Packaging failures

The majority of electronic parts failures are **packaging-related.**[citation needed] Packaging, as the barrier between electronic parts and the environment, is very susceptible to environmental factors. **Thermal expansion** produces mechanical stresses that may cause material fatigue, especially when the thermal expansion coefficients of the materials are different. Humidity and aggressive chemicals can cause corrosion of the packaging materials and leads, potentially breaking them and damaging the inside parts, leading to electrical failure. Exceeding the allowed environmental temperature range can cause overstressing of wire bonds, thus tearing the connections loose, cracking the semiconductor dies, or causing packaging cracks. Humidity and subsequent high temperature heating may also cause cracking, as may mechanical damage or shock.

During encapsulation, bonding wires can be severed, shorted, or touch the chip die, usually at the edge. Dies can crack due to mechanical overstress or thermal shock; defects introduced during processing, like scribing, can develop into fractures. Lead frames may contain excessive material or burrs, causing shorts. **Ionic contaminants like alkali metals and halogens can migrate from the packaging materials to the semiconductor dies, causing corrosion or parameter deterioration.** Glass-metal seals commonly fail by forming radial cracks that originate at the pin-glass interface and permeate outwards; other causes include a weak oxide layer on the interface and poor formation of a glass meniscus around the pin.[2]

Various gases may be present in the package cavity, either as impurities trapped during manufacturing, outgassing of the materials used, or chemical reactions, as is when the packaging material gets overheated (the products are often ionic and facilitate corrosion with delayed failure). To detect this, helium is often in the inert atmosphere inside the packaging as a tracer gas to detect leaks during testing. Carbon dioxide and hydrogen may form from organic materials, moisture is outgassed by polymers and **amine-cured epoxies outgas ammonia.** Formation of cracks and intermetallic growth in die attachments may lead to formation of voids and delamination, impairing heat transfer from the chip die to the substrate and heatsink and causing a thermal failure. As some semiconductors like silicon and gallium arsenide are infrared-transparent, infrared microscopy can check the integrity of die bonding and under-die structures.[2]

Red phosphorus, used as a charring-promoter flame retardant, facilitates silver migration when present in packaging. It is normally coated with aluminium hydroxide; if the coating is incomplete, the phosphorus particles oxidize to the highly hygroscopic phosphorus pentoxide, which reacts with moisture to phosphoric acid. This is a **corrosive electrolyte that in the presence of electric fields facilitates dissolution and migration of silver, short-circuiting adjacent packaging pins, lead frame leads, tie bars, chip mount structures, and chip pads. The silver bridge may be interrupted by thermal expansion of the package;** thus, disappearance of the shorting when the chip is heated and its reappearance after cooling is an indication of this problem.[3] Delamination and thermal

expansion may move the chip die relative to the packaging, deforming and possibly shorting or cracking the bonding wires.[1]