All-silicon ladder for CMOS monolithic pixel detectors. Thermomechanical Simulations

Nana Chychkalo

Georg August Goettingen University

The All-Silicon project focuses on the development of monolithic CMOS pixel modules. Unlike traditional pixel detector modules, which involve individually diced chips from the wafer that are subsequently glued onto a support structure, the all-silicon approach integrates several CMOS chips into a single, uniform ladder, cut from a single silicon wafer. Each ladder is diced in one large self- supporting piece, allowing for direct assembly in the detector. The all-silicon solution offers a more compact, lower-power, and cost-effective option for future high-luminosity particle physics experiments.

To reduce material even further, a Redistribution Layer (RDL) is being developed to provide efficient power distribution for the module, eliminating the need for hybrid PCBs. In addition, thermal and mechanical simulations are employed to optimize the performance of CMOS chips as well as the RDL, defining optimal air-cooling conditions to ensure effective heat dissipation to prevent overheating due to heat produced in the CMOS chips and in the RDL components.

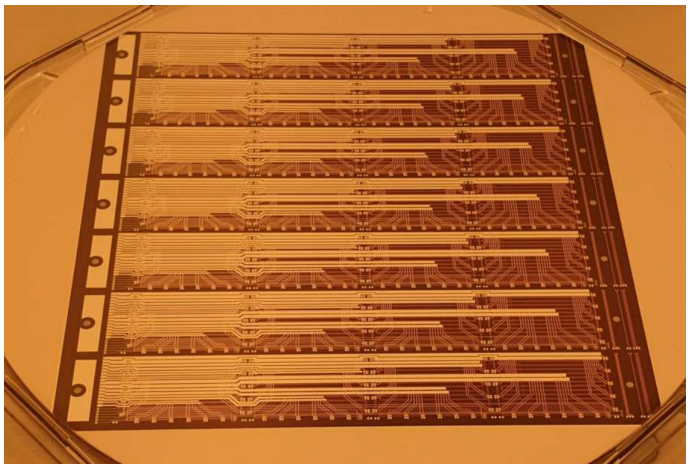

Abbildung 1: All-Silicon ladder prototype with redistribution layer.

As the project progresses, thermomechanical simulations are being carried out continuously. Their purpose is to further refine the ladder design by eliminating localized hot-spots, evaluating and optimizing the choice of materials, and ensuring the long-term stability of the structure under operational loads. An equally important objective is the definition of an efficient cooling strategy, which includes the study of advanced air-cooling solutions, as well as the potential integration of liquid-cooling components.

Together, these efforts aim to guarantee reliable operating conditions for the module in the demanding environment of high-luminosity particle physics experiments.

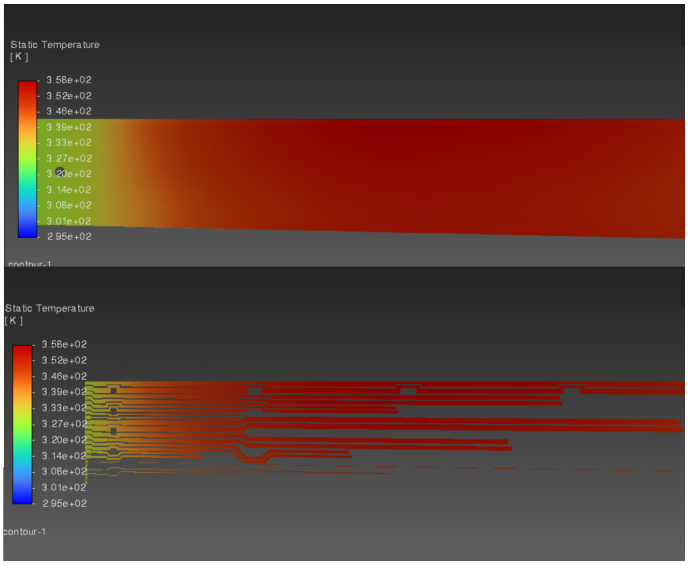

Abbildung 2: Determination of cooling requirements and hot-spots on the ladder and redistribution layer using thermal simulations.