application brief AB22

Test Considerations For P3 Series TS AlInGaP LED Chips

This application brief will help customers: understand the thyristor effect (or snapback effect) occasionally exhibited by AlInGaP chips; and help customers implement tests that screen chips that exhibit this behavior.

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Description of Thyristor Behavior

Thyristor is unwanted capacitance in series with a diode (a thyristor layer in series with the pn junction) and is best described by looking at Figures 1a and 1b.

Figure 1a – The graph below, log of current as a function of voltage, depicts characteristics of two types of diodes, one with normal characteristics shown in blue and one with a thyristor effect, the "kink" in the voltage curve, shown in red.

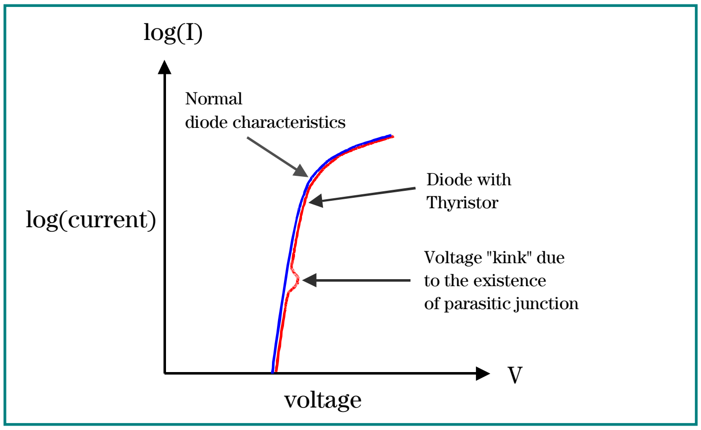
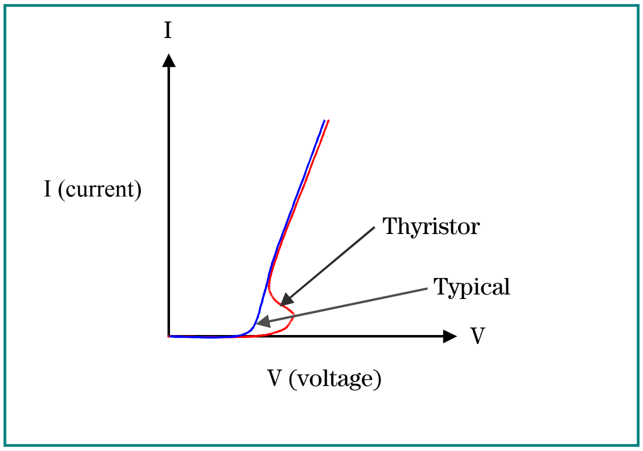


Figure 1b – The graph below, current as function of voltage, is the same as Figure 1a except that current is plotted on a linear scale. Once again, a normal diode showing typical characteristics is shown in blue and one with a thyristor effect is shown in red.



General Characteristics of Thyristor

Thyristors are temperature dependent. This means that the thyristor effect is more pronounced at lower temperatures, where reduced thermal excitation makes overcoming the capacitive barrier more difficult.

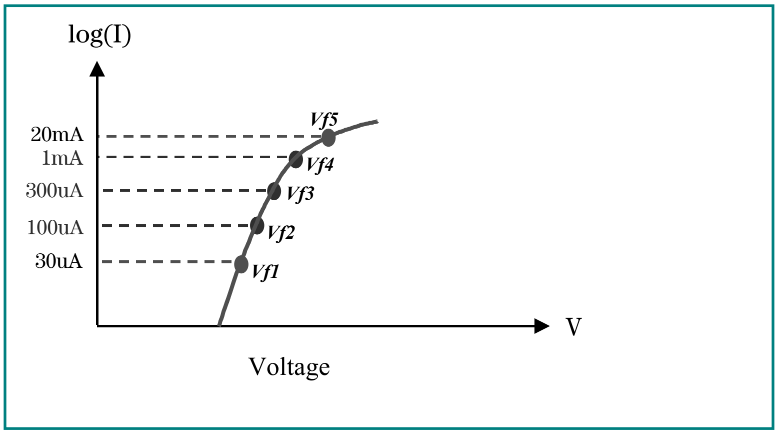
In addition, there is an effect due to ambient light. The capacitive barrier that causes the thyristor effect can be easily overcome through photo-excitation.

Recommended Testing to Screen for Thyristor

There are two test methods that can be used to detect thyristor.

A. Multiple Vf Tests
For example: Instead of testing an LED at 30µA and 20mA, test the LED at several forward voltages such as at 100µA, 300µA, and 1mA. The results of such a test might be as follows:

Figure 2 – Possible result of a Multiple Vf Test.



When plotting the above test data (see Figure 2) you might be able to detect a “kink” (a region where the lower current value has a higher Vf) in the current versus voltage graph, indicating that the die might be exhibiting a thyristor effect. However, this test might not be able to catch a mild thyristor or might not catch a thyristor with peaks not close to the five Vf test points.

To improve the possibility of detecting diodes with a thyristor effect, force current at 10µA intervals, from 0mA to at least 20mA. Along the way, the forward voltage, or Vf, needs to be recorded. A common criteria* for rejecting for thyristor is:

$$V_{peak} - V_f \text{ (@20mA)} > 0.1 \text{ V}$$

Where V_{peak} is a voltage measurement that defines a kink on the Voltage versus Current graph.

B. Capactive-Based Test (or Peak Detector Test)
The second test method to detect thyristor effect is the Capacitance-Based Test. This is a very sensitive test. With this test technique the unwanted series capacitance (the thyristor layer in series with the pn junction) of the diode is charged up until it breaks down and the voltage as a function of time of the diode is examined. See Figure 3.

Figure 3 – The figure below depicts a thyristor LED circuit model. The LED has a parasitic capacitance Cp.

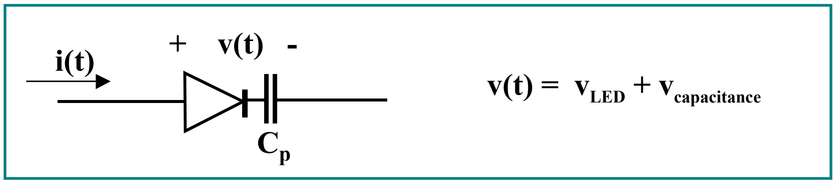
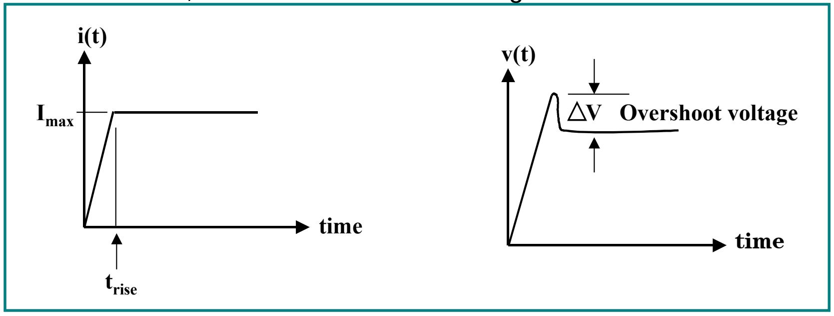


Figure 4 – The graph to the left, showing current versus time, shows the rise time of the LED. The graph to the right, showing voltage as a function of time, shows the overshoot voltage.



By varying I_{max} and t_{rise}, the thyristor sensitivity can be adjusted. For standard low current LED package testing Lumileds recommends I_{max} to be 20mA and t_{rise} to be 20µsec. A common criteria* for rejecting for thyristor is $\Delta V > 0.1$ volts.

Please note that with Capacitive-Based testing the following applies:

- The change in voltage, or ΔV, is a function of the maximum current, or I_{max}, and the rise time, or t_{rise}.
- If I_{max} is low, the ΔV is higher because of reduced junction heating.

*Lumileds' warranty obligations applicable to LED dice are solely governed by the terms of the product data sheet and are in no way modified within this Application Brief.

Company Information

Lumileds is a world-class supplier of Light Emitting Diodes (LEDs) producing billions of LEDs annually. Lumileds is a fully integrated supplier, producing core LED material in all three base colors (Red, Green, Blue) and White. Lumileds has R&D development centers in San Jose, California, Best, The Netherlands, and Malaysia. Lumileds has production capabilities in San Jose, California and Malaysia.

Lumileds is pioneering high-flux LED technology and bridging the gap between solid-state LED technology and the lighting world. Lumileds is absolutely dedicated to bringing the best and brightest LED technology to enable new applications and markets in the lighting world.

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