to applications (end-products and new technologies). Collaboration of members across Working Groups was extensive providing elegant solutions to contemporary formulation and technology problems endorsing the European scientific and industrial leadership in the field. Attack of the knowledge gaps from a broad perspective synchronously from a number academic labs and industries would have been impossible without the Action. The formation of six Thematic Clusters with members from both academia and industry focusing on hot science and technology topics with the aim to organize consortia that would submit project proposals to H2020 was another manifestation of the strength of the Action. Thematic clusters were coordinated in a liberal and flexible manner where members could address questions, express interest in joint proposals, propose other partners outside the Action in order to make proposals stronger without formal commitments or mandates. This structure could not have been effective without the confidence and support provided by MP1106 COST Action.

The efficiency of the Action can be seen in the more than 230 published scientific papers with acknowledgement to MP1106 COST Action. Many of these papers were co-authored by teams from different countries that have never collaborated before the Action. Yet, more joint publications are expected in the years to come as a result of these collaborations.

An indicative list of collaborations –apart from STSMs- between teams is as follows:

- MPI in Potsdam performed rising bubble experiments with the group of K. Malysa in Krakow and on emulsion stabilization experiments with the group of R. Orr in Porsgrunn
- The group of T. Sosnowski from Warsaw University of Technology made a common application for HARMONIA 5 project (nanoparticles-lung surfactant interactions) together with the group of Francesca Ravera at CNR Genoa.
- Bubble bouncing experiments are performed by the groups of K. Malysa (PAN Krakow) and N. Vandewalle and S. Dorbolo in Liege.
- Collaboration of P. Colinet (Uni Brussels) with Profs Catherine Colin and Dominique Legendre (IMFT - Toulouse) about the numerical modeling of boiling bubble growth and the influence of a dissolved component and temperature gradient in the liquid (generating a significant Marangoni effect).
- The University of Sofia (K. Marinova) organized cooperation with Unilever and the

company Kruess.

- The University Paris Sud performed together with IPF in Paris an experimental studies of surfactant-enhanced alkaline/diluted heavy oil systems.
- Investigations on the role of the interfacial rheology in bubble formation and bubbling processes. (A. Salonen-FR, in collaboration with D.Fairhurst – UK and R. Pugh – CH.
- A study on Interfacial Rheology of surfactant systems performed between Univ. Naples and MPI-KGF (STSM of Perazzo, Guido & Miller)
- Collaborations of CNR in Genoa is running with the MPI-Golm, Univ. Tessaoniki and Univ. Aix-Marseille in microgravity-related experiments for emulsions and droplet interfaces.
- Collaborations of CNR in Genoa is running with the MPI-Golm also on the investigation of bubble rising in surfactant-polluted sea waters.
- The group of CNR – IENI in Genoa has also collaboration with G. Cristofolini (Dept. Physics - Univ. Parma-Italy) on dynamic properties of particle-laden surface layers.
- Rising bubble experiments are performed with the group of K. Malysa in Krakow (Miller DE)
- Krakow team (Malysa PL) with Golm team (Miller DE)
- Krakow team (Malysa PL) with Liege team (Dorbolo BE)
- Krakow team (Malysa PL) with Sofia team (Exerova, Mileva BG)
- Krakow team (Malysa PL) with IWRI Australia team (Krasowska AU)
- Cooperation with Unilever NL and Kruess DE (Marinova BG)
- David Fairhurst UK, Martin Shanahan FR and Sefiane UK on droplet evaporation
- David Fairhurst UK and Bob Pugh CH on foam stability
- Victoria Dutschk NL and Jaroslav Katona RS on a new multidisciplinary consortium 'Inkjet printing'
- -Victoria Dutschk NL and Zoran Šaponjic RS and COST CM1101 on nano-functionalization of textile materials
- A fruitful cooperation with physicians and biologists lead to interesting results on electric active biocompatible surfaces to be used as biosensor (Guido IT)
- Food model systems characterization (Navarini, Karapantsios; Guido; Liggieri, Langevin)
- Bernhard Peters LU, with Luciano Navarini, Illy café, IT and Alidad Amirfazli CA.
- Cees v.d. Geld NL with the AMC (Amsterdam Medical Center) and EMC (Erasmus Medical Center) concerning boiling in blood as occurring in endovenous laser treatment.
- Cees v.d. Geld NL with Bronkhorst B.V. and TNO leading to a STW proposal for scientific research with financial support of various industrial partners.
- Cees v.d. Geld NL with Océ on the topic of evaporating droplets on a porous substrate.
- Karapantsios GR with School of Veterinary Medicine (AUTH) for sensing bubbles in anesthetized pigs.
- Katona RS with UPS and IFP Energies Nouvelles
- Sefiane UK with Shanahan FR on droplet evaporation
- Koutsos UK with Karapantsios GR on nanoparticles surface characterization
- Langevin FR with ULB on Thin liquid films
- Langevin FR with IFP Energies Nouvelles on Enhanced Oil Recovery
- Langevin FR with ULiege on Foams in Microgravity
- P Colinet BE with IMFT – Toulouse (Colin, Legendre) and University of Thessaloniki

(Karapantsios) ondesorption of gases from liquids by boiling, applications in heat transfer and in greenhouse gases regeneration. STSM planned.

- M. Antoni FR with R. Miller DE on pickering emulsions and interfacial rheology
- M. Antoni FR with K. Sefiane UK on nanofluid droplet evaporation
- G. McHale UK with N. Shirtcliffe DE and K. Sefiane UK

The table below shows the extent to which it would have been possible to achieve each of the Action's objectives without the Action networking.

MoU objective	Possibility of achievement without Action networking		
	Fully	Partially	Impossible
The main objective of the Action is to organize a European interdisciplinary cooperation platform directed towards scientific added value and improvement of industrial, environmental and medical applications concerning interfaces, bubbles and drops.		X	
Improvement of the fundamental understanding of the general interface structure and evolution dynamics. This will be achieved by a combination of theoretical development, the implementation of novel numerical techniques for solution of the governing equations and the exploitation of novel experimental techniques concerning both single and multiple interfaces		X	
Development of new materials relevant to creation of Smart and Green interfaces. These materials cover the whole span of size range and it can be surfactants, macromolecules, solid surfaces, solid foams, aerosol particles.		X	
Development of novel and improvement of existing diagnostic techniques employing knowledge emerged from the first two objectives. The term diagnostics refers to the identification of the properties of the interfaces and to general real/life applications (e.g. medical diagnosis) in which interfaces/bubbles/drops intervenes.		X	
Development or improvement of marketed industrial technologies and end user applications relevant to interfaces, bubbles and drops. The objective covers from consumer products to classical industrial processes and to computational tools for their design and optimization.		X	

Extent of the networking

Our Action has more than 430 registered participants <https://docs.google.com/document/d/1zGnV0-9d5VH-MNCyFJRoc1w0ccOwEwV5voffAkm1d-s/edit?pli=1> . Despite the substantial effort of the MC of the Action to integrate equally all members into the network activity of the Action it proved practically impossible to do so. In

fact, some of the members have participated only once in an event while others participated in almost all events. But this was also because of the limited budget of the Action that did not allow to support all participants to come to all events. It was a role for MC members to select participants from their country in each event. Selection of participants for the meetings, Training Schools and STSMs was based on scientific merit and geographical and gender balance with priority to ESRs if there were more demands than those possible to satisfy.

Inclusiveness was adequately dealt with by the Action with the STSM coordinator being from Turkey and the Dissemination Manager being from Bulgaria. Furthermore, 16 inclusiveness countries have signed the MoU (32 in total) while 115 active members in different events were from inclusiveness countries.

ESRs had their own Working Group, ESRG, with 86 members which represents about 20% of the total membership in the Action. ESRG has been running horizontally across the four science WGs. The Grant Holder is an ESR himself and was elected as the ESRG leader. ESRs participation in meetings is 22%, in STSMs is 76% (targeted in MoU 70%), in Training Schools is 84% of the total participation.

As regards gender balance, the WG2 leader is a female and so is also the Gender Balance Manager. There are 15 women in the MC (76 members in total), ~20%. Females WGs members are 131 which represent 29% of the total WGs members. Females participation in meetings is about 26% and in Training Schools 42%. Females' participation in STSMs represents about 41% which is a very important achievement considering that the female percentage in total membership is only 29%.

I.D. Impacts

The impacts that have resulted, or might result from the Action are described in the following table.

Description of the impact	Type of impact ⁴	Timing of impact ⁵
Increasing the scientific knowledge beyond the current state-of-the-art	Scientific/technological	Achieved
Creating High level ESRs for careers in high level science and R&D management	Scientific/societal	Achieved
Training ESRs on issues related to smart and green interfaces establishing contacts between European labs	Scientific/societal	Achieved
Advancing creativity and entrepreneurial capacity of ESRs	Societal/economical	Achieved/Foreseen within 2 years
Promoting collaboration between academia and industry	Technological/economical	Achieved

⁴ Scientific/ technological, Economic, Societal

⁵ Achieved/ Foreseen within 2 years/ Foreseen 2-5 years/ Foreseen 5-10 years/ Foreseen 10+ years

Setting consortium of partners aiming at submitting research projects proposals to forthcoming European Calls	Scientific/Technological/economical	Achieved/Foreseen within 2 years
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I.E Dissemination and exploitation of Action results

Describe the Action's dissemination and exploitation approach as well as all activities undertaken to ensure dissemination and exploitation of Action results and the effectiveness of these activities.

Item/ activity	Target audience	Result	Hyperlink
Dedicated website as depository of all announcements and reports produced in the Action	1. Action members 2. Universities/Research Institutions/Industries 3. National and European Research funding agencies 4. Opinion formers and Policy makers 5. Media 6. General public	1. Increased visibility, and transparency of activities and outcomes 2. Increase in distribution of information and documentation of scientific data and materials 3. dissemination to broader audiences	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/index.xhtml
E-mail network for (a) registered members and (b) MC members	Action members	Coordination and information exchange	costmp1106@lists.auth.gr mcofmp1106@lists.auth.gr
Announcements for job, post-doc and PhD positions	Action members	Fast spread of news, announcements, timely update	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/jobs.xhtml

		Increase in the collaborative work and joint publications between members	
Presentations in Workshops, and conferences, Training Schools	1. Action members 2. Universities/Research Institutions/Industries	dissemination to broader audiences	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Links with other networks ITN-MC	1. Action members 2. Universities/Research Institutions/Industries	Increase in the collaborative work and joint publications	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events_2013.xhtml#1
Joint publications of review articles and edited books	1. Action members 2. Universities/Research Institutions/Industries 3. National and European Research funding agencies 4. Opinion formers and Policy makers 5. Media 6. General public	dissemination to broader audiences	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/publications.xhtml
Publication of workshop and STSMs reports	1. Action members 2. Universities/Research Institutions/Industries	dissemination to broader audiences	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml

	3. National and European Research funding agencies 4. Opinion formers and Policy makers 5. Media 6. General public		
1 st Annual Workshop (13-14.09.2012, Dublin, Ireland)	Scientific/Companies	87 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
2 nd Annual Workshop "Smart and Green Interfaces 2013 (Prague)" (21-22.03.2013, Prague, Czech Republic)	Scientific/Companies	126 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Fluid/Fluid Interfaces in Science and Technology Sofia	Scientific/Companies	41 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Smart and Green Interfaces: Multiphase flows with/without phase change, Zaragoza	Scientific/Companies	23 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Wetting of solids: Material and kinetic aspects, Cargese	Scientific/Companies	19 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Annual Workshop "Smart and Green Interfaces": 22- http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml Scientific/Companies24.04.14, Marseilles.	Scientific/Companies	145 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Heat and Mass Transfer on a Solid Substrate Wetting of complex surfaces EINDHOVEN	Scientific/Companies	26 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Nanomaterials and Nanotechnologies and "Nanostructured Materials for Water Treatment/Purification Antalya	Scientific/Companies	23 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Medical Diagnostics and Advanced Therapies Sustainable Food Science and Technology Napoli	Scientific/Companies	19 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Smart and green interfaces - achieving dynamic control and tuning of the nature of a solid surface's interfacial interactions with liquids and with soft matter Nottingham	Scientific/Companies	6 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Annual Workshop "Smart and Green Interfaces", Management Committee	Scientific/Companies	114 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml

Meeting - Working Group Meeting Belgrade			
Working Group meeting jointly with Bubble and drops Interfaces 2015 Golm	Scientific/Companies	32 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Working Group meeting: Fundamentals and Diagnostics Sofia	Scientific/Companies	27 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml
Annual Workshop "Smart and Green Interfaces" Athens Greece	Scientific/Companies	98 participants	http://cost-mp1106.lcpe.uni-sofia.bg/xhtml/events.xhtml

I.F Action success(es)

COST regularly communicates the successes of Actions. What aspect(s) (outcomes and/ or impacts, rather than activities) of this Action is/ are the most suitable for communication?

- A large number of registered Action members, more than 430, despite the limitations to support all of them to participate to the events organized by the Action which was discouraging for many.
- Organization of Thematic Clusters on hot science and technology topics aiming to organize partners' consortia to submit proposals to H2020 Calls. The six Thematic clusters were: (1) Nanomaterials and Nanotechnologies, (2) Nanostructured Materials for Water Treatment and Purification, (3) Medical Diagnostics and Advanced Therapies, (4) Sustainable Food Science and Technology, (5) Heat and Mass Transfer on a Solid Substrate, (6) Wetting of complex surfaces, A few proposals have been already submitted mostly with no success while other proposals are still under evaluation. Apart from it, a serious collaboration between partners on these topics has initiated.
- Foundation of a new international conference series called "Smart and Green Interfaces" with which the Action's Annual workshops were running jointly. This allowed scientist from around the globe to attend and share with the Action new ideas and developments in the field. It si foreseen to continue the series on a biennial basis.
- The collaborative work and advancements made in the Action have been summarized in a Review paper prepared by the officers of the Action in one of the most prominent scientific journal in the field V. Dutschk, T. Karapantsios*, L. Liggieri, N. McMillan, R. Miller and V.M. Starov, "Smart and green interfaces: from single bubbles/drops to industrial environmental and biomedical applications", ACISci., 209, 109-126, 2014, <http://dx.doi.org/10.1016/j.cis.2014.02.020> A similar effort as regards an CRC edited volume has been undertaken for the end of the Action and currently feedback and potential contributions is collected from members. This volume will be devoted to a Review of Smart and Green Interface Instrumentation and its Commercialization

Indicative Scientific and Technological breakthroughs are:

- Self-shaping of oil droplets upon cooling It is shown that by using appropriate cooling protocols, they can induce phase transitions in micrometer sized liquid hydrocarbon droplets. A series of complex regular shapes are obtained in this way.

Dimension of the success

■ Breakthrough:
scientific, technological or
socioeconomic

This mechanism offers insights into achieving complex morphogenesis from a system with a minimal number of molecular components (oil, water, surfactant). These fascinating findings were published in Nature 528 (2015) 392–395. (N. Denkov and S Smoukov Sofia, Bulgaria, & Uni. Cambridge, UK).

- Peculiarities for protein-surfactants mixed adsorption layers at low bulk concentrations. It is found out that a very small addition of a non-ionic surfactant at low concentrations to a protein solution like β -casein (BCS) can change much in the adsorption behaviour of protein molecules. (R. Miller -MPI Potsdam, Germany).
- Structures in mixed lipid-nanoparticle monolayer. The chemico-physical interfacial properties of mixed lipid-nanoparticle Langmuir monolayers are investigated. The results show that particles modify the surface pressure–area (Π –A) isotherms and the rheological behaviour of the monolayer. These studies promote our basic understanding of the interaction of nanoparticles with biological systems, e.g., cell membranes and lung surfactants. (L. Liggieri- CNR Genoa, Italy)
- Experiments on bouncing bubbles at the liquid interface demonstrating the possibility to maintain the bubble bouncing, without coalescence, by supplying kinetic energy in the form of applied vibrations of proper frequency and amplitude. (K. Malysa PAN- Krakow)
- Digital Holographic Interferometry, has been applied for the first time to obtain quantitative information about the local evaporation rates and temperatures along the interface of an evaporating droplet (P. Colinet, ULB Belgium).
- A systematic investigation of shear-induced banding in confined biphasic liquid–liquid systems was done by rheo-optical investigation. Rheological measurements show that band formation is associated with a viscosity decrease with respect to the homogeneous case, thus implying that system microstructure is somehow evolving toward reduced viscous dissipation under flow. (S. Guido & S. Caserta, Univ Napoli, IT)
- An innovative rapid test has been patented to safely and easily distinguish fresh from prolonged fried oil based on the wicking speed (penetration rate of oil/gas interface) of oil into porous substrate (T. Karapantsios, AUTH Thessaloniki).
- Particle interactions with lung surfactant: model Maximum bubble pressure (MBP) tensiometry was employed to evaluate the physicochemical impact of novel

<p>multifunctional composite powders, suitable for drug delivery by inhalation, on the dynamic activity of model pulmonary surfactant. The research provides a new insight into the possible changes in the dynamic interfacial behavior of pulmonary surfactant after therapeutic interventions. studies (T. Sosnowski, Warsaw University of Technology, Poland).</p> <ul style="list-style-type: none"> • New surfaces reducing bacterial infection. These surfaces belong to the class of green chemistry materials since the disinfection needs as reagents air (O₂), water vapour (air) and light (low intensity solar irradiation); applying a relatively new sputtering technology to produce thinner coated surfaces requiring much lower amounts of non-renewable metal resources like Cu, Ag. (J. Kiwi, EPFL, Switzerland) • Development and scale-up of novel protein microfibers for structuring and encapsulation using in-shear solvent attrition", in collaboration with WUR, Unilever and Friesland Campina, focusing on green (solvent free) methods for creation of protein micro-fiber for sustainable food products (S. Stoyanov – Unilever NL) • Novel treatment of textile materials by drug solutions exposed to laser radiation in order to be used on the human skin. Some of the phenothiazine solutions exposed prolonged time intervals to laser radiation have much better activity against several bacteria. (V. Dutschk Twente Univ. NL, M. Pascu National Institute for Lasers , Plasma and Radiation Physics, RO) 	

II. Management Report

II.A. Overview of expenditure

The table below summarises the Action's expenditure throughout its four year life.

	Grant Period 1	Grant Period 2	Grand Period 3	Grand Period 4	TOTAL
GP start and end dates	2012/06/02 - 2013/06/01	2013/06/02 - 2014/06/01	2014/06/02 - 2015/06/01	2015/06/02 - 2016/05/30	
Grant Holder Institution	AUTH	AUTH	AUTH	AUTH	
Meetings	125950.6	127912.6	108800	114655.6	477318.8
Training schools	28982.81	28728.44	28800	3000	89511.25
STSMs	17340	23030	33750	15000	89120
Dissemination	2000	1600	1991	2,000.00	7591

OERSA ¹	152.7	344.1	570	1740	2806.8
Total Scientific Expenditure	174426.11	181615.14	173911	136395.6	666347.85
FSAC ²	20765.07	27242.13	26085.56	20459.34	94552.1
TOTAL	195191.2	208857.3	199996.6	156855	760900.1

¹OERSA = Other Expenses Related to Scientific Expenditure (e.g. bank charges)

²FSAC = Amount received by Grant Holder for Financial Scientific and Administrative Coordination

II.B. Budget and Participation management

II.B.1 Budget spent in relation to individuals/ institutions outside participating COST countries

STSMs from or to institutions from countries other than Participating COST countries

The table below describes the added value STSMs to approved institutions in IPC or NNC or Specific Organizations and any STSMs from an approved institution in an NNC to a participating COST country.

Grantee		Host		Date	Topic and value added to the Action
Institution	Country	Institution	Country		
Add home institution and country		Add host institution and country		Date	Describe topic of the STSM and the added value to the Action

Invited Speakers

The table below highlights the added value of Invited Speakers from COST countries that have not accepted the MoU and/ or non-participating NNC, IPC or Specific Organisations whose participation at a meeting or Training School was reimbursed by the Action.

Participant name	Institution	Country	Event date	Topic and added value to the Action
Alidad AMIRFAZLI	Mechanical Engineering at Lassonde	CA	11-16/9/2012	Prof. Amirfazli is an expert in water management in fuel cells, anti-icing systems for wind turbine/aircrafts printing technology, application of pesticides, spray cooling, additive manufacturing, and related instrumentation. He gave an overview of experiments and theories related to spray cooling.
Mohamed Hamed	MacMaster University.	CA	21-22/03/2013	He presented his work concerning the Mechanistic Wall Heat

					Flux Partitioning Model of Nucleate Boiling Under Impinging
Vladimir Pletser	Chinese Academy of Sciences	CN	4-6/5/2016		Dr. Pletser is an expert in microgravity during aircraft parabolic flights and he gave an overview on the effect of gravitational acceleration absence on physical systems.
Yuji Suzuki	Tokyo University	JP	22-24/04/2014		Prof Suzuki is an expert Micro-Nano Technology applications and presented his work Microscale Combustion: Surface Effect on Gas-phase Reaction.
Saule Aidarova	Kazakh National Technical University	KZ	4-6/5/2016		Prof Aidarova is an expert on the effect of Interfacial Properties on Materials Electrochemical Properties and she presented her work concerning “ Effect of Interfacial Processes on the Electrochemical Properties of Carbon Based Electrodes for Supercapacitor Applications”
James Ferri	University of Lafayette	US	4-6/5/2016		Prof. James Ferri is an expert in Nanoparticle Surface Chemistry and he presented his work concerning: “Comparative Framework for Binder Formulation Development for Inkjet-based Three Dimensional Metal Printing”

Dissemination meetings

The table below highlights the added value of Dissemination Meetings financed from Action funds.

Participant name	Role	Countr	Date	Location	Topic and added value
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		y			to the Action
Add	Add	Add	Add	Add	Describe the speaker's topic and the added value to the Action

II.C. Participants

Management Committee

Name				Country	Email address
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II.D. Specific matters

This section is **confidential** to the Management Committee, and the COST Association (Administration, Scientific Committee and Committee of Senior Officials); and is not included in the version of the report that is published on the COST website.

The Action encountered the following particular difficulties in the implementation of the Action (e.g. imbalances of participation across the Working Groups, inactive country representatives).

It is rather expected that for an Action of this size (more than 430 members) imbalances of participation across WGs may exist. WGs 1, and 3 being oriented more towards science have been more active and productive whereas WG4 being oriented towards industrial and end-users applications was less active and eventually shifted towards commercialization and IP related issues. Handling the budget for such large number of members proved sometimes difficult because several members have been excluded from MP1106 support based on different criteria every time. Scientific merit, geographical, gender balance and ESR priority criteria were implemented. Some country representatives were inactive throughout the project (e.g., Bosnia & Herzegovina)

The MC did not accept the pending intentions to accept the MoU shown in Section I.A for the following reason.

Not applicable

II.D.1 Suggestions for improvements to COST framework/ procedures

The COST Association is committed to the continuous improvement of the COST framework.

Please describe below any improvements that you believe should be made to COST.

-

II.D.2 Sustaining the network beyond the Action

If there are plans to sustain the network beyond the end of the Action please describe these below.

In the last MC meeting in Athens in May 2016 it was decided to keep the mailing list of the Action active for announcing new job, Post-doc or PhD positions.

In the same MC meeting it was also decided to continue with the international conference series "Smart and Green Interfaces" on a biennial basis. Depending on the year, the conference may run jointly with the established conference series "Bubble and Drop Interfaces"

II.D.3 Emerging topics/ developments in the field of the Action

Please describe any emerging topics or potentially important future developments identified during the Action and that could potentially be addressed by future COST activities such as Actions S&T Conferences or Exploratory Workshops.

The issue of emerging topics that could potentially addressed by future COST Actions has been discussed at different events of the Action. However, at the last annual workshop of the Athens one topic has sorted out and was intensively discussed that of "**Nanobubbles- science and applications**". MP1106 officers offered to draft a first proposal on this intriguing and highly unexplored topic, motivated by the recent solid proof of the presence of nanobubbles in several natural environments and industrial applications.

Annex 1

Definitions:

COST Action Challenge (main aim)	"The research question addressed by the COST Action targeting scientific, technological, and / or socioeconomic problems"
COST Action Innovation	"The creation and / or development of new or improved concepts, products, processes, services, and / or technologies that are made available to markets, governments and society"
COST Action objectives	"COST Action objectives are the results that an Action needs to achieve in order to respond to meet its challenge. These are SMART (Specific, Measurable, Achievable, Relevant, Timely) and twofold: research coordination objectives and capacity building objectives."
COST Action research coordination objectives	"Achieving these objectives turns COST Actions from initially scattered teams into one transnational team and leverages the existing funded research. These objectives entail the distribution of tasks, sharing of knowledge and know-how, and the creation of synergies among Action participants to achieve specific outputs."
COST Action capacity building objectives	"Achieving these objectives entail building critical mass to drive scientific progress, thereby strengthening the European Research Area. They can be achieved by the delivery of specific outputs and / or through network features or types and levels of participation."
COST Action networking activities	"any activities organised by the COST Action (whether or not directly funded by COST) in order to achieve research coordination and capacity building objectives."
COST Action networking tools	"instruments through which eligible activities can be funded"
COST Action outputs	"direct results from the COST Action activities. These can be codified knowledge, tacit knowledge, technology, and societal applications."
COST Action impact	"the short- to long-term scientific, technological, and / or socioeconomic changes produced by a COST Action, directly or indirectly, intended or unintended."
COST Action deliverable	"a distinct, expected and tangible output of the Action, meaningful in terms of the Action's overall objectives such as a report, a document, a technical diagram, a software etc. Action deliverables are used to measure its progress and success."
COST Action milestones	"Control points in the Action that help to chart progress. They are also needed at intermediary points so that, if problems have arisen, corrective measures can be taken. A milestone may be a critical decision point in the Action where, for example, the MC must decide which of several technologies to adopt for further development (e.g. core group and MC

	meetings, mid-term reviews)”
Inclusiveness Target Country (ITC):	Current COST Member Countries targeted by the COST inclusiveness Policy (“Inclusiveness Target Countries” (ITC)): EU 13 (Bulgaria, Cyprus, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia, Slovakia), EU candidate countries (the former Yugoslav Republic of Macedonia, Montenegro, Republic of Serbia, Turkey) and potential EU candidate countries (Bosnia and Herzegovina). In addition, to comply with the EC criteria for ‘Spreading Excellence and Widening Participation’, Portugal and Luxemburg are included.