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Modelling,Control and Management of Thermal Effects in Circuits of the Future

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Final report on dissemination activities	

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Contents

1 Introduction

The objective of Task T8.2, whose third year of activity is summarized in this document, is to spread Europe-wide the knowledge gained during the execution of the THERMINATOR project. Due to the good results obtained during the first two years of the project, the THERMINATOR partners decided to follow the same guidelines used for the first year, thus implementing the same actions: (i) Maintain the THERMINATOR web-site, (ii) publication of scientific articles in books, technical journals, conference and workshop proceedings, (iii) publication of press releases in international, national and local/regional newspapers and magazines, as well as in international, national and regional/local events such as fairs and exhibits

The dissemination activities regarding publication of articles and papers, as well as additional advertisement initiatives such as participation to conferences, fairs and other public events, are surveyed, on a partner-by-partner basis, in details in Section 2 of this document. In particular, a common reporting template was defined in order to allow the Project Officer and the Reviewers to easily identify the different kinds of actions that each involved partner has undertaken, and to maintain the same structure as in the previous dissemination reports. It should be mentioned that, from the list of publications, we can deduce that a strong collaboration between THERMINATOR partners has been carried out. In fact some papers have been published by different authors of different affiliations.

Section 3 gives details on the organization of two special half-days within an important international workshop (THERMINIC) on thermal-related research topics.

2 Dissemination Activities of Individual Partners

2.1 ST

Publications

Paolo *Magnone, Claudio Fiegna, Giuseppe Greco, Gaetano Bazzano, Enrico Sangiorgi, Salvatore Rinaudo,,* **"Numerical Simulation and Modeling of Thermal Transient in Silicon Power Devices",** Proceedings of the IEEE 13th ULIS 2012, 5-7th of March, 2012, Grenoble, France / published in a special issue of Solid State Electronics.

Sassone A., Calimera A., Macii A., Macii E., Poncino M., Goldman R., Melikyan V., Babayan E., Rinaudo S.; **"Investigating the Effects of Inverted Temperature Dependence (ITD) on Clock Distribution Networks"**; Proceedings of Design, Automation & Test in Europe (DATE'12) conference, Dresden, Germany, 2012.-P.165-167

Giuseppe Greco, Salvatore Rinaudo, Steffen Holland **"Modeling, Control and Management of Thermal Effects in Electronic Circuits of the Future"** European Nanoelectronics Forum, Munich, Germany, 20-21 Nov, 2012

2.2 SYNOPSYS

Publications

Sassone A., Calimera A., Macii A., Macii E., Poncino M., Goldman R., Melikyan V., Babayan E., Rinaudo S.; **"Investigating the Effects of Inverted Temperature Dependence (ITD) on Clock Distribution Networks"**; Proceedings of Design, Automation & Test in Europe (DATE'12) conference, Dresden, Germany, 2012.-P.165-167

Melikyan V., Gevorgyan A., Baghdasaryan A., Melikyan H.; **"Thermal Via's Placement Zones Identifying Using Voronoi Diagrams"**; Proceedings of the 32th International Scientific Conference Electronics and Nanotechnology (ELNANO 2012), Kiev, Ukraine, 2012.-P.77-79

Melikyan V., Babayan E., Harutyunyan A., Melikyan N., Zargaryan G.; **"Method of Reducing Thermal Dependence of Timing Delays of Digital Integrated Circuits"**; Proceedings of 5th All-Russian scientific-technical conference "Problems of Developing Advanced Micro- and Nanoelectronic Systems -2012" (MES-2012), Moscow, Russia, 2012. –P409-412

Melikyan V.Sh, Durgaryan A.A., Balabanyan A.H., Babayan E.H., Stanojlovic M., Harutyunyan A.G.; **"Process-voltage-temperature Variation Detection and Cancellation Using On-Chip Phase-Locked Loop"**; Proceedings of the 56th Electronics, Telecommunications, Computers, Automatic Control and Nuclear Engineering (ETRAN) Conference, Zlatibor, Serbia, 2012.-P.EL1.2-1-4

Melikyan V., Babayan E., Harutyunyan; **"A. Pattern-Based Approach to Current Density Verification"**; Proceedings of the 4th Small Systems Simulation Symposium 2012, Nis, Serbia, 2012.-P.58-61

Melikyan V., Balabanyan A., Babayan E., Durgaryan A.; **"Decreasing of Frequency Variation in High-Speed Ring Oscillator using Bandgap Reference"**; Proceedings of the 32th International Scientific Conference Electronics and Nanotechnology (ELNANO 2012), Kiev, Ukraine, 2012.-P.79-81

Roldman R., Bartleson K., Wood T., Melikyan V., Babayan E.; **"Synopsys' Low Power Design Educational Platform";** Proceedings of the 9th European Workshop on Microelectronics Education (EWME 2012), Grenoble, France, 2012.-P.23-26

Melikyan V., Babayan E., Harutyunyan A.; **"Pattern-Based Approach to Current Density Verification"**; Electronics, Faculty of Electrical Engineering, University of Banja Luka, Volume 16, Number 1, Serbia, 2012.-P.77-82

Melikyan V., Harutyunyan A.; **"Modeling of IC Interconnects and Power Rails"**; Chartarapet, Yerevan, 2012

Melikyan V., Durgaryan A., Khachatryan A., Manukyan H., Musayelyan E.; **"Self-compensating Low Noise Low Power PLL Design"**; Proceedings of IEEE East-West Design & Test Symposium (EWDTS'12), Kharkov, Ukraine, 2012.-P.29-33

Melikyan V. Sh., Gavrilov S.V., Aharonyan V.K., Aslanyan N.K., Hovhannisyan A.S.; **"On-die CMOS Termination Resistor for USB Transmitter"**; RAs National Academy of Science and SEUA, Yerevan, RA, Vol. 65, N 3, Yerevan, 2012.-P. 295-304

Other presentations (courses, seminars, etc.)
Cilento T., **"Package Reliability Analysis with Coupled Electro-thermal and Thermal-mechanical Modeling";** MRS SPRING MEETING, April 2013.

Master courses
 "Low Power Design Techniques" in State Engineering University of Armenia Advanced IC Physical Design" course in Yerevan State University.

 "Digital Design Flow" in Moscow Institute of Electronic Technology.

 "Design of Nanoscale Sigma-Delta Modulators" in Moscow-Bavarian Joint Advanced Student School.

 "Physical Verification Runset Development" in Moscow-Bavarian Joint Advanced Student School

2.3 POLITO

Publications
Wei Liu; Calimera, A.; Nannarelli, A.; Macii, E.; Poncino M.; **"Layout-Driven Post-Placement Techniques for Temperature Reduction and Thermal Gradient Minimization,"** IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, To appear, 2012

Sassone, A; Liu, Wei, Calimera A., Macii, A.; Macii, E; Poncino, M.; **"Modeling and characterization of thermally induced skew on clock distribution networks of nanometric ICs,"** Elsevier Microelectronics Journal 2012, in press, available online DOI: 10.1016/j.bbr.2011.03.031

Tenace, V.; Miryala, S.; Calimera, A.; Macii, A.; Macii, E.; Poncino, M.; **"On the Efficacy of Layout Constrained Body-Biasing for Temperature Induced Clock-Skew Compensation",** THERMINIC-12: IEEE International Workshop on Thermal Investigations of ICs and Systems, Budapest, Hungary, 2012.

Goldman, R.; Melikyan, V.; Rinaudo S.; Calimera, A.; Macii, A.; Macii, E.; Poncino, M.; **"Investigating the Effects of Inverted Temperature Dependence (ITD) on Clock Distribution Networks",** DATE-12: IEEE Design Automation and Test in Europe, pp. 165-166, Dresden, Germany, 2012.

Participation to Conferences and Workshops
DATE-12: IEEE Design Automation and Test in Europe
Dresden, Germany, March 2012.

GLSVLSI-12: ACM/IEEE Great Lakes Symposium on VLSI,
Salt Lake City, USA, May 2012.

ISCAS-12: IEEE International Conference on Circuits and Systems,
Seoul, Korea, May 2012.

DAC-12: ACM/IEEE Design Automation Conference,
San Francisco, CA, USA, June 2012.

ISLPED-12: ACM/IEEE 2012 International Symposium on Low Power Electronics and Design, Redondo Beach, CA, USA, August 2012.

PATMOS-12: IEEE International Workshop on Power and Timing Modeling, Optimization and Simulation, New Castle, UK, September 2012.

THERMINIC 2012: International Workshop on Thermal Investigation of ICs and Systems, Budapest, Hungary, September 2012.

ICCAD-12: IEEE/ACM International Conference on Computer-Aided Design,
San Jose, CA, November 2012.

Other presentations (courses, seminars, etc.)
Enrico Macii, "**Power Analysis and Low Power Design**", ALARI Master Course, Lugano, Switzerland, February 2012.

Enrico Macii, "**Thermal Aware Design Techniques**"seminar at the University of California Los Angeles (UCLA), Los Angeles, California, USA, April 16, 2012.

Enrico Macii, "**Low Power and Thermal Aware Design**", seminar at University of California Berkeley, San Francisco, California, USA, April 20, 2012.

Enrico Macii, "**Thermally Induced Skew on Clock Distribution Networks: Modeling and Characterization**", seminar at the SEOUL NATIONAL UNIVERSITY, Seoul, Korea, May 18, 2012.

Enrico Macii, "**Thermal Insensitive Devices**", invited speech at STMicroelectronics, Catania, Italy, July 27, 2012.

Enrico Macii, "**Effects of Inverted Temperature Dependence (ITD) on Clock Distribution Networks**", seminar at the École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland, October 4, 2012.

Andrea Calimera, Alberto Macii, "**Thermal-Aware Design Techniques for Digital ICs – Basics**", Therminator Course, Torino, Italy, December 2012.

Andrea Calimera, Alberto Macii, "**Circuit- and Physical-Level Thermal-Aware Design Techniques for Digital ICs**", Therminator Course, Torino, Italy, December 2012.

2.4   OFFIS

Publications

Reef Eilers, Malte Metzdorf, Sven Rosinger, Domenik Helms, Wolfgang Nebel**, "Phase space based NBTI model"**, Proc. of International Workshop on Power and Timing Modeling, Optimization and Simulation (PATMOS), 2012

Other presentations (courses, seminars, etc.)
Sven Rosinger, Patrick Knocke, **"Low Energy System Design Lecture"**, OFFIS - Germany.

2.5   BME

Publications

Szalai Albin, Czirkos Zoltán, Székely Vladimír, **"A quasi-SPICE electro-thermal simulator"**, In: Proceedings of the 18th International Workshop on THERMal INvestigation of ICs and Systems (THERMINIC'12). Budapest, Hungary, 2012.09.25-2012.09.27. pp. 190-195.

Gergely Nagy, László Pohl, András Timár, András Poppe, **"Yield enhancement by logi-thermal simulation based testing",** In: Proceedings of the 18th International Workshop on THERMal INvestigation of ICs and Systems (THERMINIC'12). Budapest, Hungary, 2012.09.25-2012.09.27. pp. 196-199. Paper 42.

Gergely Nagy, András Timár, Albin Szalai, Márta Rencz, András Poppe, **"New simulation approaches supporting temperature-aware design of digital ICs"**, In: Proceedings of the 28th IEEE Semiconductor Thermal Measurement and Management Symposium (SEMI-THERM'12). San Jose, USA, 2012.03.18-2012.03.22. pp. 313-318. (ISBN: 978-1-4673-1109-0)

A Timar, M. Rencz, **"Temperature dependent timing in standard cell designs",** In: Proceedings of the 18th International Workshop on THERMal INvestigation. Budapest, Hungary, 2012.09.25-2012.09.27. pp. 179-183.

A Timar, M. Rencz, **"Real-time heating and power characterization of cells in standard cell designs",** MICROELECTRONICS JOURNAL (2012) IF: [0.919*]

A Timar, M. Rencz, **"Acquiring real-time heating of cells in standard cell designs",** In: Proceedings of the 13th IEEE Latin-American Test Workshop (LATW'12). Quito, Ecuador, 2012.04.10-2012.04.13. pp. 121-125.

Gergely Nagy, András Poppe, **"Simulation Framework for Multilevel Power Estimation and Timing Analysis of Digital Systems Allowing the Consideration of Thermal Effects",** In: Proceedings of the 13th IEEE Latin-American Test Workshop (LATW'12). Quito, Ecuador, 2012.04.10-2012.04.13. pp. 1-5.

Participation to Conferences and Workshops

Organization of conference sessions
LATW 2012 (Quito, Ecuador) – Special session 3: Thermal Aware Design and Test (Friday, April 13th 2012) - *Organizer: Márta Rencz, Technical University of Budapest, Hungary*

Therminic 2012 (Budapest, Hungary) – **Therminator session (Wednesday, September 26th 2012**) - Organizer: *András Poppe, Technical University of Budapest, Hungary*
See Section 3 of this document.

2.6   CSEM

Publications
Marc Pons, Jean-Luc Nagel and Christian Piguet; **"Maximum Delay Variation Temperature-Aware Standard Cell Design",** ICECS 2012 19th IEEE International Conference on Electronics, Circuits, and Systems, Seville, Spain – December 9-12, 2012

C. Piguet, **"Ultra-Low-Power Signal Processing in Autonomous Systems», Chapter 9 of Book « Energy Autonomous Micro and Nano Systems**", pp. 241-272, Editions iSTE Wiley 2012, Editors Marc Belleville and Cyril Condemine, ISBN 978-1-84821-357-9

M. Pons, F. Moll. C. Abella, C. Piguet, **"Process Variations Aware Design",** Poster at FETCH 2012, Alpes d'Huez, France, January 9-11, 2012 SIGN

Marc Pons, Marc Morgan and Christian Piguet, **"Fixed Origin Corner Square Inspection Layout Regularity Metric",** DATE'12, Dresden, Germany, March 12-16, 2012

C. Piguet, **"Engineers, you have to go for GreenTech!";** Keynote talk, FTFC 2012, Paris, 6-7 June 2012

Participation to Conferences and Workshops
ICECS 2012: IEEE International Conference on Electronics, Circuits, and Systems
Seville, Spain, December 2012.

DATE-12: IEEE Design Automation and Test in Europe
Dresden, Germany, March 2012.

FETCH 2012: Ecole d'hiver Francophone sur les Technologies de Conception des Systèmes embarqués Hétérogènes
Alpe d'Huez, France, January 2012.

FTFC 2012: IEEE Faible Tension Faible Consommation
Paris, France, June 2012.

Other presentations (courses, seminars, etc.)
C. Piguet, **"Microelectronic Technology"**, ALaRI Course on Embedded Systems, University of Lugano, Switzerland, October 15-17, October 24-25, November 5- 6, 2012

C. Piguet, **"Microelectronics for Systems-on-Chips",** EPFL, Lausanne, October-December 2012.

C. Piguet, **"Green Electronics",** ISEP, Paris, April 13, 2012

C. Piguet, **"Green Electronics",** ISEP, Paris, September 7, 2012

2.7   IMEC

Publications

Steve Stoffels, Herman Oprins, Denis Marcon, Karen Geens, Xuanwu Kang, Marleen Van Hove and Stefaan Decoutere *"***Coupled electro-thermal model for simulation of GaN power switching HEMTs in circuit simulators***",* THERMINIC 2012, Budapest - Hungary, 25-27 September 2012, pp. 1-6

Oprins H., Cherman V., "**Numerical and experimental characterization of hot spot dissipation in 3D stacks**", Electronics Cooling Magazine, Vol. 18(2), 2012, pp. 18-23.

3 Dissemination Through Dedicated Workshop Special Sessions

THERMINIC (International Workshop on Thermal Investigation of ICs and Systems) Workshops are a series of events to discuss the essential thermal questions of microelectronic microstructures and electronic parts in general. In particular, **THERMINIC 2012** (http://therminic.eu/therminic2012/index.php) also addressed, in addition to the "traditional" thermal management problems, stress and thermal-stress-related-reliability issues, both in micro- and opto-electronics fields.

As in 2010 and 2011, in **THERMINIC 2012** (25-27 September 2012, Budapest, Hungary), THERMINATOR partners (leaded by BME) have organized a special half-day session dedicated to disseminate the project results to the thermal management community. This special session consisted of six technical papers strictly related with the research topics followed and developed within the THERMINATOR project.

The technical program can be found at this url:
http://therminic.eu/therminic2012/prog.php

Below some details regarding the presentations given in this half day special session:

Therminic 2012, Therminator Special Session
Budapest, 25-27 September 2012. – participants: 75

Therminator Special Session

Thermal aware design methodology for small signal discrete products
Steffen Holland, Martin Röver, Hans-Jürgen Kühl, Hans-Jürgen Witt, Remo Quade, *NXP Semiconductors (Germany)*

Coupled electro-thermal model for simulation of GaN power switching HEMTs in circuit simulators
Steve Stoffels, Herman Oprins, Denis Marcon, Karen Geens, Xuanwu Kang, Marleen Van Hove and Stefaan Decoutere, *Imec (Belgium)*

Temperature dependent timing in standard cell designs
Andras Timár, Márta Rencz, *BME DED (Hungary)*

Layout Constrained Body-Biasing for Thermal Clock-Skew Compensation
Valerio Tenace, Sandeep Miryala, Andrea Calimera, Alberto Macii, Enrico Macii, Massimo Poncino, *Politecnico di Torino (Italy)*

A quasi-SPICE electro-thermal simulator
Albin Szalai, Zoltán Czirkos, Vladimír Székely, *Budapest University of Technology and Economics, Department of Electron Devices (Hungary)*

Yield enhancement by logi-thermal simulation based testing
Gergely Nagy, László Pohl, András Timár, András Poppe, *BME DED (Hungary)*

4 Conclusion

This document surveys, partner by partner all the dissemination activities carried on during the third (last) year of the project.

Since this document closes the project time frame, it is worth mentioning that the THERMINATOR consortium has been able to produce, over the three years of the project, the following dissemination results:

- 88 Publications
    - 17 Journal papers
    - 71 Conference papers

- 90 Dissemination actions
    - 42 conferences participations
    - 10 tutorials
    - 23 courses
    - 3 keynote speeches
    - 7 workshops
    - 5 seminars

For more details please refer to deliverables D8.2.2, D8.2.4, D9.2.4 and D9.2.5.