Grant Agreement number: 248752

Project acronym: PRIAM

Project title: Printable functionalities for truly autonomous, intelligent lighting and signalling systems

Funding Scheme: ICT-2009.3.3

Start date of Project: 01.01.2010 **Duration: 36 months**

WP 3
Deliverable D3.4PU
Processed BB sub-assemblies

Document Name: D3_4 PU

Revision: Draft

Author: K. Keränen, A. Kinart, M. Antonipieri, J. Salomon, H. Bohlmann

---

Due date of deliverable: **31. December 2012**

Actual submission date: **31. December 2012**

Project co-funded by the European Commission within the 7 FP		
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)	

Content

List of Figures

Summary and objectives

The PRIAM project has developed two demonstrators: a parking status indicator and an automotive rear lamp. The 3D CAD models have been generated taking into account the components specifications, automatic R2R assembling processes and the European standards for the two applications. Each demonstrator comprises different building blocks ("BB"): the Lighting BB, Electronic BB, PV modules and Batteries. The single building blocks were manufactured and assembled to result in the final demonstrators. This document summarizes the results from single building blocks manufacturing and their integration.

1 Synergies among partners

In order to identify the right processes for assembly of all building blocks all PRIAM partners have been involved, each partner supplying his own expertise and capabilities.

2 Activities done

2.1 Architecture design

The demonstrators are composed of the following main building blocks:

- Lighting BB
- Electronic BB
- PV modules
- Batteries.

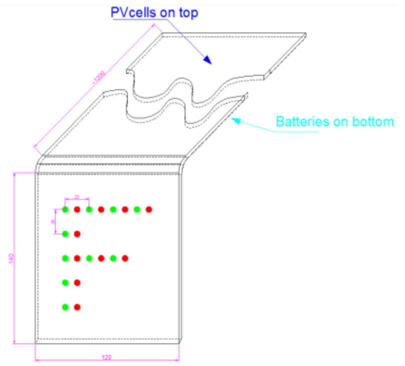
Building blocks were assembled onto a common backplane.

2.2 Description of the building blocks

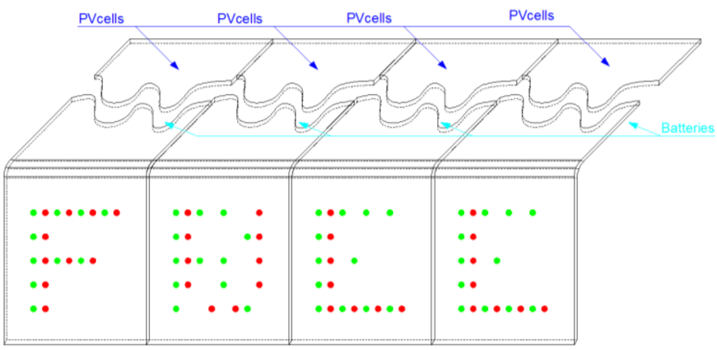
The lighting BB of the traffic lamp contains several red and green LEDs that permit to represent the words FREE in green colour and FULL in red colour. The preliminary demonstrator (High Mounted Stop Lamp) contains a cluster of red LEDs that permit to obtain the required intensity. The final demonstrator (Rear Combination Lamp) constitutes of red LEDs for the position and stop functions and yellow LEDs for the turn indicator. Each LED has particular micro-optics in order to obtain the required beam from the European standards. The activation of the LED clusters is managed from the Electronic BB with a CPU that controls the LEDs in base of ambient light, proximity of vehicles and the residual autonomy of the batteries. For the Energy harvesting and storage two main BBs were foreseen: PV modules and batteries. PV modules are based on commercial solar cells whereas the batteries have been developed from the consortium. The energy part has been designed to obtain autonomy of 15 hours.

2.3 Architecture of the Info panel demonstrator

The architecture of the traffic lamp demonstrators are represented in the following pictures. The lighting BB is located in the front, the PV modules part is slightly inclined in order to reach the higher efficiency in energy conversion of the PV module and the batteries are placed in the bottom side. The final demonstrator (parking status indicator) is an assembly of 4 Led-letter info panels.



Preliminary demonstrator (M24)



Final demonstrator (M36)

Figure 1: architecture of the Info panel.

2.4 Architecture of the automotive demonstrator

Two demonstrators for automotive application have been proposed: High Mounted Stop Lamp (HMSL) and Rear Combination Lamp (RCL). A vision of their assembly on FIAT Punto (2010) is shown in following figure. The autonomy, flexibility and integration of such conformable systems will take benefits to: reduction of plastic consumption, reduction in volume, improvement in power safety and energy autonomy, improvement in intelligence and communication, safety during parking/driving as well.

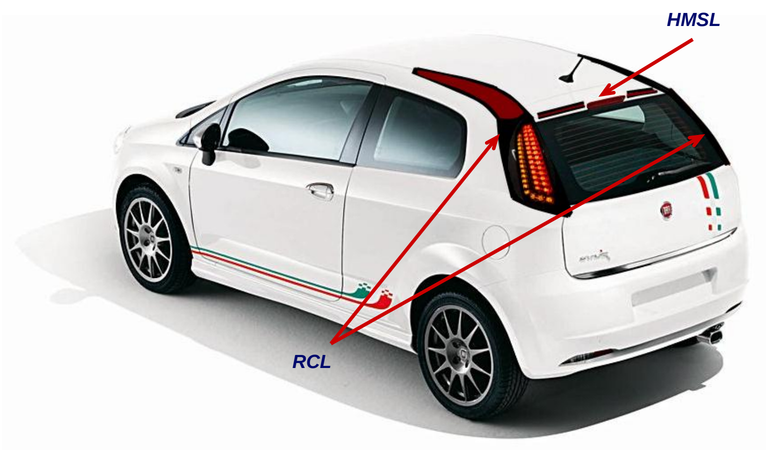
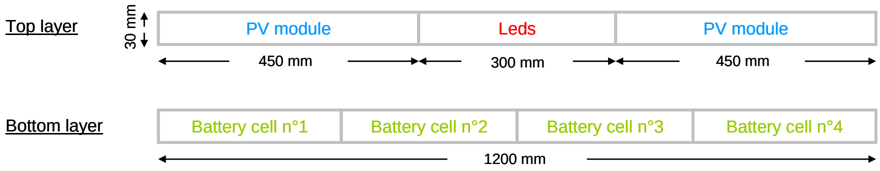
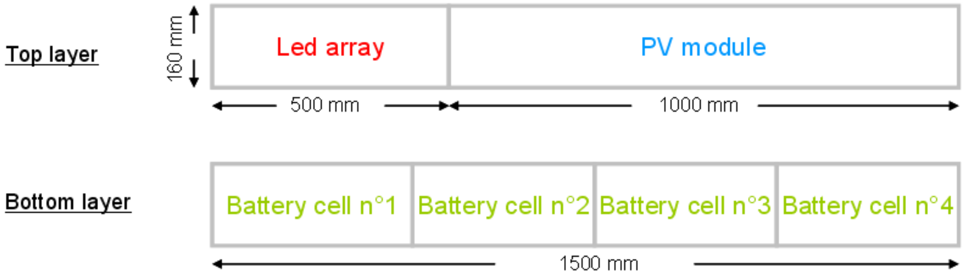


Figure 2: proposal of RCL and HMSL on FIAT Punto 2010.

The architecture of the HMSL and RCL respectively are represented in the following pictures



Preliminary prototype: High Mounted Stop Lamp



Final prototype: Rear Combination Lamp

Figure 3: architecture of the HMSL (demo M24, M36).

2.5 3D models

For both demonstrators, i.e., the High Mounted Stop Lamp as well as the Info Panel, all data has been collected and represented in 3D-CAD designs to give a detailed description of the demonstrators.

From single elements like bare die LEDS up to subsystems and final product everything is fully described. As software tool has been used SolidWorks®. The level of detail is also required to produce samples via a Rapid Prototyping approach. The following pictures illustrate examples of the first Letter of the traffic lamp and the automotive High Mounted Stop Lamp 3D models.

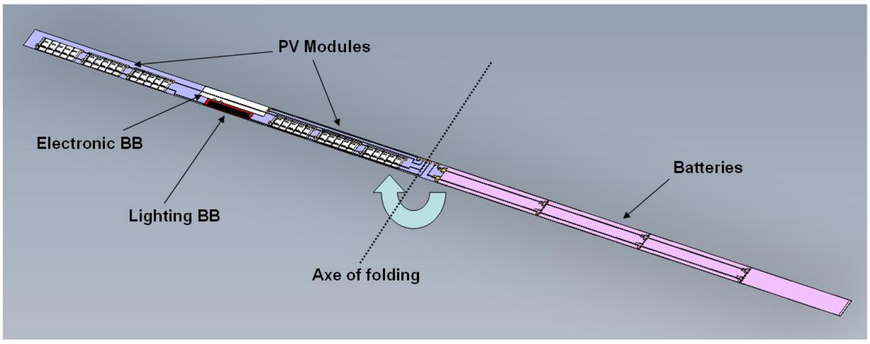


Figure 4: 3D Model of the HMSL.

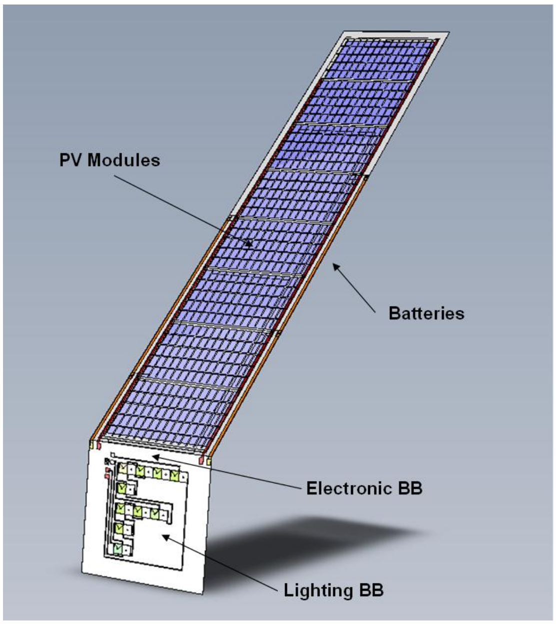


Figure 5: 3D Model of the Info panel letter.

2.6 Lighting BB processing

The lighting BB for the final demo - the layout of which is depicted in Figure 6 - has a total of 82 LED chips, of which 36 were red and 46 green LEDs. In addition there are 21 resistors. The size of the substrate is 120 mm x 290 mm.

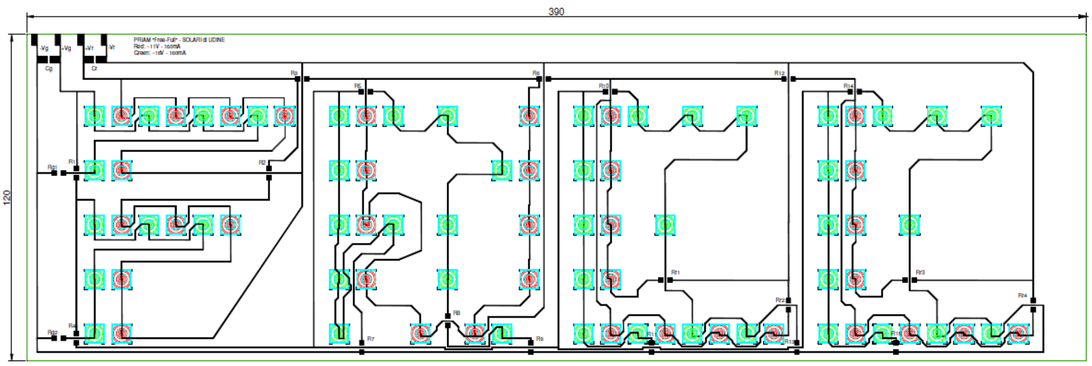


Figure 6: The FULL/FREE lighting demo.

The substrate was manufactured using R2R rotary screen printing with silver conductive paste for making the conductors. Rotary screen printing was used in making the backplanes. The process is a push-through process where ink is pushed through a fine fabric screen made of plastic or metal threads. The non-image areas of the screen are covered with a photopolymer stencil that determines the printed image. The screen has a cylinder shape and the stationary squeegee and ink are located inside the cylinder. As the screen cylinder rotates, the squeegee forces ink out of the screen apertures onto the substrate. Figure 7 shows part of a manufactured web.

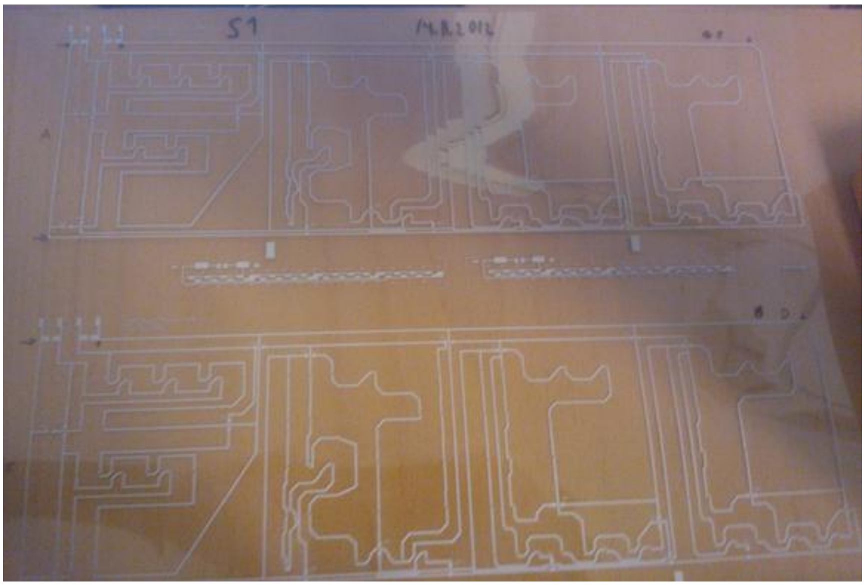


Figure 7: Printed web with two FULL/FREE substrates and two RCL substrates between them. Thickness of conductors: 12.5µm in average

The assembly and bonding of the components was performed with the EVO 2200 R2R bonding machine installation (see Figure 8).

Figure 8: Datacon EVO 2200 R2R bonding machine.

For the electrical interconnection of the components to the substrate thermode bonding was used. Key bonding process parameters in thermode bonding are temperature, bonding time, pressure and adhesive volume. Adhesive was dispensed to the contact area of the components, and the LED components were picked from wafers, and the resistors were picked from waffle packs. LEDs were placed onto the substrate with contact areas facing the respective areas on the substrate. Each chip was pressed with a heated tool to transfer energy to cure the dispensed adhesive between the contact areas. The resistors were bonded using isotropic conductive adhesive (ICA). In Figure 9 FREE –word lighted with green LEDs is shown.

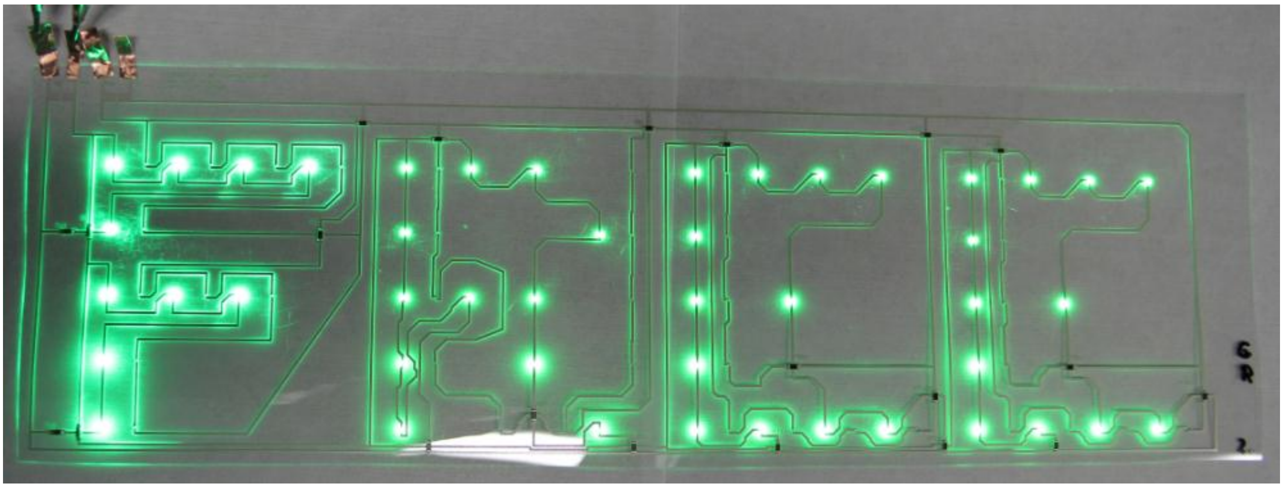


Figure 9: Green LEDs lighting the FREE -word.

2.7 Battery and PV module integration

The battery and the PV module assembly onto the backplane was expected to be performed by lamination process. In this view, battery lamination trials have been undertaken in order to firstly define the lamination parameters which seem to be relevant for the process and secondly prove the feasibility of this process. The battery lamination was realized in two steps: the first step consisted in bonding the adhesive onto the battery and the second step concerned the attachment of the battery onto the backplane.

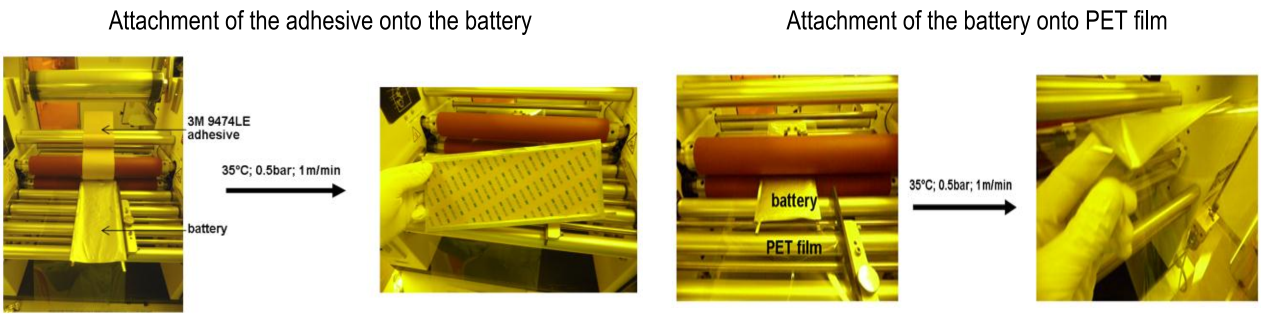


Figure 10: Battery lamination trials

For electrical connections copper foil stripes soldered onto the contact pads of PVs were used to contact to the backplane. One step lamination process could be envisaged with specific equipment based on co-lamination concept. In this case the adhesive is sandwiched between the substrate and the battery and then laminated. This concept can be adaptable to the PV module too.

2.8 Interconnection of “Light Tiles” on substrate via Inkjet printing

Amepox Microelectronic, in cooperation with microTEC, prepared via connection on the flexible substrates using the developed new nanosilver ink (commercial name Nano Ink AX JP-60n) and Ink-jet printing technology. This process allows, for example, the integration of microTEC´s "Light pads" with the flexible circuits, s.***Figure 11***. This process can potentially be done in a Roll-to-Roll process, since the production of the light tiles as well as the inkjet printing and sintering processes are R2R compatible.

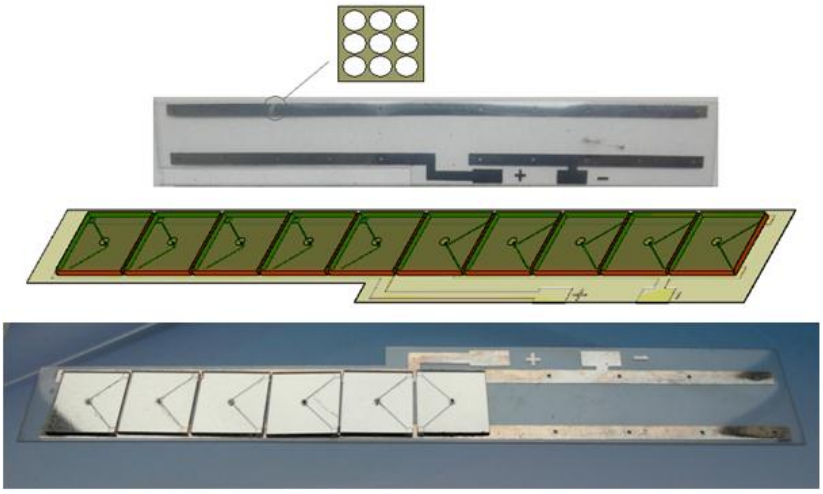


Figure 11: Integration of light pads using ink-jet printing technology

2.9 Interconnection lines for Lighting BBs on substrates via Inkjet printing

Amepox Microelectronics printed microstructures HMSL lighting BB and Info panel Lighting BB using AX JP-60n on the low cost flexible substrates (Polyethylene terephthalate foil (PET) and Polycarbonate foil (PC)). Sample printouts are presented in Figure 12:

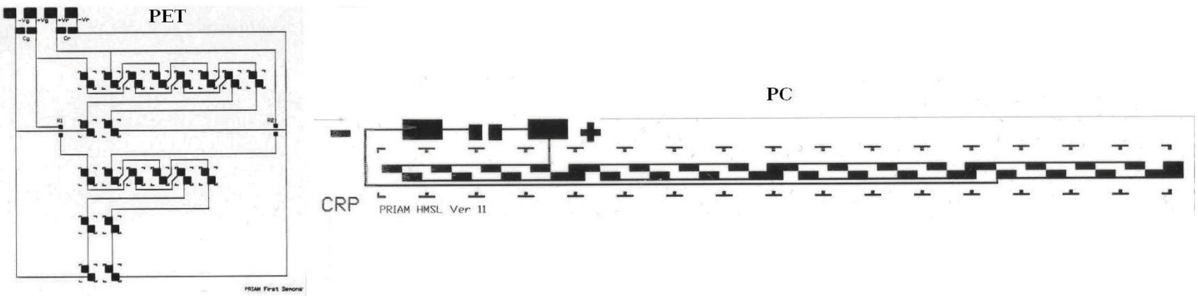


Figure 12: Infopanel lighting BB on PET foil and HMSL lighting BB on PC foil.

Interconnection of electrical Lighting BB on the flexible substrates needs printing technologies with the highest level of resolution and repeatability. The Ink-Jet systems were based on a principle which is well known from the ink jet printers.

2.10 Optics production and assembly on lighting BB

The production of the optics is done by hot embossing technique on polycarbonate foils. In order to maintain the bendability of the final demonstrators, a solution based on separate optical elements is chosen. Each optic is placed on a plastic frame and glued with UV curable adhesive. In the following picture the optic and the plastic frame.

Each optical system, constituted of a micro-fresnel mounted on a plastic frame, is placed in correspondence of each LED by pick and place machine and glued with UV-curable adhesive. On the printed layout, reference marks were foreseen for the optics alignment. Alternative technology for high volume production is the injection molding of plastic materials. The micro-structured nickel insert can be embedded in a mold where is present also the cavity for the plastic frame. With this process millions of optics per year can be produced and placed in dedicated trays. The optics can be easily removed from the tray and placed on the plastic foils by pick and place machines. Following figures show the results of the attachment and interconnections of optics (Info Panel and HMSL respectively) within the lighting BB.

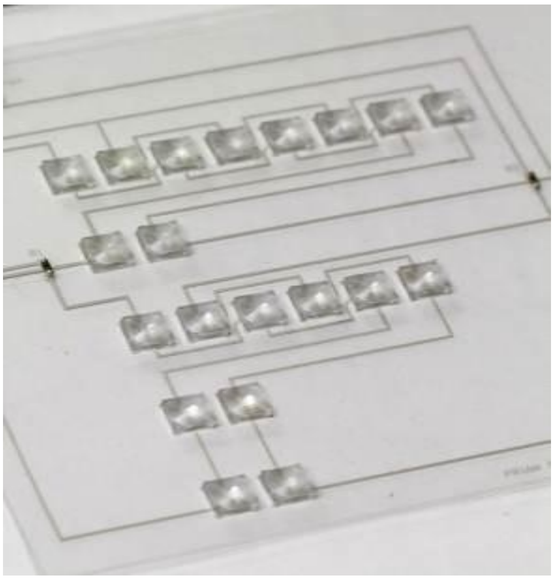


Figure 13: Info Panel lighting BB assembly

Figure 14: HMSL lighting BB assembly

2.11 Electronics BB manufacturing

Electronic BBs wiring was implemented on Polyimide foil using silver inks and rotary screen printing. For the assembly of SMD components there are two possibilities: the electronic parts are assembled in the same roll to roll line or the electronic BBs are separated from the printed roll to sheets and assembled in sheet to sheet technology. The only method which allows high yields, high performance in term of adhesion, thermal and electrical conduction is standard SMT technology. For the assembly of SMD components in Roll to Roll line, special P&P machine and reflow oven have to be introduced. These machines are based on standard architecture but implements handling systems compatible with roll to roll technology.

Figure 15: R2R SMT line – Courtesy of Automated Assembly Corporation

Electronic BB sheets can be assembled also in standard SMT lines adopting particular fixture for the handling. These fixtures have a sticky layer on the top surface (assist tape) and permitted to maintain the foils during the three stages of the SMT process: screen printing of the solder paste, components placing and reflow.

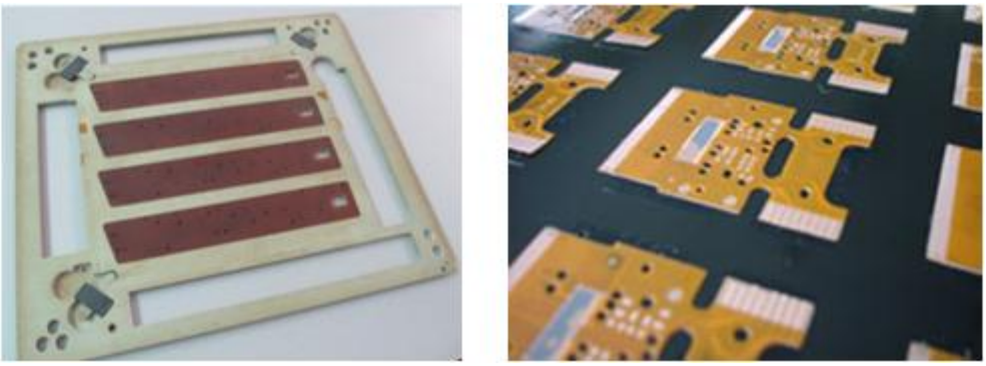


Figure 16: example of flexible PCBs mounted on adhesive fixtures

The electronic BBs for the preliminary demonstrators were manufactured in the SMT line available in CRP. They were laminated in a second step on the main backplane.

Figure 17: CRP pilot line.

3 Conclusions

The architecture and detailed final 3D models were generated. The processing of BBs and their sub-assemblies and mechanical interconnections were described. All the data and selections are in line with the preliminary experiments reported within other deliverables. Deliverable D5.3, public version, will provide a summary of the assessment of the manufactured prototypes.