Thermal ageing of electronic component solder joints for space applications

Vincent Voet[1,2], Frederik Van Loock[1], Christophe De Fruytier[2], Aude Simar[1], Thomas Pardoen[1]

1. Institute of Mechanics, Materials and Civil Engineering (iMMC), UCLouvain, Place Sainte Barbe 2, Louvain-la-Neuve 1348, Belgium
2. Thales Alenia Space Belgium, Rue Chapelle Beaussart 101, Mont-sur-Marchienne 6032, Belgium

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INTRODUCTION

Electronic assemblies used for space applications must fulfill high-end standards in terms of quality and reliability. These assemblies, made of components soldered on printed circuit boards (PCBs), are exposed to thermal cycling due to the satellite's orbit around the Earth and/or due to interrupted operating modes. Mismatches in the coefficients of thermal expansion of the assembly's materials, i.e. components, solder joints and PCBs, lead to cyclic deformation and fatigue damage within the joint [1,2,3]. This behavior is governed by the elasto-viscoplastic response [4,5] of the low melting temperature (tin-lead) solder alloys under typical satellite operation conditions and the damage resistance of the material and interfaces.

AIM OF THE STUDY

The aim of the present study is to estimate the probability of failure of component assemblies comprising solder joints. Many factors may impact the solder joint lifetime. This includes the mounting process, the component size and geometry, the thickness or stand-off height of the solder layer between the component and the PCB, and the width/length of the copper footprint on the PCB.

PRESENT WORK

Here, we focus on leadless surface mounted resistor solders joints (see Fig. 1). Preliminary experiments have shown that these joints are prone to premature crack initiation and growth within the solder layer during thermal cycling. Finite element (FE) simulations making use of a temperature-dependent elasto-viscoplastic constitutive model for the solder material are conducted in the Abaqus FE software package. Crack initiation and propagation is modelled via cohesive elements located at the interface between the component and the joint. Experimental data have shown that failure usually occurs close to this interface. We analyse the dependence of the predicted number of thermal cycles for crack nucleation and the predicted crack propagation rate upon key model parameters. These parameters include the elasto-viscoplastic constitutive properties of the solder, the mismatch in the coefficients of thermal expansion, the geometry of the assembly (e.g. the component and the joint), and the thermal cycling profile.

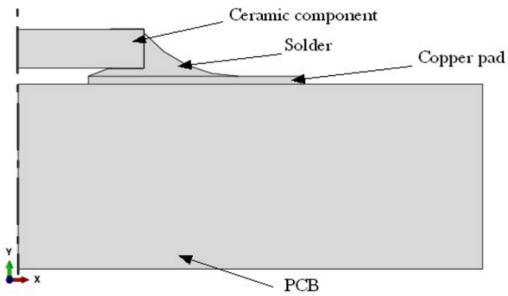

Figure 1: Electronic assembly of a chip resistor.

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