Characterization of the Polysilicon Resistor in Silicon Strip Sensors for ATLAS Inner Tracker as a Function of Temperature, Pre- And Post-Irradiation

- After the high luminosity upgrade of the Large Hadron Collider, the strip part of the Inner Tracker (ITk) detector will be exposed to the total particle fluences and ionizing doses reaching the values of $1.6 \cdot 10^{15}$ $1\,\mathrm{MeV}\ \mathrm{n_{eq}/cm^2}$ and $0.66\,\mathrm{MGy}$, respectively, including a safety factor of 1.5.

→ Radiation hard n^+-in-p micro-strip sensors were developed by the ATLAS ITk strip collaboration and are produced by Hamamatsu Photonics K.K.

- For the purpose of this study 14 test chips were irradiated by gammas from ^{60}Co source at UJP Praha, reactor neutrons at Ljubljana JSI TRIGA Reactor, $27\,\mathrm{MeV}$ protons at Birmingham and $70\,\mathrm{MeV}$protons at CYRIC.
- Rbias dependence on temperature was fitted using the exponential function: $R_{\mathrm{bias}}(T) = a \cdot \exp\left(\frac{b}{T}\right)$, from which the activation energy was determined as $E_a = 2 \cdot k \cdot b$, where k is the Boltzmann constant.

→ Average value of the activation energy is $E_a = (55.8 \pm 0.1) \cdot 10^{-3}\,\mathrm{eV}$.

→ Activation energy does not depend on irradiation.

- Since the activation energy does not depend on irradiation, it is possible to fit all measured data using the same function by shifting it only in the direction along the initial resistance.
- Measured R_{bias} values of each test chip were compared with a curve obtained from the formula: $R(T; T_m, R_m) = R_m(T_m) \cdot \exp\left(\frac{b}{T} - \frac{b}{T_m}\right)$, where R_m is R_{bias} value of individual test chip measured at temperature T_m.
- For the parameter b we used the value $b = 312.2\,\mathrm{K}$ obtained from the fit of data measured for unirr. sensor.

→ Predicted R_{bias} development matches very well with the measured values.

→ By measuring just one R_{bias} value at certain temperature, it is possible to extrapolate R_{bias} values for other temperatures, which can be used for R_{bias} temperature normalization.

- By plotting the dependence of R_{bias} vs irr. dose, it is obvious that R_{bias} is independent of irradiation dose and particle type.