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Analysis of the Behavior of SMD Connectors Injected with Polyethylene and Irradiated after Lead-free Soldering

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1. Introduction

Under pressure from advances in technology and the need to reduce costs, the electronics industry has had to adapt to the Surface Mount Technology (SMT) process in order to produce smaller and better electronic circuit boards[1].

One of the great challenges of this process is the use of materials that can withstand the high temperatures of the remelting furnace that are necessary for the complete melting of the solder paste, thus resulting in efficient soldering of the Surface Mount Technology (SMD) components onto the printed circuit board. Among the various types of SMD components, connectors are usually the ones that suffer most from the high thermal requirements of this process and are currently injected with high thermal performance materials such as polyphthalamides (PPA)[2].

In addition to the high cost of these materials, the processing parameters are very strict so that complete crystallization of the material occurs in the mould cavity, thus requiring high temperatures. Only with this complete crystallization will the thermoplastic component be able to pass through the remelting furnace without deforming[3].

Radiation aims to modify polymers by means of molecular alterations resulting from radiation-induced reactions due to the occurrence of two effects: scission of the polymer chain causing degradation and cross-linking which would be the formation of cross-links in the chain, so chemical and physical changes that can occur in the irradiated polymer will depend on the chemical composition and the nature of the radiation [4]. For cross-linking polymers, electron beams are mainly used due to the high doses required[5].

As studies show that high-density polyethylene shows significant structural changes after being irradiated [6], this work aims to analyze the behavior of the SMD connector injected with polyethylene and irradiated with an electron beam after lead-free soldering.

2. Methodology

The specimens were injected with three different types of polyethylene:

- Specimens A = Low density polyethylene, natural color (PEBD NT)
- Specimens B = High density polyethylene, natural color (PEAD NT)
- Specimens C = High density polyethylene, with 17% fiber glass, black color (PEAD FV17)

The polyethylene specimens A, B and C (Fig. 1) were irradiated with a semi-industrial ^{60}Co irradiator at CETER at IPEN, with irradiation doses of 100 kGy and 300 kGy.

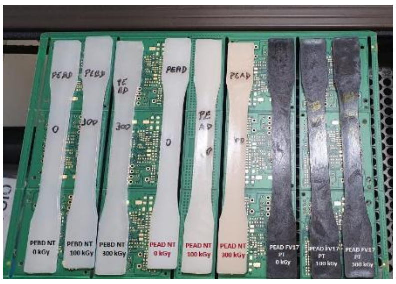

Figure 1: Non-irradiated and irradiated A, B and C polyethylene specimens (100 kGy and 300 kGy doses) before going through the lead-free reflow soldering.

To submit the A, B and C polyethylene specimens non-irradiated and irradiated at 100 kGy and 300 kGy doses the lead-free reflow soldering (approximately 8 minutes) at temperatures from 110 to 260°C.

The thermal performance of polyethylene samples A, B and C, non-irradiated and irradiated at doses of 100 kGy and 300 kGy, after lead-free reflow soldering, was evaluated to verify the sample with the best performance

The mechanical properties of the irradiated polyethylene specimens with the best results after the lead-free reflow soldering were compared by means of density, moisture content, load content, Shore D hardness, tensile strength, tensile modulus, elongation, flexural strength, flexural modulus and IZOD impact resistance without notch tests.

The thermal properties of the irradiated polyethylene specimens with the best results after the lead-free reflow soldering were compared by means of melting temperature, thermal deflection temperature, VICAT softening point, differential exploratory calorimetry and glass transition temperature tests.

SMD connectors (Fig. 2) with the irradiated polyethylene with the best result after the lead-free reflow soldering were injected.

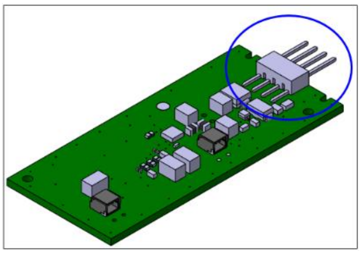

Figure 2: SMD connector soldered onto the PCB.

Part of the SMD connectors injected with the polyethylene irradiated with the best results after the lead-free reflow soldering were irradiated with a semi-industrial ^{60}Co irradiator at CETER at IPEN, with irradiation doses of 100 kGy and 300 kGy.

The thermal performance of SMD connectors injected with irradiated polyethylene with the best result after the lead-free reflow soldering were compared.

3. Results and Discussion

The A, B and C polyethylene specimens non-irradiated and irradiated at 100 kGy and 300 kGy doses at the IPEN - CNEN Radiation Technologies Center in a semi-industrial Co-60 were submited the lead-free reflow soldering (approximately 8 minutes at temperatures from 110 to 260°C) and the PEHD FV17 irradiated with 100 kGy and 300 kGy doses showed the best thermal performance (they didn't melt and deform) (Table 1).

Table 1: Non-irradiated and irradiated the A, B and C polyethylene specimens (100 kGy and 300 kGy doses) after going through the lead-free reflow soldering.

Specimens	IRRADIATION DOSE			STATUS
	0 kGy	100 kGy	300 kGy	
PEBD NT	Melted complete	Severe melting	Light melting and sucking	**NOT OK**
PEAD NT	Severe melting of edges, sucking and slight deformation	Severe deformation and sucking	Medium deformation and sucking	**NOT OK**
PEAD FV17 PT	Medium deformation and sucking	Without change	Without change	**OK**

The results showed that the high-density polyethylene, with 17% fiber glass, black color (PEAD FV17) study had its mechanical properties altered after radiation doses of 100 kGy and 300 kGy. Checking the mechanical properties of the specimens showed an increase in tensile modulus (38% for the 100 kGy irradiation dose and 312% for the 300 kGy dose) and IZOD impact resistance without notch (17% for the 100 kGy irradiation dose and 35.7% for the 300 kGy dose). Elongation decreased by 18% for the 100 kGy irradiation dose and 67% for the 300 kGy dose.

The SMD connectors injected with the PEAD FV17 irradiated with 100 kGy and 300 kGy doses showed the satisfatory thermal performance (they didn't melt and deform) (Fig. 3).

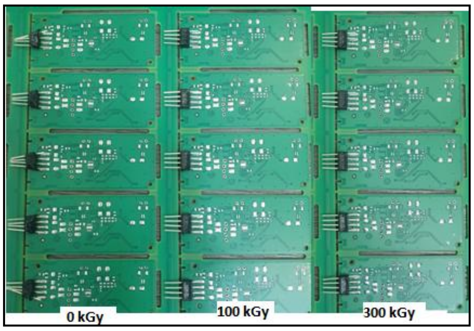

Figure 3: Non-irradiated and irradiated SMD connectors (100 kGy and 300 kGy doses) after going through the lead-free reflow soldering.

4. Conclusions

The irradiated SMD connectors injected with PEAD FV17 showed satisfactory thermal performance (without melting and deformation) after the lead-free reflow soldering.

Despite the fact that these connectors showed satisfactory thermal performance, the respective specimens did not show significant variations in the results of the thermal tests completed so far in terms of melting temperature and thermal deflection temperature.

The results obtained in the mechanical tests (tensile strength, tensile modulus, elongation, flexural strength, flexural modulus and IZOD impact resistance without notch) showed an indication of cross-linking of the specimens after irradiation which, as a consequence, gave the irradiated PEAD FV17 greater thermal stability at the peak temperature (260°C) during the lead-free soldering

For future work, the intention is to carry out scanning microscopy and X-ray diffraction tests to analyze the crystalline phase between the non-irradiated and irradiated SMD connectors at doses of 100 kGy injected into PEAD FV17.

Acknowledgements

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