Implementing T_J Monitoring in ACOL Burn-in (cont'd)

The Alternating Current Operating Life (ACOL) burn-in process is designed to subject a semiconductor device (like a diode) to conditions that closely approximate the electromechanical stresses that occur in real-life applications. To accelerate the impact of the stresses in the diode, the diode is subjected to an elevated temperature and to an operating forward-biased current (I_F) so as to make the junction temperature (T_J) operate at or near is maximum designed-for limits.

The difficulty in implementing this burn-in process lies in the knowing the junction temperature. Above designed-for specification junction temperature levels will provide excess stress and are likely to damage or destroy diodes, thus causing production lot rejection.

Key to insuring that a diode is not over stressed is knowledge of T_J during the burn-in process. While attempts to correlate package or lead surface temperature to T_J have normally been used, the best way can only be accomplished by a direct measurement of T_J using a well-accepted measurement approach that makes use of the well-defined relationship between forward voltage (V_F) and T_J (see Tech Brief TB-02). All that is required is to use a predetermined Measurement Current (I_M) for a time period long enough to capture V_F and to then use the difference between the initial value (before power is applied) and the final value to calculate the temperature rise due to the power dissipation.

Figure 1 shows the basic circuit and waveforms normally associated with ACOL burn-in. The magnitude of AC forward current (I_F), controlled by the Adjustable Resistor, sets the power dissipation within the diode to elevate T_J to the desired level when the voltage waveform is positive. The reverse voltage (V_R) is usually at or near the Reverse Breakdown Voltage (V_{BR}) specification; the corresponding current (I_R) is usually very low.

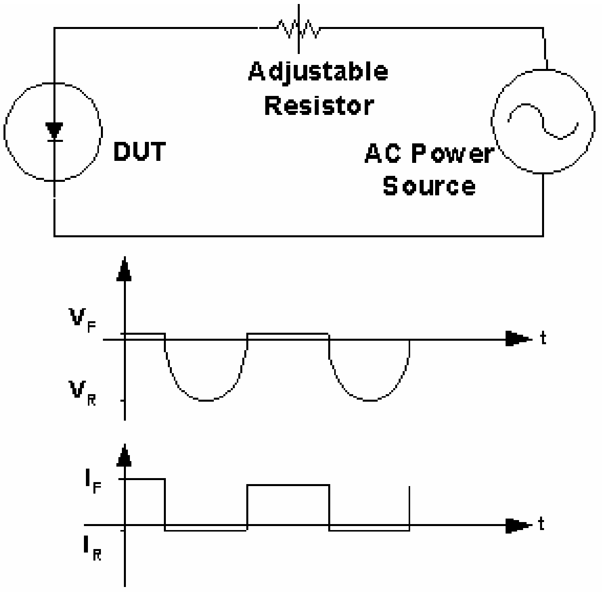

Figure 1

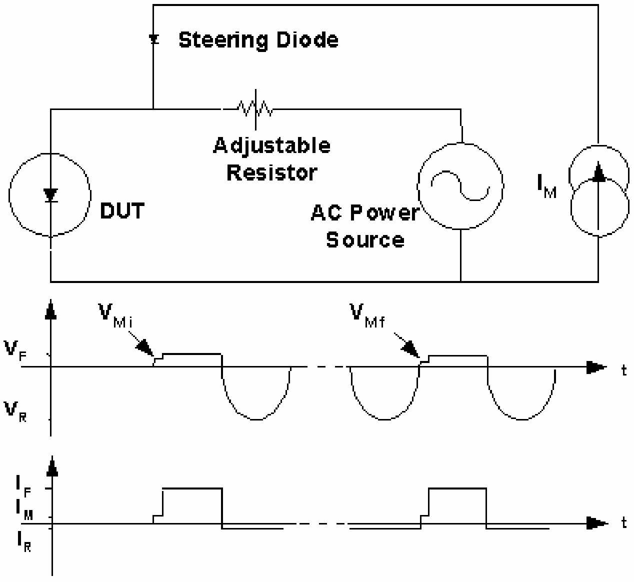

Figure 2

Implementing T_J Monitoring in ACOL Burn-in (cont'd)

Figure 2 shows the same circuit modified with the addition of an I_M source and steering diode (to avoid reverse voltage into the I_M source). After the diode is inserted into the burn-in environment with I_M applied and allowed to reach a temperature equilibrium condition before power is applied, the initial Measurement Voltage (V_{Mi}) is read and recorded. This voltage corresponds to the initial T_J (T_{Jo}). The AC Power source is turned on and the I_F set to some initial value. The V_M is monitored on a periodic basis and compared to V_{Mi} value; The difference between the two (referred to as ΔV_M or ΔV_F) is multiplied by the K Factor (see TB-02) to produce a ΔT_J. Adding ΔT_J to the initial temperature (T_{Jo}) produces in the absolute value of T_J.

$$T_J = T_{Jo} + (\Delta T_J) = T_{Jo} + (\Delta V_M \times K) = T_{Jo} + ((V_{Mi} - V_{Mf}) \times K)$$

The T_J will vary as a function of time until a steady-state condition is reached. Depending on the burn-in environment, the size of the diode, the amount of power dissipation, and the mounting configuration of the diode on the burn-in board, the time to reach steady state can vary anywhere from several minutes to several hours. A semi-log plot of ΔT_J or ΔV_F versus time (on the lag axis) will produce a Heating Curve that can be useful in determining exactly when a steady-state condition has been reached.

As discussed in TB-04, the Heating Curve can also be used to learn more about the diode thermal internal conduction and the external performance.