

Sapphire sensors WS

11 January 2024

Introduction

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Introduction

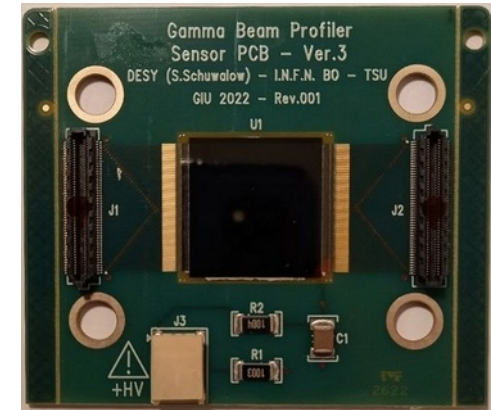
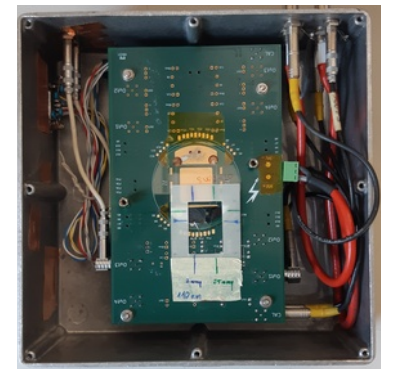
- **Thanks everybody**, and in particular Daniele Trucchi and Benno Margesin, **for participating** in this sapphire micro-strip mini-workshop !
- The goal of this meeting today is to report and discuss about the **fabrication of these new type of sensors** and their **basic properties** and **exchange experiences** with other groups that have worked with sapphire and diamond sensors
- We foresee to organize a second meeting to discuss the performance of the micro-strip sensors, since the analysis of the precision measurement data taken so far is now being finalized and it is easier to reserve two half days instead of one full day

R&D program

- The R&D program was proposed by the late Sergej Schuwalow and has been carried out with contributions from colleagues of:
 - Tomsk State University
 - Queen U. Belfast
 - INFN-Bologna and INFN-Padova
- the motivation was to develop a sensor to measure the profile of the **inverse Compton gamma bunches** to be produced by **electron-laser interactions** in an experiment (LUXE) aimed at studying the transition to the **strong QED regime**
- the sapphire looked promising for
 - the **excellent radiation resistance** (up to 10 MGy),
 - **low leakage current** at room temperatures even after high irradiation
 - **low cost:** ~ 1000 less expensive than synthetic diamond
 - expected low charge collection efficiency compensated by the relatively intense and very short bunches expected at LUXE (10^7 - 10^9 photons, with energy up to 16 GeV)
- key performance goal: **5 μm** profile width resolution
- important design choice: **reduce as much as feasible the thickness of the sensor** for transparency and maximum CCE

Sensors developed

- three main type of sensors developed so far:
 - **thin pad sapphire sensors** equipped with low-noise charge amplifiers for initial assessment **of sensors CCE**
 - **4-strip sensors** to measure the radiation hardness using an intense electron beam (with no amplification)
 - **192-strip sensors** prototypes with multi-channel "commodity" electronics providing charge amplification and digitization(CAEN FERS)
- sapphire produced in
 - Germany (SITUS Technicals GmbH Wuppertal)
 - **110 μm** thickness
 - US (Univ. Wafers)
 - **150 μm** thickness
 - Russia (Monocrystal)
 - **150 μm** thickness



Agenda

Sapphire procurement and electrode deposition at Tomsk and FBK

- 09:15 **Introduction**
Speaker: Mauro Morandin (Istituto Nazionale di Fisica Nucleare)
- 09:20 **Microstrip sensor production at Tomsk**
Speaker: Dr Anton Tyazhev (Tomsk University)
- 09:30 **Microstrip sensor production at FBK**
Speaker: Benno Margesin (FBK Trento)
- 09:40 **Experience with diamond metallization and effect of non-ohmic contacts**
Speaker: Dr Daniele Trucchi (CNR Montelibretti)
- 10:00 **Strip resistivity**
Speakers: Pietro Grutta (Istituto Nazionale di Fisica Nucleare), Sergii Vasiukov
 Strip resistivity_WO...
- 10:05 **Discussion: lesson learnt, suggestions for future productions**
Speaker: ALL

Characterization and qualification of sapphire sensors with X-rays

- 10:45 AM **Measurements in Tomsk**
Speaker: Dr Anton Tyazhev (Tomsk University)
- 10:55 AM **Measurements in Padova**
Speakers: Sergii Vasiukov, Sergii Vasiukov (Istituto Nazionale di Fisica Nucleare)
 Characterization an...
- 11:05 AM **Diamond measurements under irradiation and measurement of CCE and mu-tau**
Speaker: Dr Daniele Trucchi (CNR Montelibretti)
- 11:25 AM **Discussion: exploitation of X-rays for future sapphire characterization, possibility of disentangling and mitigating non-ohmic contact effects**
Speaker: ALL

Tea Break

Measuring CCE and mu-tau for sapphire sensors

- 12:05 PM **Measurements of CCE with pad sensors and an alpha source, plasma effects**
Speaker: Mauro Morandin (Istituto Nazionale di Fisica Nucleare)
 MM_WS_GBP_11jan...
- 12:15 PM **Measurements of CCE with pad sensors with a low intensity electron beam**
Speaker: Pietro Grutta (Istituto Nazionale di Fisica Nucleare)
 LUXE240111_Meas... LUXE240111_Strip r... Measurements of C...
- 12:25 PM **Discussions: how to improve the current evaluations of CCE and mu-tau**
Speaker: ALL

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First session: sensor production

- the first batch of 192-ch sensors were produced at Tomsk (Russia) and bonded in INFN-Pisa
- the second batch was produced at FBK (Italy) and bonded at CERN
- metallic electrodes depositions were performed in different ways:

Sensor production	Tomsk State University (TSU)	Fondazione Bruno Kessler (FBK)
Strip material	Cr (~60 nm) + 1 μ m Al for contacts	Cr (30 nm) + Al (200 nm)
Back-side layer material	Cr (20 nm) + Ni (200 nm)	Ti (30 nm) + Al (200 nm)

- what are the lessons learned by these first productions that can be taken into consideration for future productions?