DETERMINING LOCUS OF FAILURE WITH MODERN SURFACE ANALYSIS METHODS

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Many technologies and processes rely on bringing together two dissimilar materials which must remain in intimate contact during service. During testing and sometimes during use, these materials separate. It is important to know just how the two materials came apart in order to analyze the mechanism of failure. Often just looking at the failure surfaces is not enough to determine failure mechanism, especially when failure takes place at or near the interface between the two materials. The use of modern methods of surface characterization such as ISS, SIMS, AES, XPS and SEM are described here to determine locus of failure.
INTRODUCTION

Numerous technologies rely on a system in which two materials are placed in intimate contact and must remain so for the life of the resulting part. Joining methods such as welding, soldering and adhesive bonding are examples of such processes. Metallic and polymeric coatings on metals to provide corrosion resistance, enhance appearance or to take advantage of some property of the couple, provide another of the many examples. Following fabrication, various mechanical tests are performed to determine how well one material adheres to the other. Tests are also performed under accelerated conditions to determine the durability of the bonded material in long time service. Often the only information recorded from such tests is a numerical value of the force or energy necessary to cause the bonded structure to fail. Equally important is where the joint failed. Careful examination of the failure surfaces by the methods to be discussed here allows determination of the locus of failure. Good\textsuperscript{1} says "There is great practical importance to the correct identification of the failure locus. It is obvious that the measures which must be taken to remedy an interfacial failure are different from those which must be taken to remedy "cohesive" failure in either bulk phase".

DISCUSSION

Where Can Failure Occur?

In a simple two component system such as shown in Figure 1 (Good\textsuperscript{1}) failure may take place in one or more of the five regions. That is, failure may propagate in either of the two bulk phases (1 and 5), at the interface (3) or in regions of A and B very near the interface (2 and 4). It has been the long-standing opinion of some workers\textsuperscript{2} that most failures which are called interfacial (region 3) are in reality failures in a weak boundary layer (WBL) occurring very near the interface.

Frequently it is not simple using visual or even microscopic examination of adhesive bonds to determine after testing whether an apparent adhesive failure occurred at the interface due to improper wetting or at some new interface, leaving behind a thin layer of adhesive on the adherend or oxide on the adhesive.\textsuperscript{3} There is a resolution limitation of about 100 Å for most scanning electron microscopes (SEMs) which makes very thin organic films difficult to detect, especially when the adhesive is a pure polymer containing no fillers of higher atomic number than the polymer to increase contrast. Optical and staining methods have been reported to determine the presence of adhesive films. However, the optical technique uses the interference phenomenon, which is applicable only to fairly