

Thermoelectric modules reliability improvement methods

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The problem of thermoelectric modules (TEM) reliability improvement remains important. The breaks down of TEM happen due to sudden or gradual failures. The gradual failures are mainly caused by diffusion of solder (Sn) into semiconductor material structure (Bi_2Te_3) during TEM work operations that leads to destruction of semiconductor material structure and subsequent failure of the TEM. A mathematic model was offered to calculate diffusion of solder (Sn) into semiconductor material structure (Bi_2Te_3). The model is a superposition of two ones: stochastic and functional. The stochastic model describes probability of no-failure operation by the following formula:

$$P(t) = \Phi \left[\frac{C_{kp}(x) - C_s \left(1 - \operatorname{erf} \frac{x}{2\sqrt{D \cdot t}} \right)}{\sqrt{(\sigma_c \cdot t)^2}} \right]$$

The functional model means investigation of diffusion coefficient at initial conditions (D_0) and energy of activation (E_a) by making experiments and graphs construction to define temperature dependence of these data as well as to calculate diffusion coefficient (D) further. The results of diffusion modeling of the solder components into semiconductor material structure (Bi_2Te_3) show that probability of no-failure operation depends significantly on solder concentration changes in semiconductor. Therefore the failure of TEM happens at a critical value of solder components concentration.

The betterment of antidiffusion coatings properties and methods of their application is one of method of thermoelectric modules reliability improvement.