Silicon Sensor Alliance: Radiation Detector Development for the LHC Upgrade

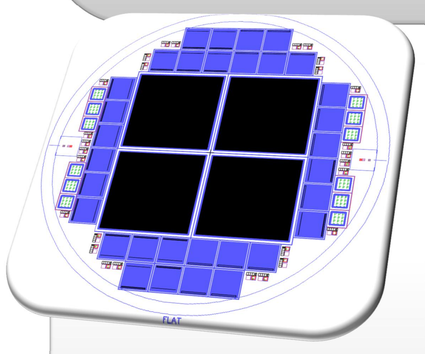
X. Wu[1], J. Kalliopuska[1], S. Eränen[1], J. Härkönen[2], W. Kaplan[3], M. Lozano[4], M. Boscardin[5], R. Röder[6]

[1]VTT, Espoo, Finland; [2]Helsinki Institute of Physics, Finland; [3]Acreo AB, Kista, Sweden;

[4]IMB-CNM, Bellaterra, Spain; [5]FBK, Trento, Italy; [6]CiS, Erfurt, Germany

INTRODUCTION

Silicon Sensor Alliance (SSA) gathers European institutes together to answer for the large need of silicon sensors for CERNs LHC upgrade. Currently more than 90% of the LHCs sensors were fabricated outside European countries. The aim of the SSA is to be a qualified and reliable union in Europe to manufacture and provide uniform and high quality radiation detectors to meet the requirement of LHC upgrade. The partners participating in the first fabrication demonstration are VTT (Finland), CiS (Germany), FBK (Italy), CNM (Spain), Acreo (Sweden). To be ready and successful in the first market survey of CERN, it is necessary that all participants are able to provide uniform sensor quality at different foundries and have a reference of this result. It is the first time that a number of SSA partners have initialized a joint demonstration to fabricate radiation hard AC-coupled silicon sensors at different European foundries and planned unbiased testing of them to obtain reference and publicity among the LHCs experiments.

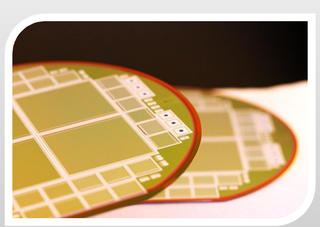


CHALLENGE OF SENSORS FOR LHC UPGRADE

- Radiation hard: Luminosity of 10^{35} $cm^{-2}s^{-1}$ (corresponding to total fluences of 10^{16} cm^{-2})
- Low depletion voltage: practical limit of 500 V
- High quality and uniformity

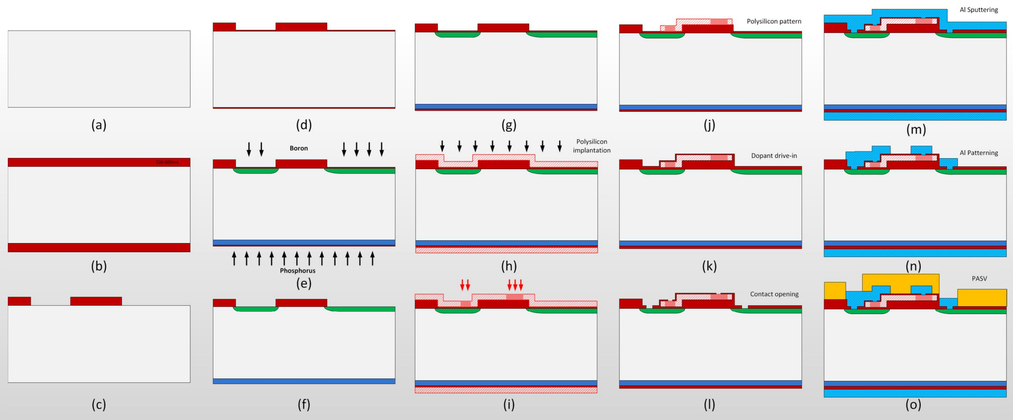
FABRICATION

All SSA members share and follow same process flow. Heat treatment between 400-600 °C is avoided to suppress thermal donors



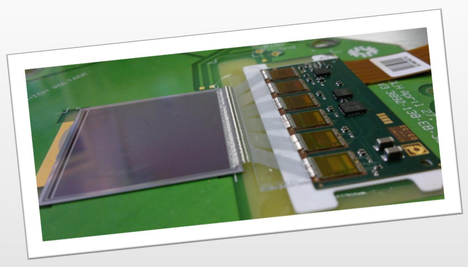
Wafers used in the process:

- n-type <100>
- 100mm / 150mm Magnetic Czochralski wafers (Okmetic) & 100mm / 150mm Float Zone wafers (Topsil)
- Resistivity >2000 Ω·cm (MCz-Si) and >5000 Ω·cm (Fz-Si)
- Oxygen concentration in MCz-Si ~5.7 × 10^{17} cm^{-3}

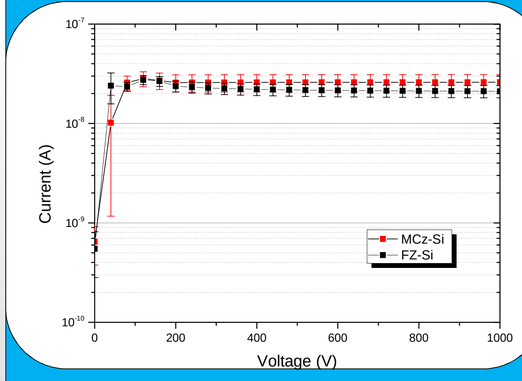


ELECTRICAL PERFORMANCE

The preliminary electrical characterization was performed for 1 × 1 cm^2 mini-strip sensors on both MCz-Si and Fz-Si wafers. All the measurements reported here have been performed at room temperature in a dark probe station.

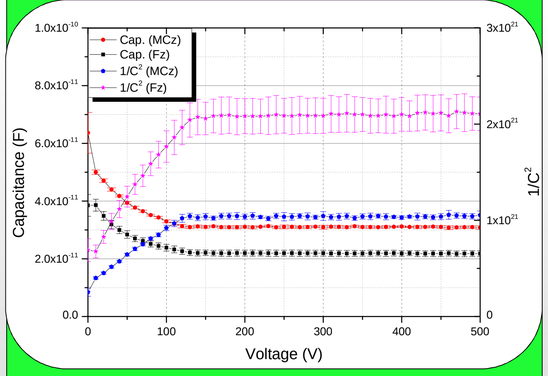


Leakage Current



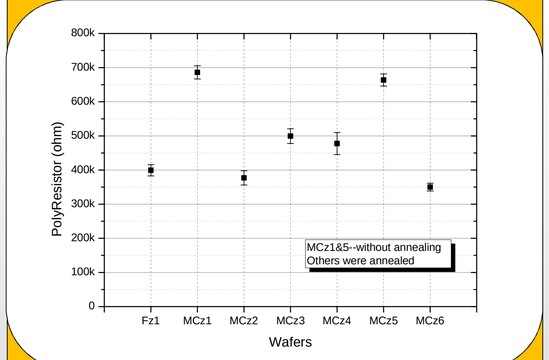
- **Total leakage current of 26 nA/cm²**
- **No breakdown below 1000 V**

Capacitance-Voltage



- **Full depletion voltage ~130V**
- **Total capacitance 30nF@full depletion**

Poly-Resistor



- **MCz1 and MCz5 are not annealed.**
- **Poly-resistance ~0.5 MΩ after low temperature annealing (350°C)**

BEAM TEST

Mini-sensors are now irradiated by 24 GeV protons coming from CERN PS accelerator. The maximum fluence is 1 × 10^{16} cm^{-2}, which is the fluence that innermost pixel detectors will receive in future Super-LHC. After irradiation, the sensor will be characterized at CERN.
Full-size sensor is hybridize to CMS readout board and irradiated with 220 GeV muon beam from SPS accelerator.

VTT TECHNICAL RESEARCH CENTRE OF FINLAND
Tel. +358 404 803 449 Fax +358 20 722 5815
xiaopeng.wu@vtt.fi www.vtt.fi www.vtt.fi/detectors