Chapter 4

An Economic Analysis

It has now been established that ESD can damage virtually any semiconductor. However, establishing how often that occurs in a specific manufacturing facility, or the consequence of that damage, has proven to be extremely difficult. For that reason, approvals to expend funds for ESD precautions are sought reluctantly and are often denied. This chapter will illustrate a technique that has proven successful in estimating the economic benefit of ESD precautions and, subsequently, in establishing a systematic and cost-effective prevention plan.

Essentially, this approach consists of conducting carefully controlled experiments in a manufacturing environment so as to provide comparisons with and without ESD precautions on given production lines. The results of these experiments will make it possible to justify the general use of ESD precautions on the same production lines, thereby establishing the opportunity to evaluate the impact of ESD precautions on manufacturing. Manufacturing data is then gathered and compared with the experimental data. This combination of experimental and manufacturing data should provide a strong argument for the application of ESD precautions throughout all manufacturing facilities.

For companies starting their own ESD program, the five case studies presented here will provide a solid base of irrefutable economic evidence on which to build a business case. These studies also provide convenient examples for the development of additional experiments on
other production lines. *This experimental technique provides a scientific means of not only assessing the impact of ESD damage but also of evaluating which control techniques will be effective and which will be overkill.*

Additional experimental data and case studies may be found in much of the published ESD literature, especially in the proceedings of the EOS/ESD Symposia. The additional data and case studies combined with the experimental data presented here, or the results of any proprietary experiments, make a strong case with which to enlist broad based management support for a corporate commitment to ESD control. As ESD control programs are implemented in different manufacturing facilities, the information provided by these experiments can be used to form the basis for realistic handling requirements and for auditing programs that verify across-the-board compliance.

The five case studies are divided, by product line, into three main topics. Case Study 1 (Resistor Failure) briefly documents an isolated experiment involving PWB assembly. Case Studies 2, 3 and 4 focus on the manufacture of components and PWB assemblies and combine experimental data with actual manufacturing data. Case Study 5 demonstrates the difficulty in developing satisfactory control techniques for handling ultrasensitive devices.

**Case Study 1: Resistor Failure Due to Automation in Production**

Internal customer complaints from an AT&T manufacturing location in North Carolina prompted a study of damaged resistors. The resistors involved were thin film integrated circuit precision resistors, specified to be within a tolerance of ±0.2 percent. However, rather than being precise well-controlled resistors, they demonstrated values actually four to five times higher than the intended value. Customer complaints were certainly justified and worthy of close inspection.

The damaged resistors are illustrated in Figure 4-1. The resistor on the right shows lightning-like damage appearing as lines running across the material in the pattern of a “crow’s foot.” The dark area in the photograph is the tantalum nitride that makes up the resistor material. The solid light lines in the tantalum nitride are created by a laser. The laser is used to trim the resistor to a predetermined value with a tolerance of 0.2 percent. The resistor on the left demonstrates clean laser-generated lines and measures 300 ohms. The resistor on the right, with obvious damage sites, measures 1411 ohms.