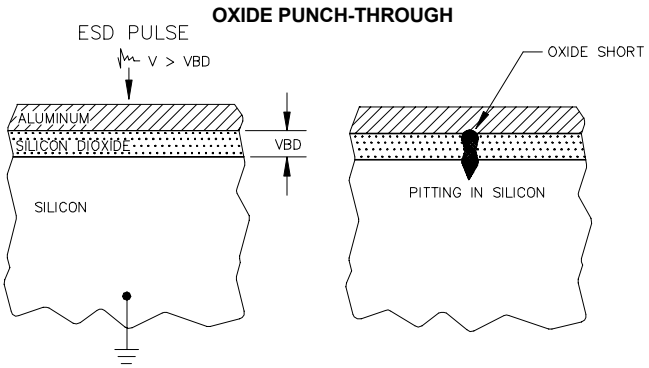
ESD Threat to Semiconductor Devices

Although the ESD pulse contains little energy, the extremely fast rise time and high power can cause semiconductor devices to fail. As IC chips become smaller, denser, and more complex, their susceptibility to ESD increases. Included in this list are Bipolar, CMOS, BICMOS, GaAs, and Schottky devices. As these semiconductors are designed into systems, the ESD susceptibility of the system hardware increases proportionally.

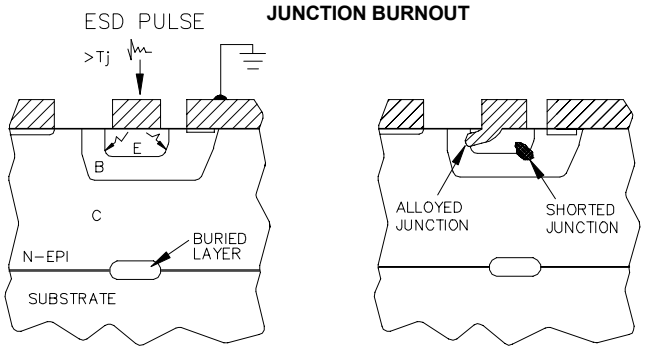
Catastrophic destruction of semiconductor devices may occur from arcing or heating. Arcing occurs as a result of the high static potential of ESD. Heating occurs as the result of the discharge current in an ESD event. The heating energy is proportional to the square of the discharge current. Damage occurs when the temperature of the region that is dissipating the ESD pulse reaches a critical value (such as the melting point of silicon). Laboratory tests have shown that semiconductors may fail after one very high discharge or may fail due to the cumulative effects of several discharges of lower potential.
Failure mechanisms in integrated circuits as a result of ESD include:

1. **Oxide Punchthrough :** This is the predominant ESD induced failure mechanism in MOS devices. Extreme over-voltage across the semiconductor oxide exceeds the dielectric breakdown strength. The thinner the oxide, the higher the susceptibility to ESD. Overheating and eventual shorting result.

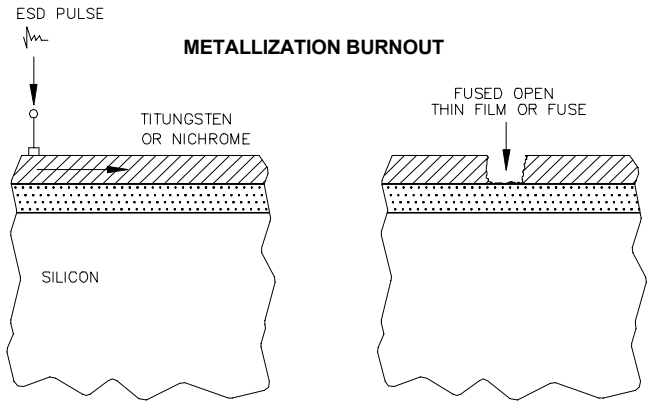


MOS devices are particularly vulnerable due to their low breakdown voltages.

2. **Junction Burnout :** Junction burnout is caused by injection of an ESD transient of sufficient energy and duration to initiate secondary breakdown. The result is high reverse leakage or a total short.



3. **Metallization Burnout :** Metallization burnout occurs upon injection of an ESD pulse of sufficient magnitude and duration to melt the metal due to resistive (Joule) heating. This results in an open circuit on the device. Localized melting of device metallization can occur as a secondary failure mechanism to junction melting and shorting.



4. **Parametric Degradation (Latent Failure) :** ESD damaged parts may not fail catastrophically. These parts may show increased leakage and will continue to degrade until premature failure occurs. Although these parts are still functional, they will likely fail early in the field.