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LCLS II FUNDAMENTAL POWER COUPLER MANUFACTURING STATUS AND LESSONS LEARNED

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Abstract

Thales and RI Research Instrument have manufactured and assembled half of the Power Couplers for the LCLSII Project,. This paper remains main characteristics of these couplers, main challenges overcomed and among them thickness of copper coating on Warm Internal Conductor (WIC) at 150 µm. It also proposes some possible optimization for a future mass production and parameters which could be relevant for a better understanding link to statistic results obtained from this production and the one from XFEL production.

MAIN CHARACTERISTICS AND COUPLERS DESCRIPTION

The design of these couplers (Fig. 1) is an adaptation of the TTF3/XFEL Fundamental Power Coupler (FPC) [1].

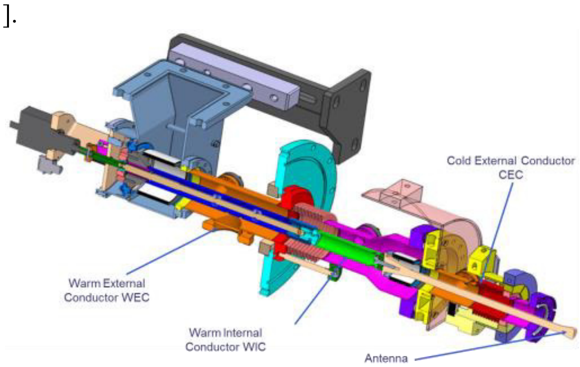

Figure 1: General Layout of the Coupler.

Main parameters of the coupler are:

- RF frequency: 1.3 GHz
- Power up to 7 kW CW
- Tuning: ± 10 mm
- Two ceramics windows

Main modifications in respect to the XFEL/TTF3 design are:

- Antenna profile in order to be adapted to the cavities performances
- Copper coating thickness of the WIC defined at a thickness of 150 µm, compared to 30 µm for E-XFEL, in order to avoid too large temperature heating when operating at full power of 7 kW.
- Residual Gas Analysis (RGA) is made during baking operation at 150°C.

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MANUFACTURING

Main metallic sub-assemblies: Warm External Conductor (WEC), Warm Internal Conductor (WIC), Cold External Conductor (CEC) and antenna (Fig. 2) were manufactured and copper coated at Thonon factory then sent to RI factory. Ceramics are TiN coated and then the coupler is assembled by Electron Beam Welding (EBW) at RI factory.

After cleaning and assembly on the test stand, they are sent to JLAB/Fermilab for integration on cryomodules.

Figure 2: CEC, Antenna and WEC.

Overview on Manufacturing Difficulties:

Due to the XFEL manufacturing experience [2] (where more than 670 couplers were manufactured at a rate up to more than 10 couplers a week) there were not a lot of difficulties for the manufacturing of LCLSII FPC.

The copper plating process is the trickiest step for the coupler manufacturing which also have been developed during XFEL production except for the WIC where the thickness of 150 µm had been obtained. During the manufacturing of all couplers, check of coating thickness (Fig. 3) and Residual Resistivity Ratio (RRR) have been done

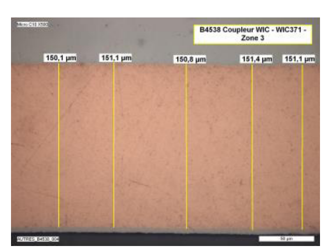

Figure 3: Example on Copper Coating Measurement

This was done also statistically on parts of main components (Figs. 4 and 5).

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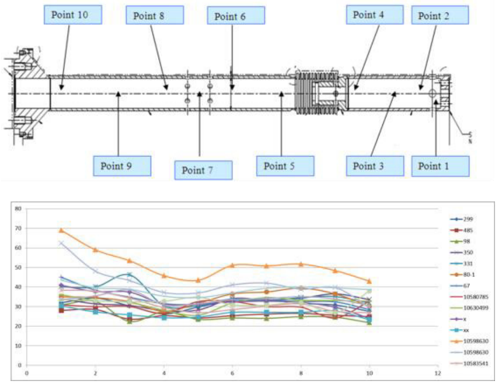

Figure 4: Measured Position for WIC at 30 µm.

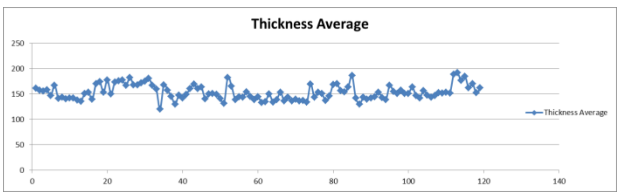

Figure 5: WIC Thickness Measurement at 150µm.

LESSONS LEARNED AND POSSIBLE OPTIMIZATION

Manufacturing improvements and possible ways to increase rate of production could be considered [3], [4].

Technical:

In order to improve manufacturing for a FPC mass production, studies could be done in order to avoid processes which are operator dependent like remaining welding steps which could be replaced by brazing. This will allow for manufacturing by batches in furnaces.

It is also necessary to clearly define objective and shared visual acceptation criteria of what is acceptable and what is not [4].

Due to the XFEL and LCLSII experience in manufacturing couplers it appears that statistically some parameters must be more clearly understood.

Among them, two parameters need to be better understood: RRR dispersion and Tinted ceramics.

Concerning RRR dispersion (Fig.6), it appears that statistically, RRR value could vary on parts (sample or part of coupler) in the same bath when coated at the same time.

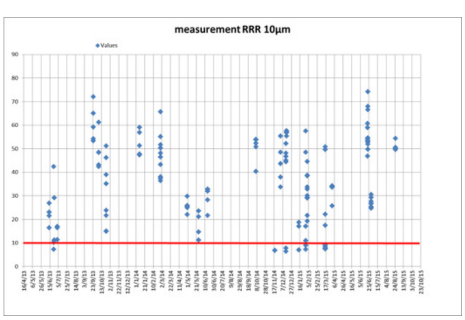

Figure 6: RRR dispersion for 10 µm coating.

Tinted ceramics occurred (Fig.7) (a few tens on a few hundred pieces manufactured)

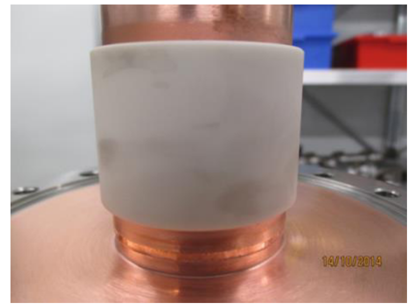

Figure 7: Example of Tinted Ceramic.

This tinted ceramics appears during RF conditioning, the only impact on conditioning being a small longer processioning time due to vacuum behavior.

Scheduling and Program:

Ramp up and ramp down on manufacturing must be strongly considered. Ramp-up is mandatory for assuring that all processes are under control and operators fully operational.

Ramp-down is also mandatory. During manufacturing, couplers are assembled by pair, and some sub-assemblies could be rejected just because their behavior is not well understood or correlated to the other coupler of the same pair. **B**ut at the end of the program, it becomes necessary to reconsider what is acceptable and what is definitely not acceptable.

STATUS

The 150 couplers for LCLSII have been delivered in due time at a rate of 4 couplers/weeks.

With E-XFEL experience, a production rate of more than 10 couplers a week and a total production of more than 820 couplers have been demonstrated, and 670 of them are on an operative accelerator.

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