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Wire Bonding on 2S Modules of the Phase-2 CMS Detector

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JC92
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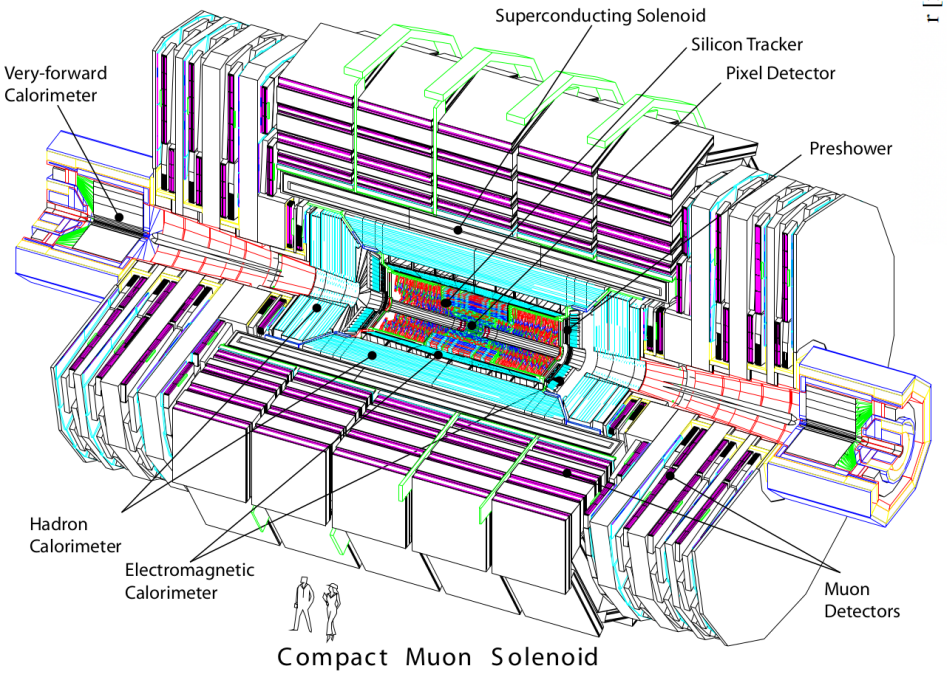
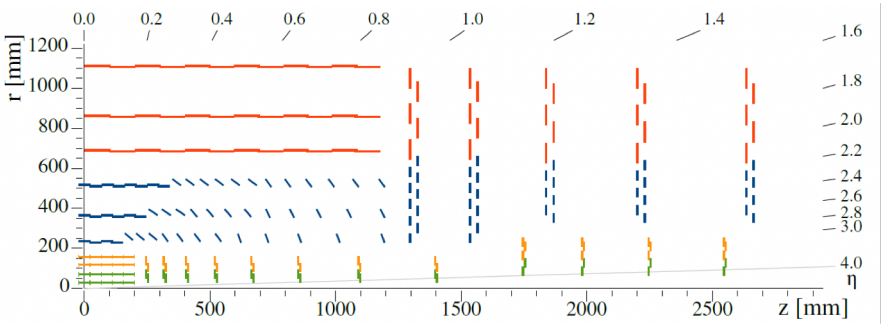
Introduction

- Background: LHC, CMS, Phase-2 Upgrade
- RWTH Aachen University is involved in the design, test and production of 2S tracker modules of the Phase-2 upgrade.
  - **Wire bonding**: electrical connection of the particle detecting sensors and the electronic hybrids which process the sensor signal. The quality of the wire has to be optimized.
  - **Encapsulation**: Because the wires are very fragile, the CMS collaboration plans to encapsulate them with a soft glue. Therefor appropriate glues have to be tested and a precise and repeatable dispensing system has to be prepared for the series production. First studies of three different glue candidates and the challenges in the dispensing process of a series production are also discussed in this theses.

The CMS Experiment at the LHC



CMS

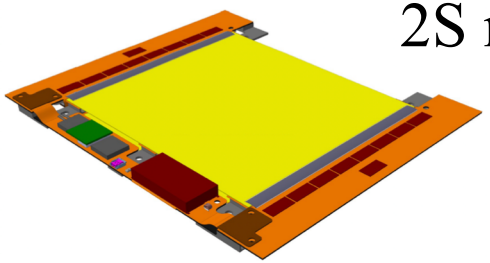


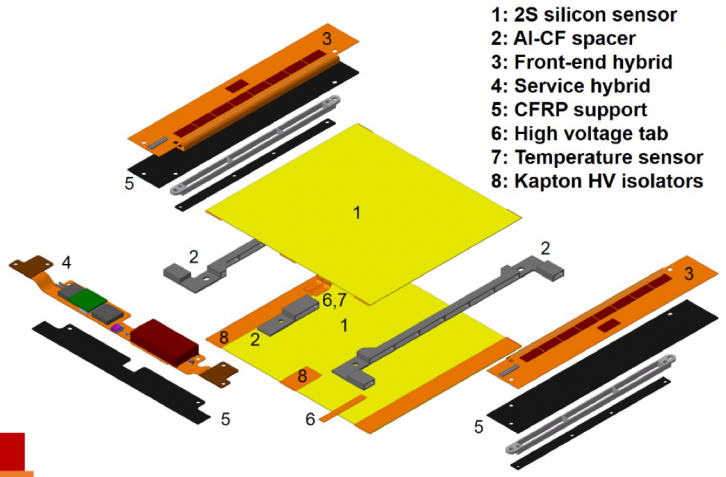
Phase-II tracker

- The 2S modules are installed in the outermost three layers of the barrel and in the outer part of the five double disks.
- The name “2S” corresponds to the two strip sensors composed in the 2S module.

The CMS Experiment at the LHC

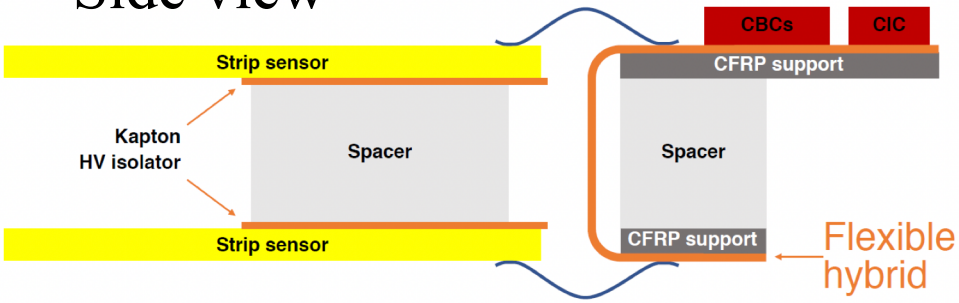
2S module





Component of 2S

Side view



➢ 2S module

- Each of the two strip sensors provides 90 cm^2 active area achieved by two rows of 1016 strips with a length of about 5cm and a pitch of 90µm.
- The strips are electrically connected to the flexible FE hybrids on both sides of the module via wire bonds. The wires are made of aluminum and have a diameter of 25µm.

Wire Bonding

- Wedge bonding process
- the most relevant parameters
- Wire bond quality test
- parameter optimization

Procedure of wedge-wedge-bonding

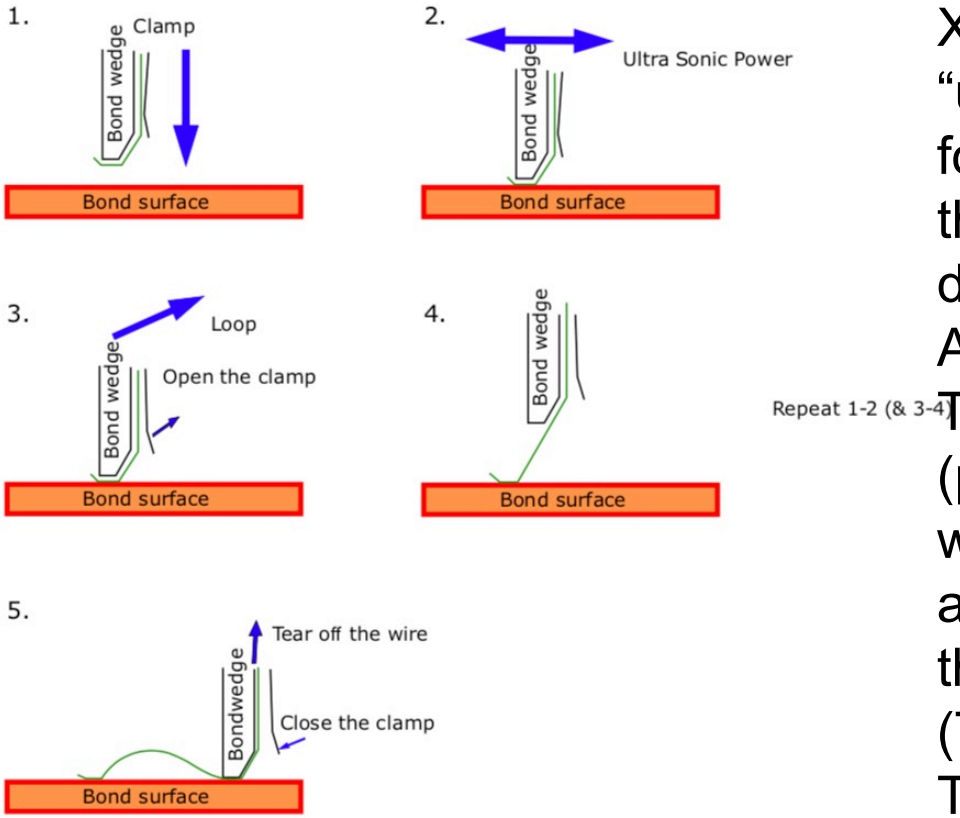


Figure 3.1: Procedure of wedge-wedge-bonding. The green line represents the aluminum wire.

Xin: In the summary (p79), it says "usually, the value of the touchdown force can be set to be the same as for the bond force". What's the difference between these two forces?

Answers(p11):

The first connection point is made (picture 1) by moving down the bond wedge onto the bond surface and applying a well-defined force which in this thesis is called touchdown force (TDF) to achieve a pre-deformation. Then (picture 2) the US power is activated while a force is still applied to the wire. This force is called bond force (BF).

Yuhang Tan: In fig3.1, how to tear off the wire?

A: close the clamp (夹钳).

Process of Wedge bonding

1. In the first milliseconds (between 4 and 10 ms) the deformation is low and the increase of temperature is slow. The bond wedge rubs the wire on the surface which removes the thin oxide layer of the wire and small contamination on the surface. Therefore this phase is called the **cleaning phase**.

2. The wire deformation and the temperature both increase while most of the energy is used to flatten the metal surface. The atomic lattices of the metals get close together and the wire partially melds onto the surface. The bond wedge rubs on the wire, which is almost at rest. This phase is called the **mixture phase**.

3. The deformation applied in this phase is small and the frictional heat at the bond wedge and the wire is conducted to the bond surface. This temperature increase supports the stabilization of the welding by diffusion. So this phase is called **diffusion phase**.

Kai: on page 12, the author introduces the three phases of the welding. the **temperature increase** is mentioned in all the three phases. Does the temperature increase being performed on purpose in order to keep the bond machine in a good working status, or , it is just some by-product in the process?
A: increase temperature to make the wire meld to fix onto the surface.

Encapsulation

Question

Shan: Knowledge about the LHC and CMS. What determines the luminosity of a detector?

A: For my understanding, the luminosity is determined by the accelerator. Maybe some factors will affect the luminosity, such as types of particles, energy of particle, types of collider (circular of linear), cost of construction and technique of magnet et al.

Question

Amit Pathak: On page- 50, The BPC-slope is defined in the way that slope below 45◦ is result in too low wire deformation values, which leads to an error stopping the machine. On the other side higher bond times should be preferred. Thus, BPC-slopes of the order 50◦ to 60◦ are reasonable setup values.
In figure 3.41, it is clear that the slope is more than 45◦ .
Why does the high wire deformation good and low wire deformation cause to stop the machine?

A: BPC- bond force control

Question

Ryuta Kiuchi: Is there any works (or ongoing plans) to develop tools, like simulation, that can predict the parameters within certain range ?

A: I don’t know very clearly. We use some experiential law and initial/default value when optimize the parameter.