Controlled Thermoplastic Polymer Adhesion to Materials Used in Electronics

Hrushikesh and P. Webb, Loughborough University

The electronics industry has relied for a long time on Printed Circuit Boards (PCBs) for electronic circuit manufacture. Although this technology of manufacturing electronic circuits has served the industry well over the years, the inherent lack of recyclability of the thermoset resins has led to end-of-life disposal problems. Use of thermoplastics as one-to-one replacements for thermoset boards, is one of the solutions to the recyclability problems posed by the PCB boards. Various other techniques like Moulded Interconnect Devices also use thermoplastics to manufacture electronics. 'Substrateless Packaging' is a process developed at Loughborough University using thermplastics to encapsulate electronics by injection moulding. The electronic components are placed inside the mould on a carrier tape (inserts) before overmoulding them with thermoplastics (fig 1).

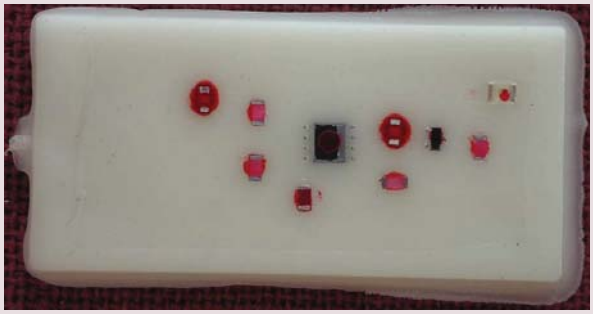

Figure 1: Electronic components injection overmoulded with thermoplastics

Interconnection between the components is then carried out by electroplating or printing conductive inks. The process is thus 'substrateless', dispensing with a circuit board. If the thermoplastic chosen is biodegradeable, then in principle components can be separated from the overmould by composing at end-of-life, enhancing the value of the waste stream and making reprocessing of circuits more economically attractive. Adhesion between the legs and metallisations of electronic components and the thermoplastic overmould is crucial to the service-life and reliability of such a product. The motivation for the current study uis to understand the mechanisms behind and be able to improve adhesion of thermoplastics to specifically tin. The magnitude of the adhesion can be expressed in terms of practical adhesion obtained by destructive testing (peel test, lap shear test, fibre pull out etc) and in terms of 'fundamental' adhesion. Fundamental adhesion refers to the forces between atoms at a bonding interface. Typically the work of adhesion is calculated using theoretical models and measured values of contact angles of test fluids on surfaces. Fundamental and practical adhesion are inter-related. The value of practical adhesion obtained from an experiment is the result of fundamental forces, mechanics of materials and variations in test sample preparation.

Injection moulding involves processing of polymers at temperatures above their melting points i.e. in liquid state, and at high pressures. The reliability of the product is essentially determined by the wetting interactions of thermoplastic with the tin at high temperature, by the crystallisation history of the thermoplastic as it cools and by the solid state interactions/adhesion of the thermoplstic with the tin at room temperature. The experimental methodology developed thus covers all three stages, i.e.; liquid-solid, solid-solid and product level adhesion (mechanical strength tests) of the system.

Progression of Work

Force Distance Measurements: Methodology to obtain force distance-curves for the tin-thermoplastic system has been finalised. The technique of functionalising the probe using gluing and Focussed Ion Beam has been done successfully. Initial results can be seen in Fig. 2.

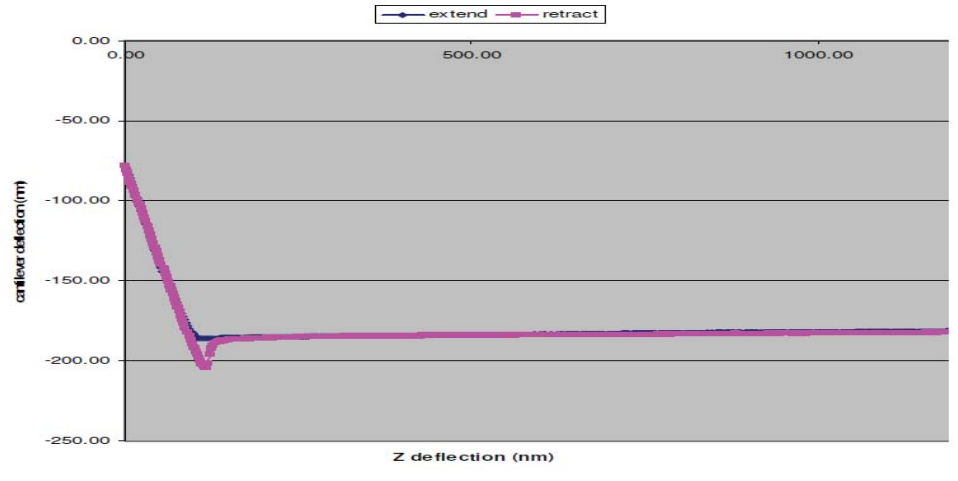

Figure 2: Cantilever deflection Vs Z-direction deflection for PS and Sn probe.

Adhesive Joint Strength: Insitu A pull test technique for measurement of practical adhesion has been developed. The effect of temperature on the pull out force measured is being investigated Initial results can be seen in Fig 3.

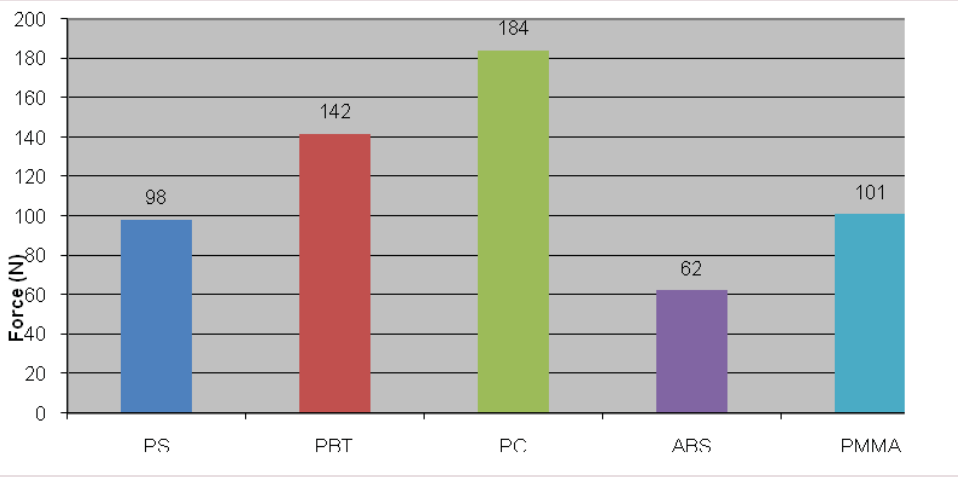

Figure 3: Comparison of joint strength samples for Sn wire overmoulded at temperature with different polymers

Contact angle at high temperature/ Wilhemly plate: The viscosity of thermoplastics makes it very hard to evaluate the contact angle. The Wilhemly plate technique will be used to determine the contact angle made by the thermoplastic with the insert at processing temperatures. This will enable us to understand the effect of basic material properties on joint strength.