ICT-611439

TERASEL

Thermoplastically deformable circuits for embedded randomly shaped electronics

Instrument : Large-scale integrating project (IP)
Thematic Priority : Information and Communication Technologies (ICT)

Deliverable D6.8

TERASEL Newsletter 2

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Contact person : Bart Plovie – imec

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Table of contents

Abbreviations

2.5D	2.5 dimensional
3D	3 dimensional
HPF	High Pressure Forming
LED	Light-emitting diode
PCB	Printed circuit board
SCB	Stretchable Circuit Board
SMI	Stretchable Mould Interconnect
SPF	Stretchable Plastic Film
TPU	Thermoplastic poly-urethane

Document history

Date	Revision	Remarks
27.3.2015	0.1	Table of contents available
12.6.2015	1.0	Draft version available
24.6.2015	2.0	Formal approval of Deliverable D6.8 by the Project Steering Committee for submission to the European Commission

1. Executive summary

The TERASEL Newsletters have the aim to support the dialog between the TERASEL Consortium and the development communities, which work on similar topics, respectively potential customers.

We want to inform the target group in the second issue about further progress of the TERASEL project, which is now half way its duration of 36 months. This second issue of the TERASEL Newsletter presents some aspects of the project in more detail. Emphasis is on the polymer processing. Also work on 2 end-user applications is presented. Finally, also a short report is provided on a major dissemination effort, namely the Ghent Light Festival 2015.

The following issues will keep the reader in track about the progress of the TERASEL project, new applications, market news, information and activities around our subject from inside and outside our project.

2. Introduction – Aim of the TERASEL Newsletter

2.1 Target groups

The following reader groups are targeted :

- Project partners
- European Commission, EC Reviewers, Scientific Officer
- Development community
- Potential customers
- Interested public

2.2 Means of publishing

So far the dominant way of publishing is by electronic means (pdf-file). The newsletter is available in the download area of the project web page: www.terasel.eu

3. Contents headlines

The contents headlines of the first TERASEL Newsletter are :

- **Introduction**
- **Demonstrator spotlight**
  - Plastic electronic
  - Centro Ricerche Fiat
- **Polymer processing**
  - PEP
  - SINTEX NP
  - Niebling
- **Light Festival**
- **Future events**
- **Contact**

4. The second TERASEL Newsletter

A copy of the second TERASEL Newsletter is provided in Section 6 (Annex).

5. Conclusion

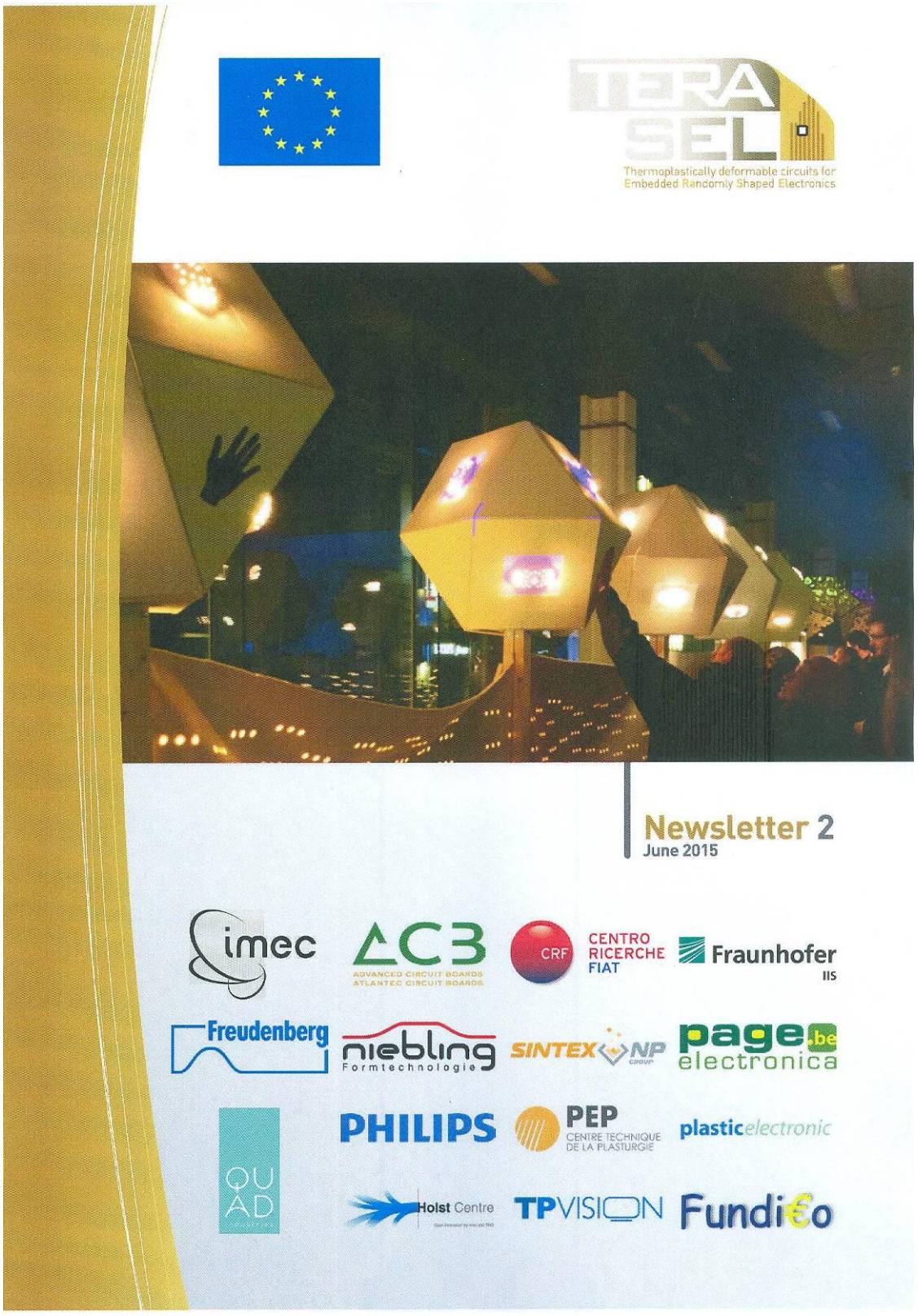
The second TERASEL newsletter has been created to support the dissemination of the aspects of thermo-plastically deformable circuits for embedded randomly-shaped electronics. It will be a continuous task to identify further relevant subjects for publication in future planned TERASEL newsletters.

This second issue of the TERASEL Newsletter presents some aspects of the project in more detail. Emphasis is on the polymer processing. Also work on 2 end-user applications is presented. Finally, also a short report is provided on a major dissemination effort, namely the Ghent Light Festival 2015.

6. Annex

6.1 Annex : TERASEL Newsletter 2

On this and the next pages a copy of the second TERASEL Newsletter has been provided.



INTRODUCTION

Dear reader,

In this second issue of the TERASEL Newsletter we describe further progress of the project which is now (May 2015) about half way its total duration of 3 years. The project has been introduced extensively in the first Newsletter, hence we refer to this document for more basic information. In short TERASEL aims to establish and demonstrate processes for the fabrication of smart 3D plastic objects, starting from flat electronic circuits, which are subsequently embedded in thermoplastic polymers and deformed to their final irregular 3D shape. For the production of the electronics 3 technologies are considered, based on conventional printed circuit board (PCB) and printing technologies, while the polymer processing part of the technologies uses vacuum forming, high pressure forming and overmoulding technologies, which are also widely used in the polymer processing industry. It is the smart combination of these different established technologies from electronics on one hand and polymer processing on the other hand, which generates the unique features of TERASEL free form and dimensionally stable 3D smart plastic objects. In that sense TERASEL aims to offer alternatives for other 3D electronics circuit technologies like rigid-flex circuits and 3D-MID.

During the first year the consortium has finetuned the different technology steps on a lab scale and has been able to demonstrate the feasibility for the production of 3D circuits by establishing suitable sequences of electronics and polymer processing steps. In the lab the technologies have been developed with transfer to industrial production environments in mind. This transfer has been initiated in the first half of the project: for certain TERASEL process flow more than half of the fabrication steps are now already executed on the production machines of the TERASEL participating companies. In the second half of the project we will fully concentrate on the transfer of the remaining steps, so that at the end of TERASEL we can offer full industrial processes for medium and potentially high volume production of TERASEL smart objects.

This second issue of the Newsletter presents some aspects of TERASEL in more detail. Emphasis is on the polymer processing with contributions from partners PEP, Sintex and Niebling. Also work on 2 (of the in total 5) end user applications is presented by partners CRF and plastic electronic. Finally also a short report is included on a major TERASEL dissemination effort, namely the Ghent Light Festival 2015, which had approximately 640'000 visitors in total, spread over 4 evenings. A roughly estimated 10% of this total were able to have a close look at the TERASEL demonstrator, an installation which was created in a joint effort by 5 TERASEL partners. This event, and many other contacts revealed a large interest in the technology and its potential applications. It is sure that in case of successful conclusion of TERASEL the technology will find applications in may more fields besides the ones targeted in TERASEL.

I wish you happy reading, and don't hesitate to contact us in case of further interest !

Jan Vanfleteren,
EU-FP7-TERASEL
general project coordinator

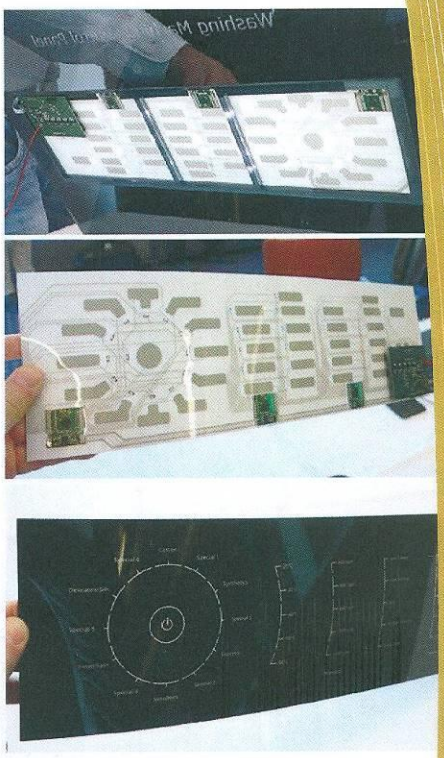
DEMONSTRATOR SPOTLIGHT

Plastic Electronic

Within the TERASEL project plastic electronic developed and produced a pre-demonstrator for a touchskin full-touch washing machine control panel, a part that should replace the existing control panels and mark the interface between men and washing machine.

All functions (touch-sensors, lighting, a display and the entire evaluation and control electronics) are integrated in a plastic part and therefore the console offers a fully closed surface. The electronic specialty of the relatively complex control console lies in the fact that there are 40 touch sensors and 40 LEDs with integrated microcontrollers that are interconnected on various wiring levels. A plug, with which the console is connected to the washing machine, is integrated as well. This control console for washing machines can be realized in various versions with different lighting and electronic concepts.

The aim was to create a control solution which is user-friendly, intelligent and intuitive at the same time. This touchskin control concept and the pre-demonstrator were presented to OEMs as well as end-users to find out about the requirements for a washing machine control panel. Also, end-user evaluations were conducted which showed that the full-touch control panel is received as very convenient by a huge majority of washing machine end-users.



Centro Ricerche Fiat

The increasing demand for more comfort, quality and appeal in the automotive interior segments as well as economic and environmental aspects that are strongly requiring a weight reduction of components, are promoting the development of smart surfaces in which a lot of functions are deeply integrated. Interior plastic parts can become "smart" that means they can include electronics functions like touch sensors, back-lighting, haptic feedbacks, actuators, in a seamless, smooth, complex-shape component. The technologies developed in TERASEL project allow the electronic circuit and components to be printed and integrated on a flexible and stretchable film that is then embedded in the plastic part.

The demonstrator developed by CRF aims to show the wide potentialities of this approach: it is made by an interior glove box with a touch sensitive surface that controls the LEDs backlighting and the opening mechanism. Electronics components, LEDs, touch pads and wiring are first integrated onto the flexible and stretchable foil and then in the front panel using TERASEL technologies.

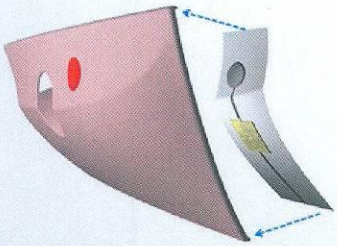
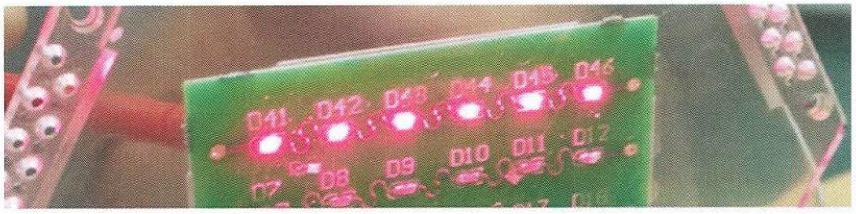


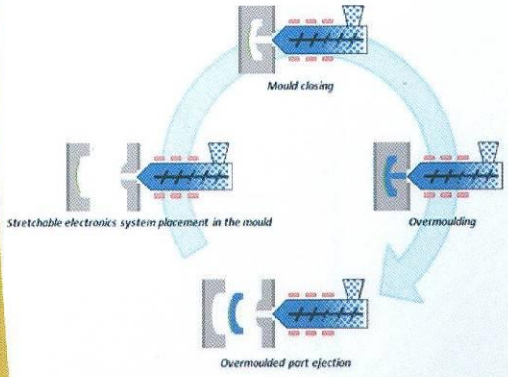
Figure 1:
electronics integrated onto flexible and stretchable foil that is then embedded in the glove box cover

POLYMER PROCESSING

PEP



Injection moulding technology is applied within TERASEL project in order to overmould the stretchable electronics systems, to bring them to their final 3D rigid shape. During overmoulding process, polymer material pellets are moved forward by a screw within a heated barrel, where they are slowly melted. When it reaches the nozzle, the melted material is injected in the closed mould. The stretchable electronics system being previously placed within the mould cavity, it is covered by the injected material. After cooling, the mould is opened, and the plastic part with embedded electronics is ejected.



Overmoulding process implies high temperatures (up to 300°C) and high pressures (up to 2000 bars). Electronic circuitry and components must withstand these harsh process conditions in order to ensure a good functionality of the final product. Within TERASEL project, PEP investigates the compatibility of the three stretchable electronics technologies (SMI by IMEC, SCB by IZM and SPF by TNO) with the overmoulding process.

Terasel technology targeting multi-material products, material compatibility is the first key point to be investigated. Overmoulding trials led to a selection of optimized material couples for each stretchable electronics technologies, also taking into account the end-users' applications requirements. In addition to material compatibility, adhesion between injected polymer and stretchable substrates (TPU for SMI and SCB, PEN for SPF) was also characterized and validated.

With high temperatures and high pressures, overmoulding process can damage the stretchable electronics if no suited precaution is taken. The overmoulding trials performed by PEP have shown promising behavior of both stretchable circuitry and components, but also revealed some potential damages. Based on these findings, specific design rules have been assessed, and are taken into account in present electronics designs, especially for the targeted demonstrators of the project.

Further process developments related to overmoulding include the implementation of thermoforming and overmoulding within the same process. Using a dedicated injection mould, equipped with a heating handling tool, thermoforming is performed within the mould, immediately followed by overmoulding. This approach is expected to open new possibilities in terms of 3D shapes parts and low processing costs.

SINTEX NP

After having defined with partners the shape and sizes of the first demonstrators, for SINTEX NP the activity of this period has been focused on processing conditions to get still functional parts after overmolding and thermoforming.On one hand, during overmolding the polymer reaches the cavity of the mold at elevated temperatures and high velocity, and on the other hand, during thermoforming the sheet is highly stretched. This leads to, on one hand, a flow which locally washes out and sometimes burns the drawn circuit. On the other hand, a non-optimized thermoforming process can create defects in the circuits.

Through different sets of trials on both processes, SINTEX NP is now able to get reproducible good parts; we now have the basis of the processing parameters to continue to ever more complicated parts. The first nice results were the formed pieces which were formed for the Ghent Light Festival. We were glad we could participate in this brilliant event!

In the coming months our work will focus in strengthening these results for different shapes, dimensions, and parts carrying even more components. These first results clearly show that electronics on printed and soft substrates are a good opportunity for the plastic industry in the coming years. The near future will be very exciting!

Niebling

The Niebling High Pressure forming process is highly integrated in the Terasel Project. Based on the possibility to heat up the laminated materials with variable temperatures from upper and lower side we`re able to reduce the influence of varying heat absorbing materials during the forming process. We use a touchless infrared heating system, so that the materials and the electronic components are more or less "protected" against the high temperatures on the surface.

The heating system allows us to reduce or increase the temperature in well-defined areas by regulating the electrical power individually on each heating element. Up to 84 single heating elements are used to heat up the foil before forming process.

The working pressure of our machines is up to 250 bar, allowing a favourable low temperature level on the foil during forming. For example our heating process with PC materials is performed at 150°C temperature setting, which is approx. 30°C lower than a comparable thermoforming process. The upper forming area is sealed during the forming process, which has the advantage that only a positive or negative forming insert on the bottom side of the foil is required.

The sensitive surface with the electrical components comes only into contact with the high pressure air. So the components must only withstand the working pressure, which was adjusted to approx. 120bar during our trials within the project. The temperature of the forming insert which is touching the bottom side of the foil can also be temperature regulated to achieve better results.

All the trials and samples that we made till now during the TERASEL Project have shown that most of the components were still functional after the Niebling High Pressure forming process. During this evaluation process sometimes small adjustments were necessary regarding the choice of foil materials and used ink as well as the constructional arrangement of the conductive strips.

Our machines allow forming of integrated electronic parts laminated on thicker materials, so that a production of parts without a backmoulding step could be realized.

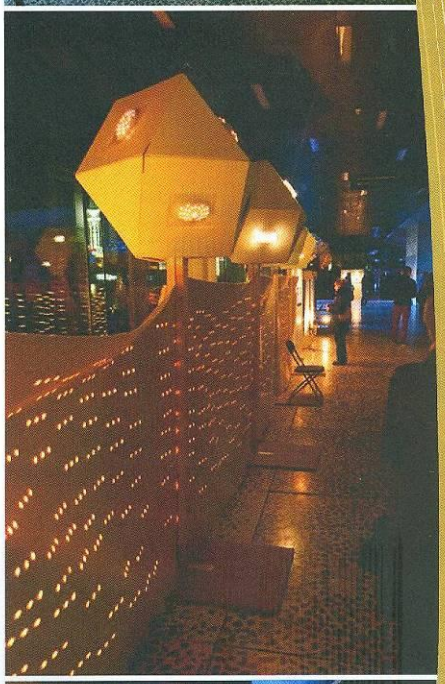
One major advantage of high pressure formed parts is to assemble them directly after forming and cutting. Based on our results we are highly confident to say that we see a realistic chance to reduce production steps and costs.

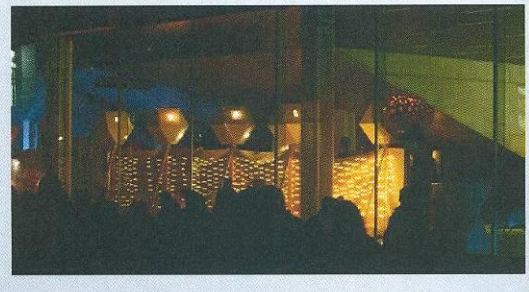
LIGHT FESTIVAL

For the third edition of the Ghent Light Festival consortium members imec, ACB nv., Page Electronics, Niebling GmBH, and SintexNP created an exemplary demonstration to showcase the concept of one-time deformable electronics, not only proving the feasibility, but also the ability to produce these devices in a short time span and in larger quantities with high reliability. The setup consisting of several interactive trees with close to 1000 integrated LEDs and an interactive textile, designed and produced by imec in co-operation with local Flemish industry, was visited by over 50 000 visitors and featured on several Belgian TV channels and through other media outlets.

Each tree contains five one-time deformable modules - employing imec's SMI technology - that respond to user interaction through a capacitive touch sensor mounted in the front panel of the tree. The 31 LEDs in each module can show a variety of animations synchronised with both the interactive textile, and a sonification system, triggered by the touch interaction.This created an immersive audio-visual experience that was able to draw attention from both close-by and far away.

The presented modules were made using a variety of finishing materials, ranging from polystyrene to polycarbonate, in combination with various types of thermoplastic polyurethane and EVA. This demonstrates the ability to tune the TERASEL technology to end-user demands without changing its core principles. Laminates containing elastomeric thermoplastic materials are not a disadvantage; when used correctly they are able to impart great resilience and mechanical strength to a product. By offering the ability to integrate the circuit board inside the plastic part the TERASEL technology can potentially reduce the mounting complexity over alternative fabrication methods.





FUTURE EVENTS

- **SEMICON WEST**
  14 – 16 July 2015
  San Francisco, CA, U.S.A.
- **IMAPS 2015**
  27 – 29 October 2015
  Orlando, U.S.A.
- **AUTOMOTIVE SURFACE 2015**
  18 – 19 November 2015
  Berlin, Germany
- **LIGHT & BUILDING FAIR 2016**
  13-18 March 2016
  Frankfurt, Germany
- **LOPEC FAIR**
  6-7 April 2016
  Munchen, Germany
- **PRINTED ELECTRONIC BERLIN**
  27 – 28 April 2016
  Berlin, Germany
- **WORLD OF TECHNOLOGY & SCIENCE**
  4-7 October 2016
  Utrecht, NL

TERASEL
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