On reduction of switching times of diodes

-By Ravi Bhoraskar (08005002)

Introduction: When the direction of voltage applied to a diode is changed from forward bias to reverse bias, a certain switching time is observed due to a surge in the reverse current, caused by the release of the built up minority charge carriers. This spike of reverse current is very less in duration but can reach high values in magnitude. Hence it can be harmful to the electronic circuit if there are a large number of such spikes. The aim of this writeup is to come up with methods to reduce the switching time of diodes.
The transient is separated into two phases: first, one of constant current, where the flow is limited by the external resistance, and second, a "collection" phase, where the current decays at a rate determined by the minority carrier lifetime and the dimensions of the diode. It is found generally that the time is minimized by decreasing lifetime and increasing the ratio of reverse to forward current.
I have found(googled) two methods to achieve the aim. The first one is the use of Schottky diodes in place of ordinary diodes. The second is to use hemispherical diodes with a small junction radius. I shall discuss both of these in brief.

Schottky Diodes: The **Schottky diode** is a semiconductor diode with a low forward voltage drop and a very fast switching action. A Schottky diode uses a metal-semiconductor junction as a Schottky barrier (instead of a semiconductor-semiconductor junction as in conventional diodes). This Schottky barrier results in both very fast switching times and low forward voltage drop. Where in a p-n diode the reverse recovery time can be in the order of hundreds of nanoseconds and less than 100 ns for fast diodes, Schottky diodes do not have a recovery time, as there is nothing to recover from.
Limitations: Firstly, the relatively low reverse voltage rating for silicon-metal Schottky diodes is a big limitation, as it severely restricts the areas of application. Secondly, reverse leakage current, increasing with temperature, leads to a thermal instability issue.

Use of Hemispherical Diodes: It is observed (see references) that spherical diodes have lower switching times than planar ones. Also, there is a rapid decrease of the storage times, Tc and Tt, with decreasing junction radius. This is caused by a decrease in the effective lifetime caused by the large increase in majority carrier density required to neutralize the excess minority carriers. However, this does not mean that we can decrease the radius indefinitely and expect the switching time to fall. This is because the values which we have got (in the references) are not real values of switching time, but in fact give an upper limit on the switching times, since, as the radius decreases, the current density, in practical cases becomes so large that the recombination near the junction is no longer linear.

References:

- http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4051692&isnumber=4051681
- http://en.wikipedia.org/wiki/Schottky_diode