Hot Probe Method for Semiconductor Thin films

→ Physical properties of thin films significantly differs from those of bulk materials.

→ There are various parameters such as thickness, Crystal structure, Composition and defects, which Characterize a Semiconductor film.

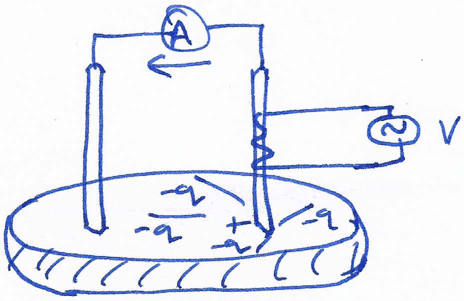
→ The parameters of charge Carriers like

(a) type of Semi Conductor
(b) impurities Concentration
(c) Mobility of Charged Carriers.
(d) Diffusion Coefficient

define the possibility to apply material for various electronic devices.

Principle

→ A Conventional hot-point probe experiment enables a Simple and efficient way to distinguish between p-type and n-type Semiconductors using a hot probe and a stand multimeter.



N- type Semiconductor.

→ while applying the Cold and hot probes to an n-type SemiConductor, positive voltage readout is obtained in meter, whereas for a p-type SemiConductor, negative voltage readout is obtained.

Experiment

→ A Couple of a cold probe and a hot probe are attached to the Semiconductor film Surface

→ The hot probe is Connected to the positive terminal of the multimeter while the Cold probe is connected to the negative terminal.

→ The thermally excited majority free Charged Carriers are translated within the Semiconductor from the hot probe to the Cold probe.

→ Mechanism for this motion within the Semiconductor is of a diffusion type Since the material is uniformly doped due to the Constant heating in the hot probe Contact.

→ These translated majority charged Carriers define the electrical potential sign of the measured Current in multimeter.

→ The hot-probe measurement may be describe as a three-step process:

① the heated probe excites additional free charged Carriers of two types.

② The hot majority Carriers begin to leave the heated part of Semiconductor Surface by a diffusion mechanism. Simultaneously, a built-in electrical field is Created between the electrodes and the Second (cold) electrode is warmed as well. This warming and the built-in electrical field tend to prevent the diffusion process upto a halt at a Steady State. This Steady State Condition exists untill the heated Source is Switched off.

③ This third process is actually a recombination of excited additional Charged Carriers.

→ This three-step process may be described, in general, by the Continuity and Poisson's equation,

$$\nabla J + \frac{\partial Q}{\partial t} = 0$$

$$\nabla E = \frac{Q}{\varepsilon_0 \varepsilon_r}$$

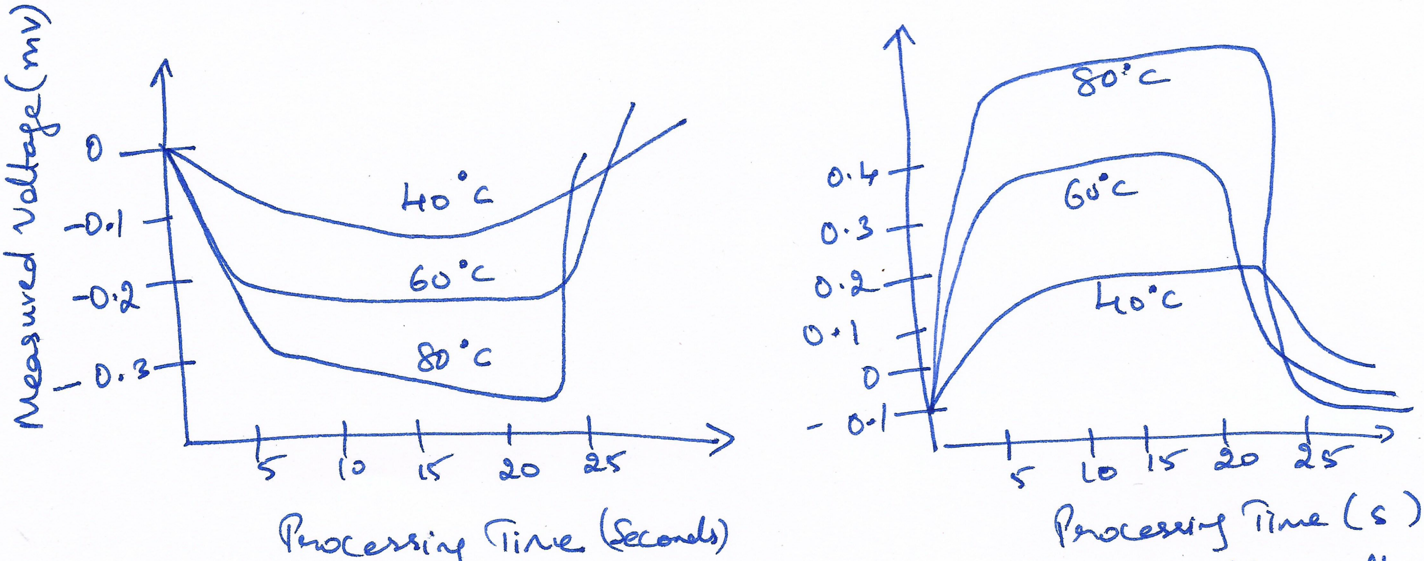
where, Q → uncompensated charge density excited by the heated electrode.

J → Current density.

ε_0 → absolute permittivity.

ε_r → relative permittivity.

E → built-in electrical field.



(a) as-deposited film of p-type

(b) thermally treated film of N-type

Hot Probe characteristics for Vanadium Oxide thin films deposited on oxidised Silicon Surface by thermal evaporation.