Integration of recycling strategies in the development of advanced multi-functional IME devices

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1-ABSTRACT

Today the IME approach shows quite some advantages (compared to standard electronics production) such as weight reduction, assembly effort reduction, increased design freedom and increased durability. However, integration of durable force sensors, operation in harsh environments (under water, extreme low temperatures (-38°C) and industrial production) and the ability to use it with gloves are still a challenge.

In the European funded MULTIMOLD [1] project (Grant Agreement No.1011138427), the consortium tackles these issues by making use of 3D-molding simulations, optical simulations for better light distribution, increased integration density of electronics after thermoforming and the integration of piezoelectronic pressure sensors.

On top of that, a recycling strategy is integrated into the build-up (design to disassemble). At the end-of-life, plastics such as TPU (thermoplastic polyurethane) or PC (polycarbonate) can be selectively dissolved and prepared for reuse. On the other hand, the conductive circuitry, electronic components, other polymers, (flex) PCBs stay in the solid phase. This solid phase therefore contains a higher concentration of (precious) metals compared to mechanical recycling techniques.

2-CONTENT

A. Technological Innovations

Following innovations are introduced in the further development and (sensing) capabilities of IME devices:

- Overmolding of printed piezoelectric force sensing replacing capacitive touch sensors suffering from poor user experiences.
- Thermoforming of flexible PCBs allowing high interconnection densities with printed elements.
- Integration of overmolded force sensors in automotive human machine interfaces (HMIs).
- Material recovery through selective dissolution of the overmolded polymer.
- Injection molded microstructures and waveguide concept for enhanced light management
- IME technology to protect electronics under harsh environments

These technologies are integrated in 3 demonstrator types: automotive HMIs, industrial HMIs and a conditioning monitoring device on wind mills

B. Recycling Strategy

The recycling strategy is illustrated in Fig.1. The procedure in terms of temperature, solvent and time are optimized enabling the selective dissolution of PC. The advantage of this method is that impurities such as fillers and additives can be removed..

In this case the metal content of the PC granulate < 0.5 m%. The mechanical properties (Young's Modulus, Elongation at break and 4-point flexural modulus) is differing only 4% from the pure PC. The solid residue contains the ink, TPU, conductive glue and components. Moreover, (precious) metals can be recovered from this residue with traditional techniques such as hydro- or pyrometallurgy, or electrochemistry.

The same method can be applied if the overmolding polymer is TPU. However, dissolution parameters need to be adapted. Next to printed electronic substrates, this method can also be applied on overmolded flex PCBs (laminated between PC and TPU).

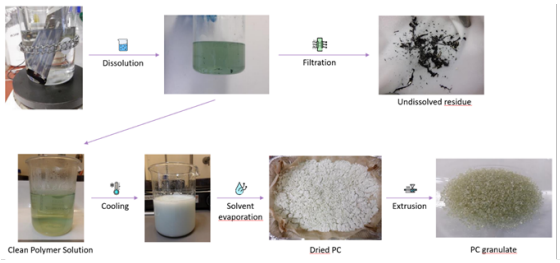

Fig. 1 Polycarbonate (PC) recovery method of a IME demonstrator made out of printed Ag ink on PC, graphical layers, conductive components (e.g. LEDs) and PC as overmolding polymer.

C. Conclusion and Future Enhancement

New technological advances are introduced in the IME devices together with a recycling process to recover a large part of the materials (both polymers and metals). In future, more complicated and better demo versions will be developed. The purity of the recuperated PC or TPU after recycling can be improved to obtain a better optical transparency.

References

[1] https://www.multimold.eu/