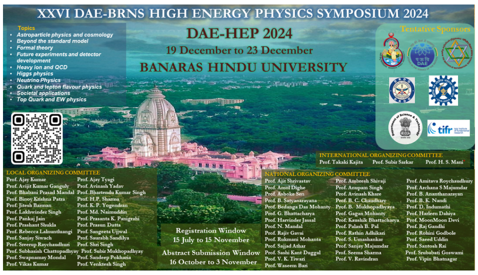

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Improved Impact Ionization Modelling for Thin Non-Irradiated Low Gain Avalanche Detectors

The present and future detector systems in High Energy Physics (HEP) require fast timing, improved spatial measurements and good signal-to-noise ratio (SNR). This prompted the development of Low Gain Avalanche Detectors (LGADs) as an attractive alternative for replacing traditional silicon sensors for 4D tracking purposes. As fast timing necessitates thin sensors, the use of thin LGADs for timing applications is beneficial as they can provide a higher SNR due to their internal charge multiplication. However, these sensors have poor spatial resolution due to the design limitations imposed by the complex structural patterning required to produce adjacent pixels. For that reason, different technologies of LGADs with different gain layer profiles are under development with the aim to improve their capabilities. Since the optimization of these sensors is still in early stages, the investigation into their response continues to be an ongoing process.

To predict and optimize the LGAD performance, Technology Computer-Aided Design (TCAD) simulations are helpful in analyzing the generated and collected charge. Recent studies using common TCAD tools have shown discrepancies between simulated and observed charge collection in thin LGADs from major manufacturers for given design parameters. This emphasizes the need to refine impact ionization model parameters which are responsible for internal charge multiplication. Further, the thin sensors in contrast to the thicker versions have higher bulk field, higher drift velocity of signal charge carriers and reduced trapping effects due to lower drift length and time. This motivates the present study to optimize the various model parameters specifically for thin LGADs.

The present simulation studies focus on the parameterization of impact ionization models for thin non-irradiated LGADs to obtain the optimized sets of values for model parameters in Silvaco. As per the availability of the measurement results, we used deep and shallow junction thin LGADs with the p-well doping profiles derived from experimental CV characteristics. Further, it is observed that the optimized values of model-parameters obtained in the present work using Silvaco produce different results as compared to the previous optimization performed using other TCAD frameworks. This is in accordance with the prior studies related to the comparison between modelling in different TCAD tools that emphasize the inherent differences in different TCAD frameworks in respect of simulation models and parameters. Enhanced ionization models for LGADs represent an initial step toward optimizing these sensors under irradiation and developing designs that address their limitations.

Field of contribution

Experiment

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