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Talk 4: Prospects of proton and ion microbeams for radiation hardness testing

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Abstract:

Proton and heavy ion microprobes with beam sizes of 1 µm or less offer unique possibilities for radiation hardness testing. Using a microbeam at low count rate (10 to 1000 s-1), individual effects of single particles can be separated and correlated with the actual position of the beam. By scanning the beam across a microstructured sample the charge collection efficiency and/or damage sensitivity can be mapped and correlated to the device layout. As one example measured at the former ion microprobe SNAKE of the Maier Leibnitz Laboratory [1], heavy ion mapping of Single Event Effects (SEE) and Single Event Burnout (SEB) of super-junction power MOSFETs will be presented utilizing carbon ion micro-beams of 55 MeV [2, 3]. Charge collection efficiency depends on the position of the impinging carbon ions and on the range when changing the energy of the ions up to 55 MeV.
The tests require expertise in beam handling and data evaluation and the data analysis is more time consuming as conventional broad beam irradiations. A major drawback of using microbeams for radiation hardness testing is that only a few of the worldwide available microprobes offer heavy ion beams of sufficient range. An alternative to heavy ion microbeams is proposed using pulsed proton microbeams that allow the deposition of hundreds or even thousands of MeV protons in a single bunch of nanosecond length [4] as a substitute of single high energy heavy ions. By adjusting the number of protons in a single bunch, the total LET of the bunch can be adjusted from low LET (< 0.1 MeV/(mg/cm²)) for single protons of some MeV up to 100 MeV/(mg/cm²) when bunching thousands of these protons in a single bunch. This would allow the use of many more of the MeV proton microprobes but requires challenging effort of proton sources and beam pulsing equipment to obtain the high number of protons in a single bunch.

[1] V. Hable et al., Nucl. Instr. and Meth. B 267 (12-13) (2009) 2090
[2] M. Gerold et al. 2018 IEEE, 2018, pp. 1-6, doi: 10.1109/IPFA.2018.8452587.
[3] M. Gerold et al.: Microelectronics Reliability 2024, DOI:10.1016/j.microrel.2023.115309.
[4] G. Dollinger et al: Nucl. Instr. and Meth. B 267 (12-13) (2009) 2008.

Presenter: DOLLINGER (UNIVERSITÄT DER BUNDESWEHR), Günther

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