Ion Beam Centre
Institute of Ion Beam Physics and Materials Research

Application for Beam Time

(Please follow remarks as specified in the proposal guidelines; use font Arial, 11 pt)

Project type: Pilot (Test) ☐ Short Term ☒ Long Term ☐ Industry ☐

Main Applicant (Name, Institution, Country):
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1 Title

Energy filter for ion implantation

2 Motivation and scientific background

The goal is to improve a process step in the production of SiC devices. In order to produce a SiC-device the SiC has to be doped. The n-dopant of choice is Nitrogen which is incorporated into an epitaxially grown SiC layer on top of a SiC wafer. These epitaxially grown layers have a rather low accuracy of the dopant concentrations. The consequence is a reduced performance of the SiC-diode. We were thinking about a solution how to improve doping accuracy. The method we found interesting is ion implantation, since the dose control of ion implanters can be easily controlled in a range of smaller 3%. Another advantage is that unmasked and masked doping is possible. The problem of the doping via ion implantation is that the monoenergetic ion beam will lead to a dopant concentration peak in a certain depth, but what one actually wants is a depth distributed doping profile. So our task was it to get a depth distributed implantation profile with in the best case only one ion implantation. We want to achieve such a depth distributed implantation profile by using a so called energy filter (Fig. 1), which is a micro patterned silicone membrane which basically consists of a thin supporting layer combined with triangular shaped structures and has a thickness of typically 5 – 10µm. It works in the following way: The ion beam comes from the left, all ions have the same energy, the ions get decelerated dependent on how much material they have to travel through, they have different energies after the filter and get therefore implanted in different depths in the substrate. Finally you get a depth distributed implantation profile.

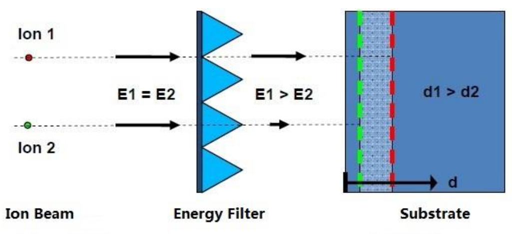

Fig. 1: Principle of the energy filter

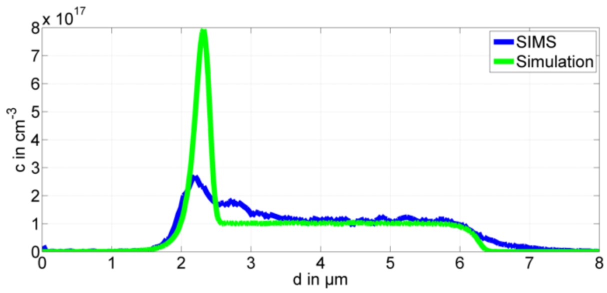

Fig. 2: Resulting implantation profile

3 Previous results on this topic (mainly related to the proposer's work)

We made a static implantation of B ions. Static means that filter and substrate did not move. The filter had a size of ca. 1 cm² and a distance of 1cm to the substrate. The substrate was a piece of silicon wafer, n-doped. After the implantation it was measured via SIMS at Fresenius-Institute in Dresden. As expected the ions were implanted with a depth distribution of 4 µm. One can see the peak in the beginning of profile as well, but the peak is smaller than expected and it has a “tail”. As a comparison the green graph shows the simulated result. We suspect 2 reasons: Channeling and losses of ions. But we could proof the working principle.

4 Description of the proposed experiment including most relevant technical data

We want to do 2 different experiments: A – Thermal Experiment, B – Doping Experiment

A – Thermal Experiment

For this experiment thin membranes are exposed to high currents and the temperature is measured with PT100 and Pyrometer and the sputtering effects are observed. The setup of the experiment has already been tested. It is still necessary to implement the Pyrometer of HZDR to the setup.

Implanter:	3 MV Tandetron
Chamber:	„Kanal 2: Einscheiben kleine Implantationskammer“
Ion Species:	C, N
Ion Energies:	up to 12MeV
Substrates:	Energy filter membranes
Amount:	implanting 4 different membranes with different parameters
1st Implant time:	**2 days**
2nd Implant time:	decision after 1st

B – Doping Experiment

First of all an energy filter holder has to be installed in the chamber. The chamber we want to use is depicted in Fig. 3. The holder is constructed by Andre Zowalla (EAH Jena) in association with Dr. Johannes von Borany and Dr. Shavkat Akhmadaliev. We want to measure Implantation profiles: SiO2 wafers → C(V), Si wafers → SIMS, SiC wafers → Diode

Implanter:	3 MV Tandetron
Chamber:	„Kanal 4: Waferhandler EATON NV-10“
Ion Species:	B, N
Ion Energies:	up to 12MeV
Substrates:	3” SiO2 wafers, 3” Si wafers and 4” SiC wafers (Energy filter in beam)
Amount:	in sum: 20 wafers
1st Implant time:	**3 days (→ for SIMS, C(V))**
2nd Implant time:	**2 days (6 weeks after 1st) (→ Diode)**
3rd Implant time:	decision after 2nd

Fig. 3: Implantation chamber with energy filter holder

5 References

[1] Bartko, J. & Schlegel, S.: Forming irradiated regions in semiconductor bodies by nuclear radiation, EU-Patent, 1980

[2] Krippendorf, F. et al.: Energiefilter für Ionenimplantation, Mikrosystemtechnik Kongress 2013 (MST 2013), 2013

[3] Zowalla, A.: Konstruktion einer Vorrichtung zur Halterung des Energiefilters, Präsentation EAH Jena, 2014