# Signal Development in Silicon Strip Sensors

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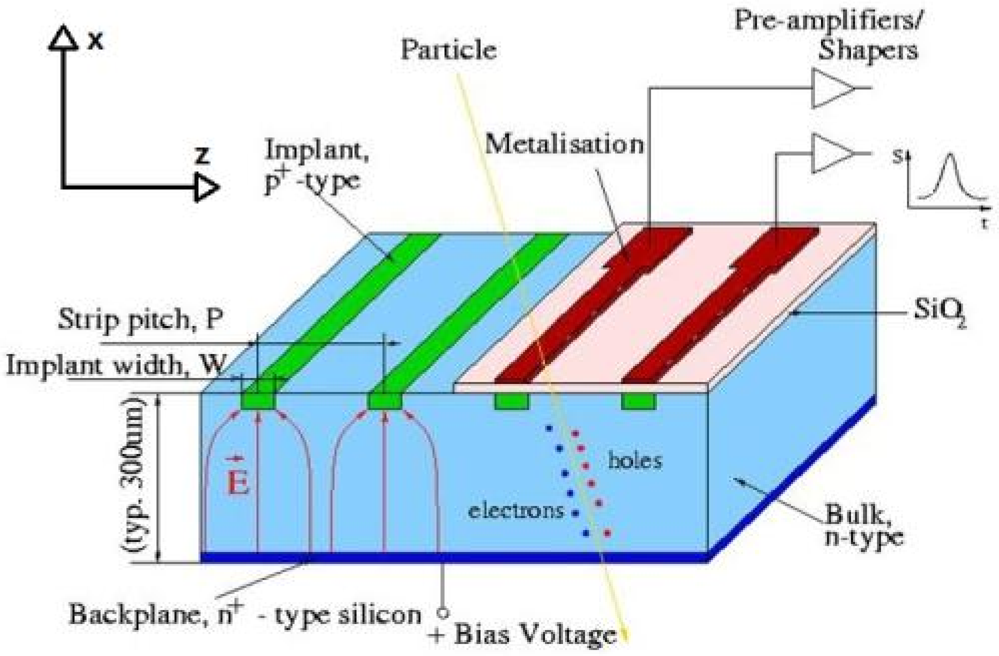
# Silicon Strip Sensors




Schematic view of an AC coupled n-type silicon trip sensor

Electron hole pairs are generated by ionizing particles. These carriers drift in the electric field, in the space charge region, and induce transient currents on the strips

According to the Shockley-Ramo theorem, the current *I*, induced by a drifting charge *q*, on an electrode is given by

$$I = q\vec{E}_W \bullet \vec{v}$$

where $\vec{v}$ is the drift velocity of the charge q and $\vec{E}_W$ is the weighting field of the considered electrode

In a strip sensor, the drifting charges are either electrons or holes. Their drift velocity is given by

$$\vec{v}_{e,h}(x,z,T) = \mu_{e,h}(E(x,z),T) \cdot \vec{E}(x,z)$$

where $\mu_e$ and $\mu_h$ are the mobilities of electrons and holes, depending on the absolute value $E(x,z)$ of the electric field $\vec{E}(x,z)$ and the temperature T

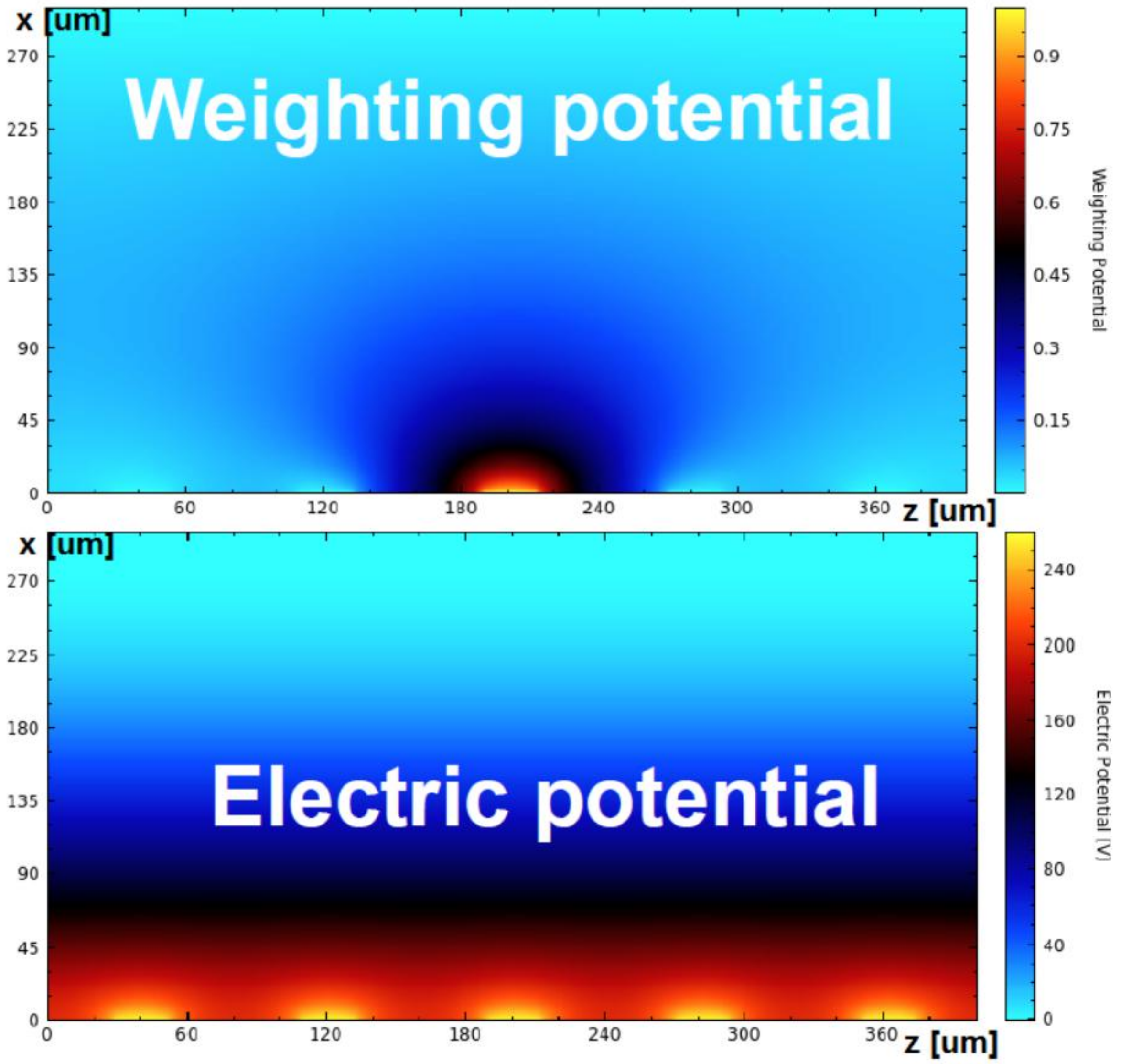
when T is fixed, the electric field $\vec{E}(x,z)$ determines the trajectory of charge carriers in the strip sensor

The coupling of the charge movement to the considered electrode is determined by the weighting field $\vec{\mathrm{E}}_{\mathrm{W}}(x,z)$. Analogue to the electric field, the weighting field can be calculated from a potential, the weighting potential $\phi_{\mathrm{W}}$, in such a way that $\vec{\mathrm{E}}_{\mathrm{W}}(x,z) = \vec{\nabla}\phi_W(x,z)$.

$$I = q\vec{E}_W \bullet \vec{v}$$

$$\vec{v}_{e,h}(x,z,T) = \mu_{e,h}(E(x,z),T) \cdot \vec{E}(x,z)$$

The weighting potential is calculated by applying unit potential to the considered strip and zero potential to all other electrodes in the strip sensor.




In left figure,electric and weighting potential for 5 strips of a silicon strip sensor with ptype bulk material.
The strips have a width of 25 μm and a pitch of 80 μm.The sensor has a thickness of 300 μm. For a n-type sensor, the electric potential would have the opposite sign. The weighting potential is only depending on the geometry and not depending on the sensor type.

When ionizing radiation creates electron hole pairs in a silicon strip sensor, each of the charge carriers drifts in the electric field and induces current on the surrounding electrodes. The total induced current is given by the sum of the currents induced by each individual drifting charge carrier.

In edge-TCT measurements, the electron hole pairs are generated by the light of an infrared laser, focused to a full width at half maximum (FWHM) of several μm. The light beam illuminates the cut edge of the sensor, in such a way, that its axis is in the plane of the sensor surface and orthogonal to the strips.

Neglecting the opening angle of the laser-light beam and the attenuation of light in silicon, an effective weighting field for this configuration can be calculated. Therefore, the average of the weighting potential has to be taken along the axis of the laser-light beam.This leads to a constant effective weighting field, similar to the weighting field of a pad diode,the constant weighting field is given by

$$\vec{E}_W = \frac{1}{W}\vec{e}_x \qquad E = \frac{U}{d} = \frac{1-0}{W}$$

bulk defects in irradiated silicon sensors may act as trapping centers for electrons and holes. To model the trapping, the electron and hole contribution of the current are multiplied by $\exp(-t/\tau_{e,h})$ ,where $\tau_e$ and $\tau_h$ are the effective trapping times of electrons and holes respectively.

Ignoring field distortions in the region of the strips, the recorded current for edge illumination with a narrow, infrared laser-light beam is described by

$$I(x,t) = I_e(x,t) + I_h(x,t) = Ae_0N\frac{v_e(x,t)\exp(-\frac{t}{\tau_e}) + v_h(x,t)\exp(-\frac{t}{\tau_h})}{W}$$

$$I = q\vec{E}_W \bullet \vec{v}$$

where e0 is the elementary charge, N is the number of generated electron hole pairs and A is a constant, given by the read-out electronics.