Version 2015-06-12

COST Action MP1308
(Action 15/04/2014 – Action 14/04/2018)

Towards Oxide-Based Electronics (TO-BE)

PROGRESS REPORT 2
(15/04/2014 – 21/12/2014)

This report is submitted by the MC Chair on behalf of the Management Committee
and is validated by the Scientific Committee of the COST Association.

Confidentiality: the document will be made available to the public via the Action page on the COST website except for Section II.D.

Executive summary of the Progress Report:

The TO-BE community is today established as the reference EU community for fundamental studies and for epitaxial-thin-film-based applications of transition-metal oxides. Many of the major EU scientists in the field have joined the Action, either directly of through their group members. Some of them are actively involved in the Action management.

29 COST countries, also including Slovakia that is actually on the way to complete the process, have signed so far the memorandum of understanding. Applicants willing to participate to the Action fill a registration form. The great majority of applications are accepted. **Registered participants to date are about 270**. This number gets updated day by day. Registered participants get included in the mailing list where our events are advertised.

The activity held with the TO-BE Action is divided in 4 Work Groups (WGs). The Action is managed by a Core Group (CG) named by the MC. A number of companies listed on our web site have also joined the Action and actively participate to our meetings. This is an important result, considering that the technology readiness level for many oxide-based applications is still relatively low.

TO-BE organises twice a year its **WG meetings** as joint events open to the whole community. During the event, WG1,2&3 organise dedicated scientific sessions and roundtables. WG0 only holds organizational roundtables. The events organised so far within our Action are:

1) The **TO-BE 2014 Fall Meeting** . The scientific program is available here The event hosted 18 Invited Talks (3 from non-COST countries), and 53 Poster presentations. We had 119 registered participants and collected 107 signatures on the COST attendance list. A MC meeting was held.

2) The **TO-BE 2015 Spring Meeting** . The scientific program is available here . The event hosted 20 Invited Talks (2 from non-COST countries), 43 Oral talks, 43 Poster presentations. We had 131 registered participants and collected 109 signatures on the COST attendance list

3) The **TO-BE 2015 Fall Meeting**, included as symposium L of EMRS Fall Meeting in Warsaw. Symposium L was named after the Action "Towards oxide-based electronics" and is explicitly mentioned on the EMRS site as organised by the TO-BE Action.
The event hosted 14 Invited Talks (2 from non-COST countries), 40 Oral talks, 52 Poster presentations, for a total of 106 contributions (there were no direct registration, since the event was within EMRS). Due to the switching of people between different symposia, only a limited attendance list of the 46 granted participants has been collected. A MC meeting was held.

Next event, the **TO-BE 2016 Spring Meeting** will be held in Warwick

TO-BE Organised jointly with CNRS a very successful **Training School**, named ISOE 2015 including 10 full days of lessons. The number of trainees was 73 and the number of trainers involved was 29. The videos of the lectures are available here.

TO-BE funded 12 **STSMs** in the course of the 1st GP and approved 7 for the 2nd GP. The STSM call is published on our web site. Applications are evaluated by a committee chaired by Laurence Mechin. The short web reports of the 1st GP **STSMs** are reported here while the full reports (not public) are available here.

Further statistical data about our events and activities are available here.

Summary assessment of Progress Review by Action Rapporteur:

The COST Action MP1308 has the following main objectives: (i) To provide a networking platform for scientists in the field of epitaxial transition metal oxides (TMOs), (ii) to advance and to coordinate the scientific research aimed at an improved understanding of properties common to different TMOs, (iii) to support the development of growth and processing technologies for TMOs, and finally (iv) to identify the most promising applications with a prospective for industrial exploitation.

The management of this Action has done an impressive job in getting the TO-BE network started: With more than 270 participants from 29 COST countries, the network has reached what one may call a critical mass.This seeds the prospect for real synergies, beyond what could be expected without the TO-BE network. Within the initial 18 months, a range of networking activities have been organized with a strong participation of people from within the COST network. In addition renown international attendees from world-class institutions have been invited to the meetings. A very positive point of the Action is that especially scientists in the early stages of their career are addressed. A first ten-day summer school (ISOE 2015) has been very successful. A web-site has been set-up which, even though it is not fully completed yet, already provides an excellent electronic platform for this Action.

Regarding the scientific and technology related objectives, the impressive progress of the Action is reflected in the significant number and quality of scientific publications. Among them are two papers in *Nature Materials* and several more in other high-impact outlets. Importantly, many of these papers are based on a collaboration of COST participants from different institutions and countries. This demonstrates that the TO-BE platform has the potential to foster further excellent scientific collaborative research in the field of TMOs. There is a favorable balance between more fundamental papers aimed at pushing the limits of current understanding of the basic properties of TMOs and papers aimed at harvesting unique properties of TMOs for promising applications. The application related work could be further promoted by the involved companies. A list of some very attractive applications of TMOs has already been assembled by the Action. Among them: Oxide-based memories and memristors, electronic and optoelectronic oxide devices, oxide-based spintronics, etc. The transfer of scientific results to players from industry is a key point for the success of this Action. The accomplishment to involve several industrial players at this early stage is noteworthy, but the dialogue with companies may require even more attention in the future. I suppose that efforts in this field may also strengthen the applications for H2020 projects from partners of the Action. The conception and implementation of the planned "*Roadmap of Oxide Electronics*" is still in its infancy, and requires more attention in the next period.

Overall, in view of the high risk of the objectives, the Action is progressing appropriately with very good achievements on the majority of its objectives. The Action is on a very good track to fully deliver the majority of the promised deliverables.

Action Rapporteur	Name: Prof. Dr. Thomas Riedl Institution: University of Wuppertal Country: Germany

Validation by Scientific Committee

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

I. Progress Report

I.A. COST Action Profile

Objective/ Aim

ORGANIZATION: To network scientists working on transition metal oxides (a) among themselves; (b) to the mainstream of solid-state technologies; (c) to Public Society

SCIENCE : To foster and coordinate a research aimed at advancing our present understanding about the way the multiple lattice and electronic degrees of freedom and of their mutual interactions determine the physical properties of TMOs

TECHNOLOGY (1) To foster the development of a technology for the growth of in-situ-qualitycontrolled, large-area epitaxial oxide films and heterostructures on different substrates including Si.

TECHNOLOGY (2) To single out the most promising applications of TMOs to nanoelectronics, microactiation/microsensing and energy conversion and to coordinate fabrication and testing of devices performed at a prototype level.

Details

MoU:	077/13	Start of Action:	15/04/2014
CSO approval date:	15/11/2013	End of Action:	14/04/2018

COST Member Countries and Cooperating State having accepted the MoU

Country	Date	Country	Date	Country	Date	Country	Date
Austria	17/01/2014	Belgium	28/01/2014	Bulgaria	03/11/2014	Croatia	07/03/2014
Czech Republic	13/10/2014	Denmark	22/11/2013	Finland	01/04/2014	France	16/12/2013
Germany	07/01/2014	Greece	20/12/2013	Ireland	29/01/2014	Israel	27/11/2013
Italy	30/12/2013	Latvia	11/03/2015	Lithuania	08/04/2014	Luxembourg	17/06/2014
Netherlands	07/01/2014	Norway	16/05/2014	Poland	10/12/2013	Portugal	21/01/2014
Romania	22/04/2014	Serbia	02/12/2013	Slovenia	26/06/2014	Spain	29/11/2013
Sweden	10/04/2014	Switzerland	24/03/2014	Turkey	13/02/2014	United Kingdom	13/12/2013

Total: 28

Intentions to Accept the MoU

Slovakia

Other participants:

Institution Name	Country
Copy from Action page on COST website	

Contacts

Chair/ Vice Chair

Position	Name	Contact details	Country	Date of PhD:	Gender
Chair:	Fabio MILETTO GRANOZIO	Dr Fabio MILETTO GRANOZIO CNRCNR-SPIN, Institute for Superconductors and Innovative Materials and Devices of the National Research Council, Complesso Universitario di Monte Sant'Angelo, via Cintia , c/o Dipartimento di Fisica dell'Università Federico II di Napoli 80126 Napoli Italy **fabio.miletto@spin.cnr.it**	IT	Nov 1995	M
Vice Chair:	Geetha BALAKRISHNAN	Prof Geetha BALAKRISHNAN University of Warwick Department of Physics, University of WarwickCV4 7AL Coventry United Kingdom **g.balakrishnan@warwick.ac.uk**	UK	1982	F

Working Group Leaders

WG#	WG Title	WG Leader	Country	Date of PhD:	Gender	Number of participants
1	Fundamental Understanding	Jeroen Van Den Brink	Germany	1997	M	193
2	Growth Control	Gertjan Koster	Netherlands	Sept 1999	M	98
3	Towards Applications	Nini Pryds	Denmark	1997	M	130
0	Management	Fabio Miletto Franozio	Italy	1995	M	17

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

Position	Name	Country	Date of PhD:	Gender
STSM Coordinator	Laurence Mechin	France	1996	F
WG0-T1 leader: internal meetings, conferences, workshops, joint projects	Tatiana Fittipaldi	Italy	2006	F
WG0-T2 leader: dissemination and website managements	Daniele Marré	Italy	1998	M
WG0-T3 leader: ECIs careers and training; short term scientific missions (STSM)	Laurence Mechin	France	1996	F
WG0-T4 leader: edition of the roadmap book/volume	Josep Fontcuberta	Spain	1982	M
WG1–T1 "Experiments" Task Leader	Manuel Bibes	France	2001	M
WG1–T2 "Theory" Task Leader	Mario Cuoco	Italy	2000	M
WG2-T1 "Large area growth" Task Leader	Judith Driscoll	United Kingdom	1991	F
WG2-T2 "Perovskite-on-Si" Task Leader	Florencio Sanchez	Spain	1993	M
WG2-T3 "Real-time monitoring" Task Leader	Alexei Kalaboukhov	Sweden	2003	M
WG3-T1 "Nanoelectronics" Task Leader	Hans Boschker	Germany	2011	M
WG3-T2 "Microactuation and microsensing" Task Leader	Alessia Sambri	Italy	2007	F
WG3-T3 "Energy conversion" Task Leader	Arie Zaban	Israel	1995	M

Action website:	http://to-be.spin.cnr.it/

I.B. Progress with MoU objectives and deliverables and additional outputs

MoU objectives

MoU objective	Achieved Yes/ Partially/ No	Evidence of (partial) achievement including hyperlink to enable assessment of the achievement[1]. Justification if full achievement is not foreseen
ORGANIZATION: To network scientists working on transition metal oxides (a) among themselves; (b) to the mainstream of solid-state technologies; (c) to Public Society	Partially	The activity progress for this section was described in the Executive Summary, which is largely about networking. This includes internal networking within the original community and dissemination toward other scientists of the oxide community and toward scientists active in neighbouring fields. The web-site itself, http://to-be.spin.cnr.it/ is a tool of both internal networking and of dissemination towards a wider community. A very ambitious goal of the Action is the editing of a Roadmap of Oxide Electronics, which should be published by the end of the Action. A successful Roadmap will help disseminating knowledge about oxide-based technologies to the wider solid-state community and to Public Society.
SCIENCE : To foster and coordinate a research aimed at advancing our present understanding about	Partially	Addressing fundamental science issues is the task of WG1**.** The research described in this objective is actively pursued end is debated at our meetings.

[1] The links to the outputs and deliverables will be used by the Action Rapporteur in assessing the progress.

the way the multiple lattice and electronic degrees of freedom and of their mutual interactions determine the physical properties of TMOs		Evidence of partial achievement of our results is given by the high level of the 10 selected joint publications reported in the table below (pages 8-9), all partially focused on the addressed scientific objectives (in particular, ref. 1, 4, 6, 8 in the list).
TECHNOLOGY (1) To foster the development of a technology for the growth of in-situ-qualitycontrolled, large-area epitaxial oxide films and heterostructures on different substrates including Si.	Partially	Addressing oxide film growth control is the task of WG2 "Large area growth", "Growth of perovskites on Si" and "Real time Monitoring of Growth" have been identified as the three main Tasks to pursue in this field under the responsibility of specific Task Leaders. Dedicated talks for these three specific issues have been organised in all meetings. Most companies that have joined the Action have a very strong involvement in such film growth issues (TSST, SOLMates, 3D-oxides, abcd Technologies, Nanovation, SINTEF) and some of them have participated and given presentations to our meetings on these topics. TSST, SOLMates, 3D-oxides, abcd Technologies and SURFACE manufacture thin film deposition systems.
TECHNOLOGY (2) To single out the most promising applications of TMOs to nanoelectronics, microactiation/microsensing and energy conversion and to coordinate fabrication and testing of devices performed at a prototype level.	Partially	Addressing thin-film based applications of oxides is the task of WG3. WG3 is divided in three Tasks: Nanoelectroncs, Microactuation and Microsensing and Energy Conversion. More specifically, the most promising fields of applications identified in the field of oxide electronics, were identified so far in this list ▪ Oxide-based memories and memristors ▪ Electronic and optoelectronic oxide devices ▪ Oxide-based spintronics ▪ Oxide-based sensors, actuators ▪ Ferroelectric/Piezoelectric oxides ▪ Oxide-based thermoelectrics and electrocalorics ▪ Oxides for photovoltaic applications ▪ Ion conducting oxides ▪ Materials for thin film batteries ▪ Catalytic effects at oxide film surfaces They have been selected as topics of next WG3 meeting at the 2016 TO-BE Spring Meeting

MoU deliverables

I am not sure about the kind of input that is expected in the column "level of progress". There is a note number ([1]) but I did not find the instructions. Can you provide and example of samples to input here?

MoU deliverable	*Level of progress*[1]	Evidence of (partial) delivery achievement including hyperlink to enable assessment of the delivery[1]. Justification if full achievement is not forseen
Obj. 1a: Conferences and meetings; training schools for early stage researchers (ESRs);	*40%*	The executive summary shows that all objectives in terms of events organization foreseen in the MoU so far have been successfully achieved.
Obj. 1b: A web site about physics, applications and events related to TMOs, with special sections dedicated	*40%*	The web site has been created and will be constantly updated and improved in the course of the Action. We plan to redesign it in the course of the 2nd GP to make it graphically more attractive.

both to Action members and to external stakeholder;		At the present stage, the site describes the Action and the Action activities. As a further service to the community, we prepared a Job Posting page that is already partially active and a Forum page (that will be activated soon) both specifically dedicated to the field of Oxide Electronics. Dedicated sections for the web site single WGs will be also activated soon.
Obj. 1c: Joint applications to H2020 programs with Industrial partners;	25%	It is unfortunately not easy to find suitable funding programs for Oxide Electronic applications today. Several attempts were made on FET Open, which has had recently an acceptance rate below 3% (1,7% in last evaluated call). Joint applications are listed in page 9. Unfortunately we are not aware of any application that was already evaluated and was successful so far.
Obj. 1d: Signed agreements and know-how transfer actions with industrial partners;	25% *probably more, not all data are yet available*	A full database of know-how transfer actions with industrial partners by TO-BE participants is not available to date. Some examples are: - ICMAB (ES). Signed agreement of cooperation with a private company on: "Use of antiferromagnetic materials for data storage". Involved participants: Florencio Sanchez (Task leader), Pep Fontcuberta (CG member). Non-disclosure agreement signed. A contract of collaboration signed and under execution. - University of Cambridge. Two contracts are active with different companies: - Applied Materials, US, who are working on HTc superconductors; - Deregallera, UK, who are interested in oxide interfaces for energy. Together these sponsors pay 200K€ per year**.**
Obj. 1e: Documented increase of female participation to scientific and management activities within this field of research.	*40%* *of what can be realistically done and checked.*	*Warning: this sentence copied literally by our MoU but it unfortunately is ill-written as an ascertainable objective. In fact, we will not be able to document if the females participation to the field of oxide-based electronics will has indeed increased by the end of the Action.* The respect of gender policies is under the responsibility of the Gender Balance Coordinator, Geetha Balakrishnan, who is also the Action Vice Chair. A constant effort is made to financially support the females with percentages exceeding by far the percentage of female population in the field. A similar effort is also made, to some extent, in the choice of invited speakers (intended with the usual meaning employed in conferences, rather than with the specific meaning given within COST). A dedicated web page on our site explains our selection criteria and displays the statistics of TO-BE activities also in terms of COST policies (gender balance, ITCs and ECIs)
Obj. 2: Scientific publications in top international reviews, invited/plenary talks in international conferences.	40%	A list of 10 relevant publications is reported in page 8-9. The high impact factor of joint papers witnesses the scientific excellence of our Action. Consider that this is an 18 months report, and the editorial phase of hop IF journals, from submission to publication, can easily last about one year. The list of invited talks held by COST participants, or even only by Core Group participants, would be far too long for the format of this report.

		We report on some examples of plenary talks delivered by COST participants at major multi-session conferences: - Jochen Mannhart, EMRS Fall Meeting (a conference with >1000 participants) Plenary talk "A New Frontier for Nano-Materials" http://www.european-mrs.com/meetings/2015-fall/plenary-session, Sept 18, 2015. This talk, dedicated to the future of oxide-based nanoelectronics. *His candidacy as plenary speaker was succesfully sponsored by the TO-BE Action, as organisers of Symposium L, when EMRS opened a call for plenary speakers at the 2015 Fall Meeting.* - Judith Driscoll (Task leader), plenary talk "Unprecedented physical properties in nanocomposite functional oxides", 5th Australia-China Materials conference, Wollongong, 21-23 July, 2014 - Judith Driscoll (Task leader), Plenary talk to be given to the International Materials Research Congress, which will be held August 14-19, 2016, in Cancun, Mexico. As another valuable example, Pep Fontcuberta (CG member) has been named as one of the four Distinguished Lecturers by IEEE magnetics for year 2016. He will therefore deliver several dozens of talks worldwide, next year, under the support of IEEE. Talks will be about "Magnetism of Oxides"
Obj. 3-4a: Editing and publishing of a technological roadmap for oxide-based technologies.	*15%*	There have been many discussion about the Roadmap, but its preparation is still at a very initial stage. "Unfortunately" the very busy year of Pep Fontcuberta (see Obj. 2) doesn't help. Some review papers regarding perspectives of oxide electronics have been written and will be published next year by some Action members, including the Action Chair. The Roadmap remains a major objective of the Action.
Obj. 3-4b: Joint projects with private corporations.	25%	This happens to be a repetition of Obj. 1c. See above.
Obj. 3-4c: Filed patents.	25% *probably more, not all data are yet available*	Unfortunately a full database of submitted patents by TO-BE participants is not available to date. A couple of examples are reported below: - DTU (DK). "Stabilized thin film heterostructures for electrochemical applications" – PCT application No. PCT/EP2014/064812. Involved TO-BE Participant: Nini Pryds (WG leader) - Cambridge Univ (UK) – "Electrolyte Membrane", U.K. patent application 1410092.9, June 2014; Involved TO-BE Participant: Judith Driscoll (WG leader)

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 that have resulted or are in progress, 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."
I hesitate to claim credit to the Action for break-through scientific developments achieved so far. Those achieved recently can only marginally be considered as a direct output of the Action.

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Co-authored publications and FP7/ H2020 proposals

Co-authored publications

Enter in the table below only publications on the topic of the Action, co-authored by at least two Action participants from two different countries participating in the Action and for which the Action networking added value. A maximum of ten publications may be entered. If the Action has more than ten such publications the Core Group should select the ten most significant ones to include in the table below.

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[2])	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[3] 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[4]?	Is it peer-reviewed?	Was the added value of the Action Networking necessary for the publication	Impact Factor (if applicable)
1	*Tunable spin polarization and superconductivity in engineered oxide interfaces,* D. Stornaiuolo,, C. Cantoni, G. M. De Luca,, R. Di Capua,, E. Di. Gennaro,, G. Ghiringhelli, B. Jouault, D. Marrè, D. Massarotti,, F. Miletto Granozio, I. Pallecchi, C. Piamonteze, S. Rusponi, F. Tafuri, and M. Salluzzo, Nature Materials DOI: 10.1038/NMAT4491 (2015)	*M Salluzzo*	*15*	- F. Miletto Granozio (IT) Action Chair, - D. Marrè (IT) CG member - G. M. De Luca (IT) WG Member, - E. Di. Gennaro (IT) WG Member, - B. Jouault (FR) WG Member, - I. Pallecchi (IT) WG Member, - C. Piamonteze (CH) WG Member, - M. Salluzzo (IT), WG Member	*WG1, WG2, WG3*	*23 January 2015*		*http://www.nature.com/nmat/journal/vaop/ncurrent/full/nmat4491.html*	*Yes on Researche Gate and/or Cond-mat*	*no*	*no*		*YES*	*It provided a framework for the collaboration*	*36,50*
2	*Extreme mobility enhancement of two-dimensional electron gases at oxide interfaces by charge-transfer-induced modulation doping* Chen, Yunzhong and Trier, F. and Wijnands, T. and Green, R.J. and Gauquelin, N. and Egoavil, R. and Christensen, D.V. and Koster, G. and Huijben, M. and Bovet, N. and Macke, S. and He, F. and Sutarto, R. and Andersen, N.H. and Sulpizio, J.A. and Honig, M. and Prawiroatmodjo, G.E.D.K. and Jespersen, T.S. and Linderoth, S. and Ilani, S. and Verbeeck, J. and Tendeloo, G. van and Rijnders, A.J.H.M. and Sawatzky, G.A. and Pryds, N. (2015). **Nature materials, 14** . 801 (2015) doi:10.1038/nmat4303	*N. Pryds*	*25*	- Pryds, N. (DK, WG leader) - Chen, Yunzhong (DK, WG member) - Trier, F. (DK, WG member) - Gauquelin, N. (BE, WG member) - Christensen, D.V. (DK, WG member) - Koster, G. (NL, WG leader) - Jespersen, T.S. (DK, WG member)	*WG 1 WG 2 WG 3*	*05 August 2014*		*http://www.nature.com/nmat/journal/v14/n8/full/nmat4303.html*	*Yes on Researche Gate and/or Cond-mat*	*no*	*no*		*YES*	*It provided framework for the collaboration*	*36,50*
3	*Large Room-Temperature Electroresistance in Dual-Modulated Ferroelectric Tunnel Barriers* Greta Radaelli, Diego Gutiérrez, Florencio Sánchez, Riccardo Bertacco, Massimiliano Stengel, Josep Fontcuberta **Adv. Mater. 27,** 2602 (2015) DOI: 10.1002/adma.201405117	**J. Fontcuberta**	*6*	- Josep Fontcuberta (ES), CG Member. - Florencio Sánchez (ES) Task Leader, - Greta Radaelli (IT), WG member&STSM grantee,	*WG 1 WG 2 WG 3*	*Nov. 2014*		*http://onlinelibrary.wiley.com/doi/10.1002/adma.201405117/abstract*	*Yes on Researche Gate and/or Cond-mat*	*no*	*no*		*YES*	*It provided a framework for the collaboration*	*17.49*
4	*Insight into spin transport in oxide heterostructures from interface-resolved magnetic mapping* F. Y. Bruno, M. N. Grisolia, C. Visani, S. Valencia, M. Varela, R. Abrudan, J. Tornos, A. Rivera-Calzada, A. A. Ünal, S. J. Pennycook, Z. Sefrioui, C. Leon, J. E. Villegas, J. Santamaria, A. Barthélémy & M. Bibes **Nature Communications 6**, 6306 (2015) doi:10.1038/ncomms7306	M. Bibes	*16*	- A. Barthélémy (FR) MC member, - M. Bibes FR) subst. MC members - J. Santamaria, (ES) WG member,	*WG 1 WG 2 WG 3*	*18 July 2014*		*http://www.nature.com/ncomms/2015/150217/ncomms7306/full/ncomms7306.html*	*Yes on Researche Gate and/or Cond-mat*	*no*	*no*		*YES*	*It provided a framework for the collaboration*	*11.470,*
5	*Giant oscillating thermopower at oxide interfaces*	D. Marré	*10*	- Daniele Marre´ (IT) CG member - Ilaria Pallecchi (IT) WG member,	*WG 1 WG 2*	*10 Sept. 2014*			*Yes on Researche Gate*	*no*	*no*		*YES*	*It provided a*	*11.470,*

[2] MC Member/ MC Substitute/ MC Observer/ WG Member/ Training School Trainee/ STSM Recipient/ Other Action Participant

[3] Open 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.

[4] 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”

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	Ilaria Pallecchi, Francesca Telesio, Danfeng Li, Alexandre Fete, Stefano Gariglio, Jean-Marc Triscone, Alessio Filippetti, Pietro Delugas, Vincenzo Fiorentini & Daniele Marre´ **Nature Communication (2015)** DOI: 10.1038/ncomms7678			-Francesca Telesio (IT) WG member, - Stefano Gariglio (CH) WG member, - Jean-Marc Triscone (CH) WG member,	*WG 3*			*http://www.nature.com/ncomms/2015/150327/ncomms7678/abs/ncomms7678.html*	*and/or Cond-mat*				*framework for the collaboration*	
6	*Spin-Orbital Order Modified by Orbital Dilution in Transition-Metal Oxides: From Spin Defects to Frustrated Spins Polarizing Host Orbitals* Wojciech Brzezicki, Andrzej M. Oleś, and Mario Cuoco **Phys. Rev. X 5**, 011037 (2015) - Published 27 March 2015	W. Brzezicki	*3*	- M. Cuoco (IT) MC-Member, Task Leader, - A.M. Oles (PO) MC-Member - Wojciech Brzezicki, (PO) WG member	*WG1*	*7 August 2014*		*http://journals.aps.org/prx/abstract/10.1103/PhysRevX.5.011037*	*yes*	*no*	*no*		*YES*	*It provided a framework for the collaboration*	*9.043*
7	*Transport limits in defect-engineered LaAlO3/SrTiO3 bilayers* Felix Gunkel, Sebastian Wicklein, Susanne Hoffmann-Eifert, Paul Meuffels, Peter Brinks,b Mark Huijben, Guus Rijnders, Rainer Wasera and Regina Dittmann **Nanoscale 7,** 1013-1022 (2015) ,DOI: 10.1039/C4NR06272H	R. Dittmann		- Regina Dittmann (DE, MC member), - Felix Gunkel (DE, WG member), - Susanne Hoffmann-Eifert (DE, WG member), - Guus Rijnders (NL, WG member),	*WG1, WG2*	*24 Oct 2014,*		*http://pubs.rsc.org/en/Content/ArticleLanding/2015/NR/C4NR06272H#!divAbstract*	*Yes on Researche Gate and/or Cond-mat*	*No*	*No*		*YES*	*It provided a framework for the collaboration*	*7,394*
8	*Electric-Field Control of the Orbital Occupancy and Magnetic Moment of a Transition-Metal Oxide* Daniele Preziosi, Marin Alexe, Dietrich Hesse, and Marco Salluzzo **Phys. Rev. Lett. 115,** 157401 (2015)	M. Salluzzo		- Daniele Preziosi, (DE, now FR) WG member - Marin Alexe (DE, now UK) WG member - Marco Salluzzo (IT) WG member	*WG1, WG2*	*10 Nov. 2014*		*http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.115.157401*	*Yes on Researche Gate and/or Cond-mat*	*No*	*No*		*YES*	*It provided a framework for the collaboration*	*7.512*
9	*Universal electronic structure of polar oxide hetero-interfaces* Uwe Treske, Nadine Heming, Martin Knupfer, Bernd Büchner, Emiliano Di Gennaro, Amit Khare, Umberto Scotti Di Uccio, Fabio Miletto Granozio, Stefan Krause & Andreas Koitzsch **Scientific Reports 5**, Article number: 14506 (2015) doi:10.1038/srep14506	A. Koitzsch		- Fabio Miletto Granozio (IT) Action Chair, - Uwe Treske (DE) WG member, - Emiliano Di Gennaro (IT) WG member, - Amit Khare (IT) WG member, - Umberto Scotti Di Uccio (IT) WG member, - Andreas Koitzsch (DE) WG member	*WG1 WG2*	*31 March 2015*		*http://www.nature.com/articles/srep14506*	*Yes*	*No*	*No*		*YES*	*It provided a framework for the collaboration*	*5.578*
10	*Self-doping processes between planes and chains in the metal-to-superconductor transition of YBa2Cu3O6.9* M. Magnuson, T. Schmitt, V. N. Strocov, J. Schlappa, A. S. Kalabukhov, and L.-C. Duda **Scientific Reports 4,** Article number: 7017 (2014) doi:10.1038/srep07017	M. Magnuson	*6*	- Alexei Kalaboukhov (SE), MC member - Thorsten Schmitt (CH), MC member	*WG1 WG2*	*28 July 2014*		*http://www.nature.com/articles/srep07017*	*Yes*	*No*	*No*		*YES*	*It provided a framework for the collaboration*	*5.578*

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	List FP7/ H2020 projects resulting from the Action in this section of the table										
2											
				Proposals							
1	Call: Interreg Med Priority Axis 1: Promoting Mediterranean innovation capacities to develop smart and sustainable growth Project number: 928 Acronym: ecoSTORM Title: Eco electronics - global solutions from Mediterranean Duration (months): 36	Matjaz Spreiter	9	Fabio Miletto Granozio(IT) Action Chair Matjaz Spreiter (SI) WG member Florencio Sanchez (ES) Task Leader Matthijn Dekkers (NL) **Industrial partner**	European Regional Development Fund	02/11/2015	06/2015	Under evaluation	First call for Interreg Med modular projects	"Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and th Bioeconomy"; "Secure, clea and efficient energy"; "	The application was planned and designed during an Action meeting
2	Proposal number: 686325 Proposal acronym: SINFONiA Proposal title: Orbital control of Spin and topological states at the Interfaces of Functional Oxide heterostructures for Nano-electronics Duration (months): 36	Marco Salluzzo (IT)	9	Marco Salluzzo (IT) WG member Fabio Miletto Granozio (IT) Action Chair Daniele Marré (IT) CG member Stefano Gariglio (CH) WG member Giacomo Benvenuti (CH), **industrial partner** Jacobo Santamaria (S) WG member Manuel Bibes (F) Task Leader Milan Radovic (CH) WG Member	European Commission	30/3/2015	09/15	Rejected	H2020-FETOPEN-2014-2015-RIA		It helped in defining the team and including the industrial partner
3	Proposal number: 687171 Proposal acronym: SuperFET Proposal title: All-oxide Superconductive Field-Effect Transistor Activity: FETOPEN-RIA-2015-1 Duration (months): 36	Alessio Filippetti (IT)	8	Marco Salluzzo (IT) WG member Daniele Marré (IT) CG member Stefano Gariglio (CH) WG member	European Commission	30/3/2015	09/15	Rejected	H2020-FETOPEN-2014-2015-RIA		marginally
4	Proposal number: 665171 Proposal acronym: NICE Proposal title: Nano Ionic Conducting materials Engineered for information application Activity: All Duration (months): 36	Carmela Aruta (IT)	5	Carmela Aruta (IT) WG member, Daniele Marré (IT) CG member Pryds, N. (DK) WG leader	European Commission	30/9/2014	03/15	Rejected	H2020-FETOPEN-2014-2015-RIA		marginally
5	Acronym: SKYSONS" Title Skyrmions and Spin-State Polarons: Exploring Intrinsic Magnetic Inhomogeneities forTechnological Applications" Duration (months): 36	Thomas Muehl (DE)	10	Fabio Miletto Granozio (IT), Action Chair Thomas Muehl (DE) Vincent Cros (FR)	European Commission	13/01/2015	15/15	Rejected	H2020-MSCA-ITN-2015		marginally

I.C. Networking

Added value of the Networking
The major added value is that people working in the same materials but in neighbouring fields get to know each other at our meetings. This included the cases of scientists from academic and industrial sector, theorist and experimentalists, scientists working on fundaments and on applications, sample growers and end-users of the samples, applied scientists working on different applications but actually working on the same materials
Extent of the networking
The TO-BE community is a large community (about 270 registered participants so far) and is growing fast. The effort in guaranteeing privileged access to COST financial resources devoted to networking for scientists targeted by COST policies (ITCs, ECIs and females) is constant. Of course, positive discrimination must be avoided. Our statistics and policies in this respect are reported here.

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[5]	Timing of impact[6]
Enter one impact per line, and specify the type and timing of the impact.		
Below the four possible impacts that might directly derive from our Action if successful are reported. They are listed starting from the most likely		
Increased networking inside the EU community active on science and applications of transition metal oxides	Scientific	2 years
Increased understanding by the community involved in semiconductor-based solid state technologies about the potential of oxide-based technologies	Scientific/ Technological and Economic	2-5 years. This is a gradual process timing is difficult to define
Increased understanding by EU and national policy makers of the need to support research on transition metal oxides	Scientific/ Societal	2-5 years.
Increased presence in the oxide community of females, ECIs and scientists from ITC	Societal	2-5 years.
Below the some possible impacts that the worldwide community working on transition metal oxides and their epitaxial-thin-film-based applications might achieve, also with a contribution from our Action		
Increased understanding of correlated electronic systems with charge/spin/orbital degrees of freedom	Scientific	This is a gradual process, timing can not be defined
Development of a reliable technology, scalable at an industrial level for large area deposition of epitaxial oxides on Si	Technological	Possible in 2-5 years
Development of a novel generation of commercial Oxide Resistive RAMs (possibly including multilevel memories beyond binary logic) based on filamentary switching, oxide vacancies migration, tunnelling electroresistance, magnetoresistance or other mechanisms.	Technological and Economic	Possible in 2-5 years
Development of commercial piezoelectric devices based on epitaxial thin film technologies, e.g. for microactuators of energy harvesting. Possible substitution of PZT based compounds with lead-free compounds	Technological and Economic	Possible in 2-5 years
Development of commercial micro solid oxide fuel cells as power sources for portable electronic devices	Technological and Economic	Possible in 2-5 years

[5] Scientific/ technological, Economic, Societal
[6] Achieved/ Foreseen within 2 years/ Foreseen 2-5 years/ Foreseen 5-10 years/ Foreseen 10+ years

Development of commercial electro-optical microdevices based on epitaxial thin film technology	Technological and Economic	Possible in 2-5 years
Use of oxide-based 2D electron gases for 2D electronics/spintronics beyond graphene	Scientific/ Technological and Economic	Possible in 5-10 years
Surface catalysis, chemical sensors. These are extremely relevant fields, but not being typically based on epitaxial films they are not fully covered by the expertise present in the Action		

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.

Add description here

Item/ activity	Target audience	Result	Hyperlink
TO-BE web site	EU community working on oxides	Dissemination of our initiatives	
Organising a TO-BE meeting as Symp. L of EMRS Fall Meeting	Scientists from neighbouring fields of materials science	Increased knowledge about the TO-BE Action	http://www.european-mrs.com/2015-fall-symposium-l-european-materials-research-society#program
Invited talk about the TO-BE Action delivered by the Action chair at Simp. L meeting	Simposium L attendees at the EMRS Fall meeting	Increased knowledge about the TO-BE Action	http://www.european-mrs.com/2015-fall-symposium-l-european-materials-research-society#program
Successfully sponsoring the candidacy of Jochen Mannhart, one of the reference figures for Oxide Electronics, for a plenary talk at EMRS 2015 Fall meeting	EMRS Attendees. Registered EMRS participants exceeded 1000	Increased knowledge of the perspectives of oxide electronics within the materials science community	http://www.european-mrs.com/meetings/2015-fall/plenary-session
Printing the TO-BE brochure	Scientists from the public and private sector participating at our meetings	Increased knowledge about the TO-BE Action	http://to-be.spin.cnr.it/

I.F. Action success(es)

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

Description of the success story	Dimension of the success ■ Breakthrough: scientific, technological or socioeconomic ■ Policy implementation (specify which policy) ■ Capacity building
There are several success stories within our community that could be mentioned, but it would not be honest, at this very early stage, to give the credit to the TO-BE Action.	

II. Management Report

II.A. Overview of expenditure

Insert below in the yellow cells the summary of figures from the Yearly Financial Reports (YFRs) of completed Grant Periods and an IFR of any incomplete Grant Period – the Totals (non-yellow cells) will automatically sum.

	Grant Period 1	Grant Period 2	Grant Period 3	TOTAL
GP start and end dates	01/06/2014-31/05/2015)	(01/06/2015-31/05/2016)	(dd/mm/yyyy-dd/mm/yyyy)	
Grant Holder institution	CNR SPIN (I)	CNR SPIN (I)	GH institution name (country code)	
Meetings	EUR 110.168,56	EUR 34.239,62		EUR 144.408,18
Training Schools	EUR -	EUR 22.822,30		EUR 22.822,30
STSMs	EUR 19.730,00	EUR -		EUR 19.730,00
Dissemination	EUR 6.739,00	EUR -		EUR 6.739,00
OERSA[1]	EUR -	EUR -		EUR -
Total Scientific Expenditure	EUR 136.637,56	EUR 57.061,92	EUR -	EUR 193.699,48
FSAC[2]	EUR 20.481,97	EUR 8.559,29		EUR 29.041,26
TOTAL	EUR 157.119,53	EUR 65.621,21	EUR -	EUR 222.740,74

[1] OERSA = Other Expenses Related to Scientific Expenditure (e.g. bank charges)
[2] FSAC = 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 Organisations 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		

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
Harold Hwang	Stanford University SLAC	US	22/09/ 2014	"Designing Electronic Phases at (001) and (111) oriented pervoskite superlattices". Engineering new electronic properties in artificial heterostructures is one of the ambitious goals supported within the TO-BE Action. Relevant to the three WGs, in part. WG1
Enrico Traversa	King Abdullah University of Science and Technology	SA	22/09/ 2014	""Going nano to convert energy: Ionic conductivity of oxide thin films and superlattices". Nano ionics is an emerging field within research on oxides, relevant to the realization of micro solid oxide fuel cells. Relevant to the three WGs, in part. WG3
Charkes Ahn* *(*C.A. eventually self-funded his mission)*	Yale school of engineering & applied science	US	22/09/ 2014	"Integration of complex oxides with semiconductors". Epitaxial growth on oxides on semiconductors is a crucial technological step for oxide based technologies. Relevant to WG2 and in particular to WG2-T2
Hanna Dabkowska	McMaster University Ontario	CA	30/03-02/04/ 2015	"Trends in Crystal Growth of Magnetic Oxides". Magnetic oxides are highly promising in spintronics due to their half-metallic properties. Particularly relevant to WG2.
Jeremy Levy	University of Pittsburgh	US	30/03-02/04/ 2015	"Oxide Nanoelectronics On Demand". The talk focused in particular on 2D electron gases at oxide interfaces. Relevant to WG1 and in perspective to WG3
Kei Takahashi	RIKEN	JP	14/09-18/09/ 2015	"Quantum Hall effect in delta-doped SrTiO3 by high temperature gas source MBE growth". Discovery of QHE is a milestone in oxide-based 2DEGs. Relevant in particular to WG1&2.
Susanne Stemmer* *(* S:S. could not attend due to a flight problem).*	University of California, Santa Barbara	US	14/09-18/09/ 2015	"Emergent Phenomena at Complex Oxide Interfaces". Central to the Action topics. Relevant to all WGs.

Dissemination meetings

The table below highlights the added value of Dissemination Meetings financed from Action funds.					
Participant name	Role	Country	Date	Location	Topic and added value to the Action
Fabio Miletto Granozio	Action chair	IT	Sept. 15, 2015	Warsaw, EMRS Fall meeting	The talk was explicitly dedicated to the TO-BE Action. Its value was to spread information about the Action itself with the materials science community. It was funded as a regular scientific meeting grant.

II.C. Participants

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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.

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