On the Behaviour of a Depletion MOSFET in the Reverse Mode of Operation

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With forward bias, the drain-source current (I_{ds}) of a MOSFET, increases with the drain - source voltage(V_{ds}). Further, I_{ds} not affected by temperature or the presence of electric and magnetic field. But the reverse biasing has been found to be sensitive to many physical parameters like ambient temperature, electric and magnetic fields. This communication reports the build up of I_{ds} in the reverse mode of operation along with the effects of some of the physical parameters.

EXPERIMENTAL

A depletion mode MOSFET (3N 200) with insulated gates was taken and a potential difference of 1.35 V was applied across drain and source in reverse bias. The current was measured by a microampere meter. Earthed copper plate was used to observe capacitative effect while a bar magnet and charged insulating rods were employed for observing the magnetic - and electric field effects respectively.

RESULTS AND DISCUSSIONS

1. Build up of I_{ds}

On applying a fixed V_{ds}, I_{ds} increased slowly attaining a saturation value in ~100 sec (Fig 1). The saturation value of the current, I_{dss} was 600 μA while for the same V_{ds} in normal mode it is 1.5 mA. The current build up rate increased for every consecutive cycle. The original growth rate could be regained by operating the MOSFET in the normal mode. The presence of a static magnetic field 'slowed down' the current build up rate. The change depended on the strength of the field.

2. Effect of temperature

The saturation current I_{dss} increased steadily with increase in the ambient temperature attaining a value of 800 μA at 70°C.

3. Effect of an earthed conductor

When an earthed conducting plate was brought in the viscinity of the MOSFET, the value of I_{dss} increased to 900 μA.

4. Effect of magnetic field

An approching or receding magnet (a changing magnetic field) decreased the instantaneous current while a static field gave a higher value of I_{dss}. A slow build up of I_{ds} was again observed when the steady magnetic field was removed (see Fig.1).

5. Effect of electric field

The positive electrically charged plate increased I_{dss} while negative charges reduced it. This field was capable of making $I_{dss} = 0$ for certain field intensity. The MOSFET attained the steady state value instantaneously when the field was removed unlike in the case of a magnetic field.

The current build up in a reverse mode could be associated with a polarisation process(1). When conduction electrons or holes are not available, a conduction path has to be stabilized for the injected charged carriers. The reorientation of bound charges along the field direction depends upon the applied field and characteristics of the material (2,3). The saturation current is observed when the restoring forces, produced as a result of strain, balanced the applied field.

However in the case of MOSFET'S the reverse current should be less than the forward current due to a doping gradient along the n-channel or due to the location of gates with respect to drain and source. But its sensitivity to the physical parameters in a reverse mode as well as the current build up phenomenon indicates a specific

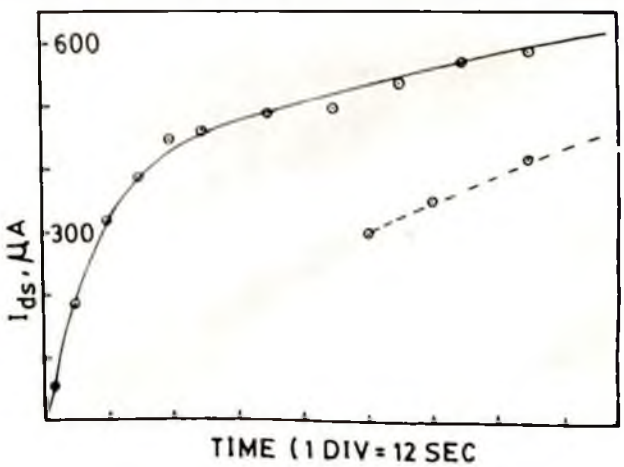


Fig. 1 Current build up in a reverse biased MOSFET. The dashed curve is the rise curve when the steady magnetic field was removed.

orientation of the host material charges or the contact wafer.

The magnetic field affected the localised charges by perturbing their orientations. On removing the field, an I_{ds} build up was observed whereas the action of electric field should be limited to a suppression or an enhancement of the flow of charge. The remarkable susceptibility of the depletion MOSFET in a reverse mode of operation to electric charges could thus be utilised in electronic switches or in detection of charge carriers.

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