Schottky Diode IV Characterization and Transient Analysis

Electronic Devices Lab : Experiment 6

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Think it. Make it. Prove it.

Aims of the experiment

1. Part 1:
   - To plot the forward and reverse bias I/V characteristics of 2 fabricated metal-semiconductor junction diodes (one Schottky contact and another Ohmic contact) using probe station.

2. Part 2:
   a. To plot the forward and reverse bias I/V characteristics of the given packaged Schottky diode.
   b. To obtain the reverse recovery times of a regular PN junction diode and a Schottky diode and compare the two.

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Schottky Diode

- Unlike the conventional PN junction diode which is formed from a piece of P-type material and a piece of N-type material, the Schottky Diode is constructed using a metal and an N-type (or P-type) semiconductor.
- Because of this, a Schottky diode has very thin depletion region. As a consequence of that, the turn on voltage of a Schottky diode is typically lower than that of a PN junction diode.

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Reverse Recovery Time

- When a diode is switched from forward to reverse bias, ideally it should switch instantly and block any current flow. But in reality, a reverse current will flow for a short period of time.

- This is caused due to stored charge in the junction, which takes time to recombine.
  Reverse recovery time of the diode is the time gap between the instant at which the reverse current starts to flow through the diode to the time instant at which it reaches to 0 (or some predefined value close to 0).

- It can be a significant source of loss in switching regulations. But it can also be beneficial in some signal switching applications.

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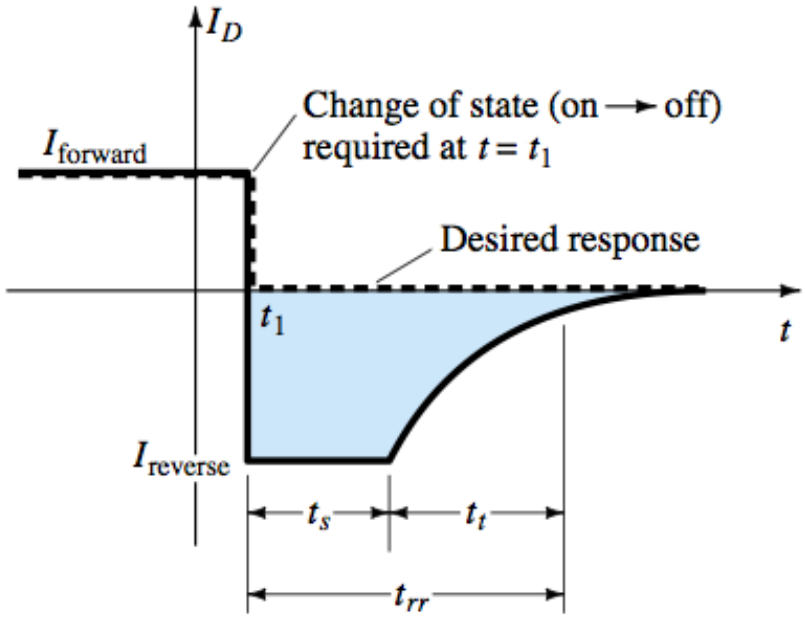
Reverse Recovery Time

The below figure illustrates what happens to the current flowing through a diode when the polarity of voltage across the diode is switched.



I_{rr} is the peak reverse current. Here, the RRT is measured till when the reverse current reaches 25% of I_{rr}.

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Components required

- Fabricated Samples
- Probe Station
- 1N5822 Schottky Diode
- 1N4007 PN Junction Diode
- Resistors - 100Ω ($\times 2$)
- Potentiometer - $1k\Omega$
- Breadboard, connecting wires

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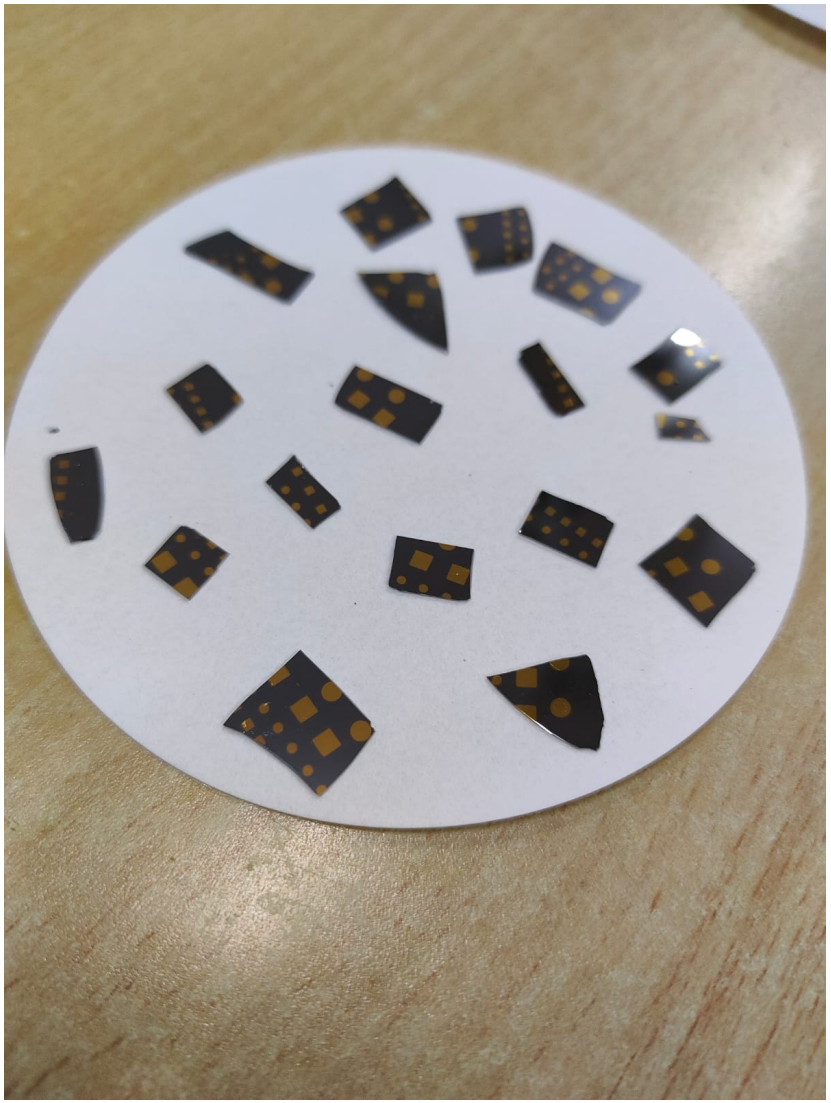
Fabricated Samples



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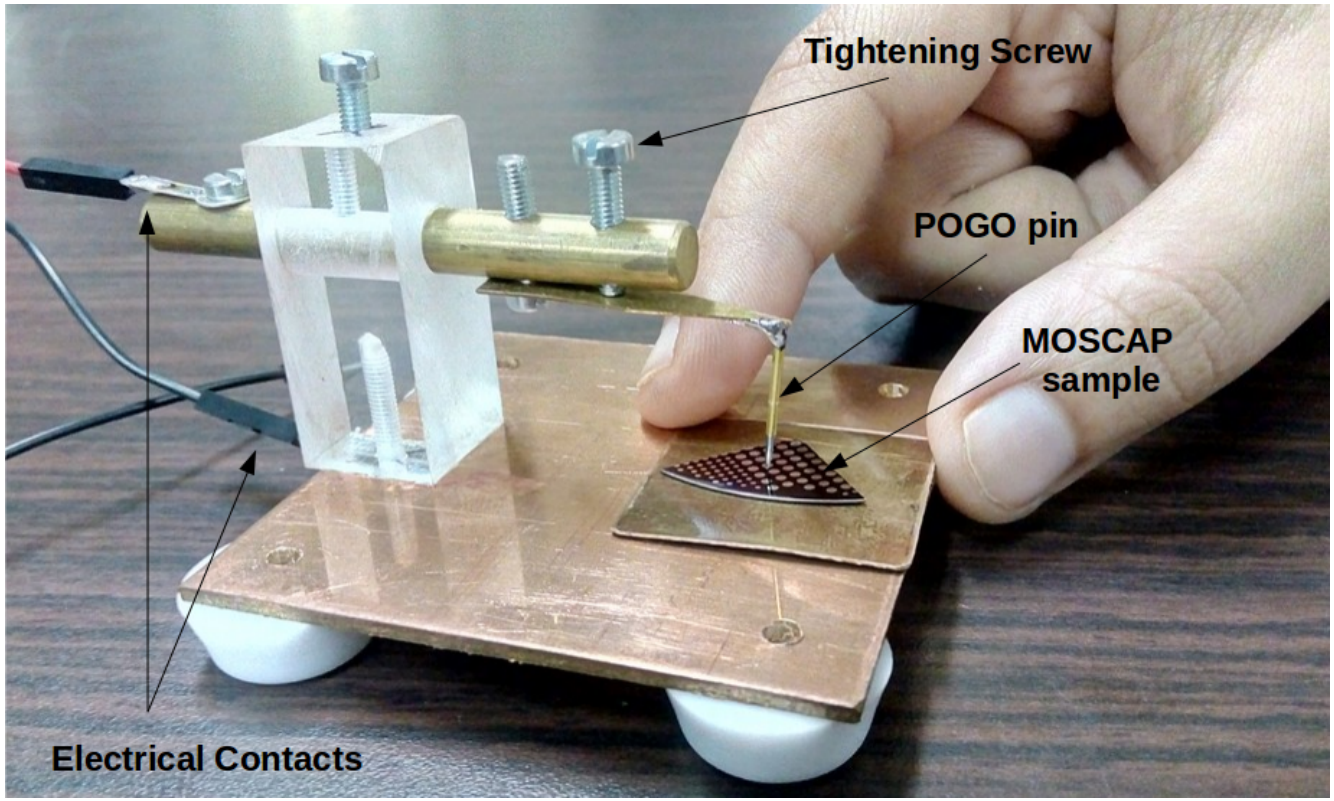
Experiment Set-up (Probe Station)



The top electrical contact which connects to the POGO pin is the positive terminal and the bottom electrical contact is the negative terminal.

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Procedure : Part 1

PRECAUTIONS:

- Handle the samples provided and the probe setup with care.
- Do not touch the wafer with bare hands. Use the brass plate to maneuver the sample.
- Do not tighten the screw of the probe too tight. Probe the sample gently.
- Place the sample back in the same box after use. Do not mix up the samples and their designated boxes.

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Procedure : Part 1

- Perform I-V characterization (both forward and reverse) of the fabricated diode samples of both $10^{15}\ cm^{-3}$ and $10^{19}\ cm^{-3}$. Use the circuit provided in Part 2a (The top contact of the sample is the + terminal of the diode).
- Provide reasoning for the difference seen in the characteristics as doping is increased. Which among the given samples has a Schottky contact and which one has an Ohmic contact?
- For the Schottky contact, extract the built-in potential (V_{bi}) from I-V data and calculate depletion widths of the diode for :
  - i No bias
  - ii 0.5V forward bias

  Use the following expression:

$$W = \left[\frac{2\epsilon_{Si}}{qN_D}(V_{bi} - V_A)\right]^{1/2}$$

  where V_A is the applied bias voltage and N_D is the doping concentration.

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Procedure : Part 2a

Measure I-V characteristics of 1N5822 Schottky diode using the following circuit.

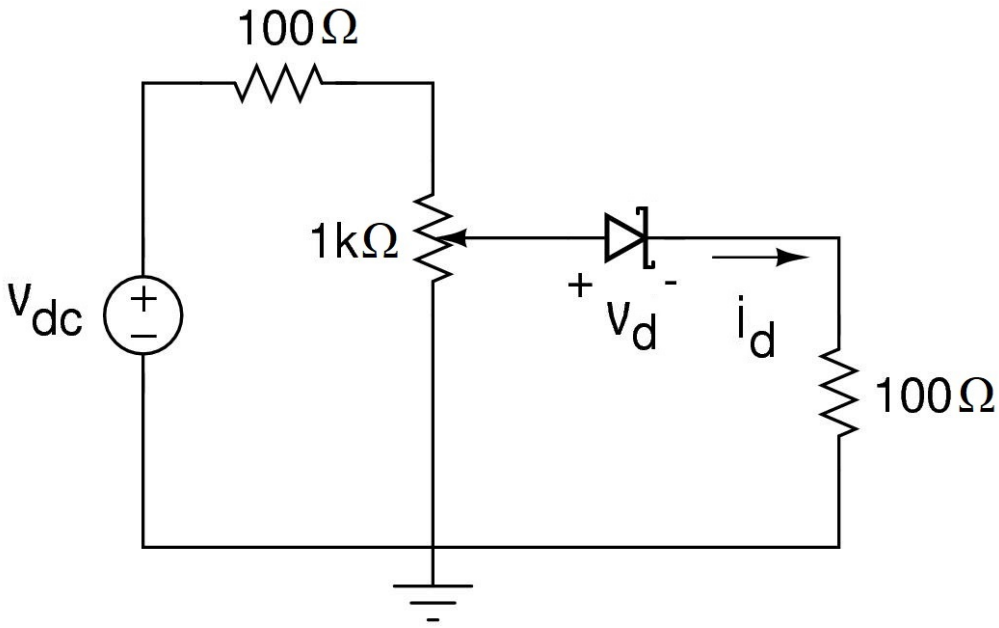

Figure: Circuit for I-V Characteristics

Make sure to measure both forward and reverse I-V characteristics.

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Procedure : Part 2b

Rig up the circuit given below (first for PN junction diode and then for Schottky diode). Apply square wave of amplitude 2 V p-p (the amplitude can be increased if needed) and frequency 100 kHz.

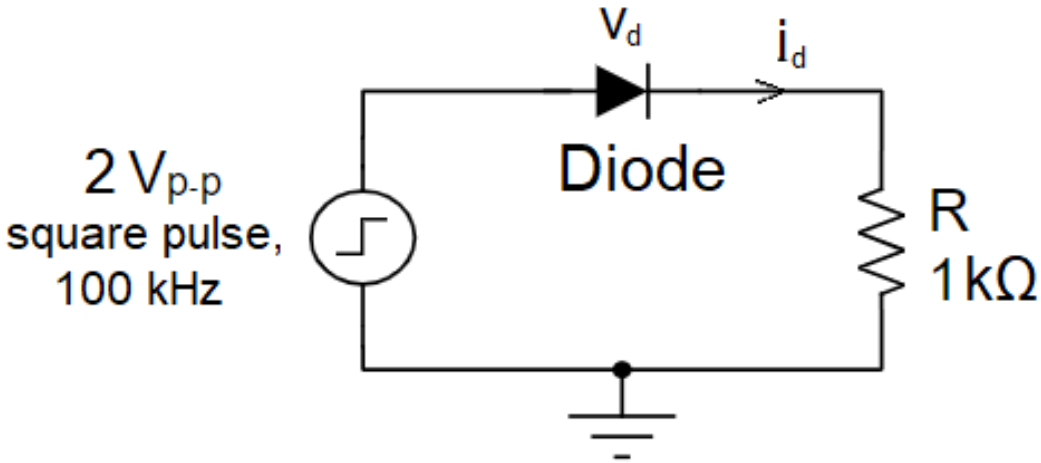

Figure: Circuit for RRT

Observe the output and note down the readings. Try to explain the difference in RRTs of the PN and Schottky diodes.

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