

# WG6 Work Package Project

## Title: SiC Material Studies with pad and strip sensors

### Project description

Wide band-gap (WBG) semiconductors are increasingly dominating the power device market, with significantly enhanced material quality. Silicon Carbide is the material used for HV power devices and would also be an attractive particle detector material due to the low leakage current of the ultra, even after irradiation. However, the material is more challenging due to anisotropy effects and a high defect concentration already in the unirradiated case. Moreover, many material parameters are not well known or described in the literature as a mix of the different polytypes. Thus, a systematic material characterization study is necessary to bring SiC to a comparable level of understanding as it exists for silicon. For this purpose, this project aims to produce a large number of simple, planar diodes that can be used for an extensive irradiation and characterization study, covering IV, CV, and CEE measurements by SPA and TPA-TCT techniques, as well as beam tests. For this purpose, FBK starts a new production line on SiC devices, which this project will qualify in parallel. Moreover, trap levels and concentrations will be studied using TSC and DLTS techniques, providing input to an irradiation model. After passing this step, also the possibility of implementing a gain layer in the devices will be evaluated, with thorough studies of impact ionization mechanisms and the behaviour of it under irradiation. This project aligns with the ECFA DRDT 3.2 (Sensors for 4D-tracking) and DRDT 3.3 (Sensors for extreme fluences) and the DRD3 research goals 6.2.

### Milestones, deliverables and timeline

| Number | Title   | Description  | Start date | End date | Institutions |
|--------|---|--|------------|----------|--------------|
| Di.1   | <i>Fabrication of Schottky Devices</i>                    | <i>First production run at FBK</i>   |            |          |              |
| Di.2   | <i>Fabrication of PIN Devices</i>                         | <i>Fabrication of junction devices at FBK</i>  |            |          |              |
| Di.3   | <i>Electronics Readout</i>                                | <i>Development of readout single</i>   |            |          |              |
| Di.4   | <i>Characterization</i>                                   | <i>Characterization of IV, CV, Charge collection, time resolution test, beam tests</i>           |            |          |              |
| Di.5   | <i>Irradiation</i>  | <i>Irradiate SiC-LGAD devices up to <math>1 \times 10^{18} \text{ n}_{eq}/\text{cm}^2</math></i> |            |          |              |
| Di.6   | <i>Study of Irradiation Defects and irradiation model</i> |  |            |          |              |

### Participating Institutions

| Country     | Collaborating Institution | Town | Institution Code | Contact                         |
|-------------|---------------------------|------|------------------|---------------------------------|
| Austria     | OEAW-HEPHY                |      | HEPHY            | Thomas Bergauer                 |
| Switzerland | CERN                      |      | CERN             | Michael Moll /<br>Susanne Kuehn |
| Romania     | NIMP Bucharest            |      | NIMP             | Ioana Pintilie                  |
| Italy       | INFN Torino               |      | Torino           | Valentina Sola                  |
| Italy       | INFN Perugia              |      | Perugia          | Francesco<br>Moscatelli         |
| Italy       | FBK                       |      | FBK              | Maurizio Boscardin              |

### Collaborative work:

The characterisation of irradiated and non-irradiated devices will be done in collaboration of WG2, WG3 and WG5, modelling of radiation damage will be done in collaboration with WG4. Dissemination and outreach will be done in WG8. Possible cross-DRD studies with DRD7.

Potential synergies with similar projects: RD50: SiC-LGAD, SiC-LGAD-TPIX, TCAD Radiation Damage Model for 4H-SiC, Defect characterization on 4H-SiC sensors.

### Funding Agencies

| Country | Funding Agency | Funding Agency Code | Representative | Institution(s) represented |
|---------|----------------|---------------------|----------------|----------------------------|
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |
|         |                |                     |                |                            |

### Contributions of Participating Institutions and Funding Agencies to the Work Package

|  | Deliverable     |                        |                                       |                 |                        |                                       |                 |                        |                                       | Total           |                        |                                       |
|--|-----------------|------------------------|---------------------------------------|-----------------|------------------------|---------------------------------------|-----------------|------------------------|---------------------------------------|-----------------|------------------------|---------------------------------------|
|  | Di1             |                        |                                       | Di2             |                        |                                       | Di3             |                        |                                       |                 |                        |                                       |
| Institution / Funding Agency                             | Material / kCHF | Physicists: FTE months | Engineers and technicians: FTE months | Material / kCHF | Physicists: FTE months | Engineers and technicians: FTE months | Material / kCHF | Physicists: FTE months | Engineers and technicians: FTE months | Material / kCHF | Physicists: FTE months | Engineers and technicians: FTE months |
| <b>Major (e.g. national) Funding Agencies</b>            |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
|  | 60              | 10                     | 20                                    | 60              | 10                     | 20                                    |                 |                        |                                       |                 |                        |                                       |
|  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
|  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
|  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
|  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
|  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| Total Major Funding Agencies                             |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| <b>Contributions from other sources</b>                  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| DEF via Institution 5                                    |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| GHI via Institution 6                                    |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| ...  |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| Total other sources                                      |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |
| <b>Total (Major Funding Agencies plus other sources)</b> |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |                 |                        |                                       |

|  | Deliverable |     |     | Total |
|--|-------------|-----|-----|-------|
|  | Di4         | Di5 | Di6 |       |
|  |             |     |     |       |

| <b>Institution / Funding Agency</b>                      | <b>Material / kCHF</b> | <b>Physicists: FTE months</b> | <b>Engineers and technicians: FTE months</b> | <b>Material / kCHF</b> | <b>Physicists: FTE months</b> | <b>Engineers and technicians: FTE months</b> | <b>Material / kCHF</b> | <b>Physicists: FTE months</b> | <b>Engineers and technicians: FTE months</b> | <b>Material / kCHF</b> | <b>Physicists: FTE months</b> | <b>Engineers and technicians: FTE months</b> |
|--|------------------------|-------------------------------|--|------------------------|-------------------------------|--|------------------------|-------------------------------|--|------------------------|-------------------------------|--|
| <b>Major (e.g. national) Funding Agencies</b>            |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
|  |                        | 10                            | 20   |                        |                               |  |                        | 10                            | 20   |                        |                               |  |
|  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
|  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
|  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
|  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
|  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| Total Major Funding Agencies                             |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| <b>Contributions from other sources</b>                  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| DEF via Institution 5                                    |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| GHI via Institution 6                                    |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| ...  |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| Total other sources                                      |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |
| <b>Total (Major Funding Agencies plus other sources)</b> |                        |                               |  |                        |                               |  |                        |                               |  |                        |                               |  |

### Project structure

| <b>Function</b>            | <b>Name</b> |
|----------------------------|-------------|
| Work Package Leader        | TBD         |
| Work Package Deputy Leader | TBD         |

