# STATUS OF THE DEVELOPMENT AND MANUFACTURING OF LCLS-II FUNDAMENTAL POWER COUPLERS

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*Abstract*

For the LCLS-II project, Thales and RI Research Instruments are working on the manufacturing and assembly of 132 Fundamental Power Couplers.

The paper describes the production of these Fundamental Power Couplers. The main characteristics are remained at 1.3 GHz.

It describes the main challenges to be overcome principally on the Warm Internal conductor, with a thickness of copper of 150 µm.

We describe the results obtained on the prototype phase and the status of the serial production on the date of the paper.

## INTRODUCTION

Fundamental Power couplers for the LCLS-II accelerator are derivate from the TTF3/XFEL fundamental power coupler [1]. They are designed with specific modifications for mounting on the accelerator and some specific design parts for required performances [2].

SLAC (Stanford Linear Accelerator) is in charge of the procurement and contract following, while associated laboratories (JLAb and FermiLab) are in charge of mounting these couplers on cryomodules [3].

The main characteristics of such couplers are:

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

The main metallic sub-assemblies of a coupler are the Warm External Conductor (WEC), Warm Internal Conductor (WIC), The Cold External Conductor (CEC) and the antenna, illustrated in Fig. 1.

The two other critical components are the two cylindrical ceramics.

Main modifications in respect to the XFEL design are:

- Antenna profile in order to be adapted to the cavities performances
- Copper coating thickness of the WIC define at 150 µm thickness in order to avoid too large temperature heating when operating at full power of 7 kW.

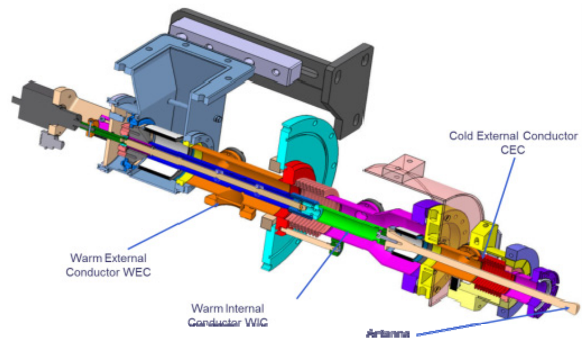


Figure 1: Coupler general layout.

## COUPLER MANUFACTURING

Main steps in the coupler manufacturing are exactly the same than the one followed for the XFEL manufacturing [4].

Main steps are: parts assemblies, copper coating of RF surfaces, TiN coating of ceramics windows. Then, EB Welding in order to achieve individual Warm and Cold part of couplers.

Then the coupler parts are clean in an ISO 4 clean room and after drying, they are integrated by pair on a transition waveguide.

After a leak check and a RGA is operated, while the coupler is baked at 150°C they are send to JLab or Fermilab for final integration.

### *Thales Production Process*

The LCLS-II couplers sub-assemblies are based on a brazing technology. This technology allows having a better reproducibility than a welded one, which is more operator dependant and also could be performed by batches, which is useful for a mass production.

All processes used for the manufacturing are derived from the experience earned on the XFEL production in order to minimize risks and optimized production scheduling.

Once the sub-assemblies are brazed and prepared, the three main one (WEC, WIC and CEC) are copper coated, as illustrated in Fig. 2 and Fig. 3.

The copper plating process is the trickiest step for the coupler manufacturing.

Thickness and tolerances on WEC and CEC are of 10 µm ± 20% on tubular parts and ± 30% on bellows, For WIC thickness is of 150 µm ± 20% on tubular parts and ± 30% on bellows.

RRR value initial specification was from 30 to 80.

For this process of copper coating dedicated and shared visual acceptance criteria has been defined by all the participants of the program in order to have common and objectives criteria on the visual aspect of copper coating. This is one of the most important documents of the program, this document was adapted from the one of XFEL manufacturing process [5].

Figure 2: Warm External conductor.

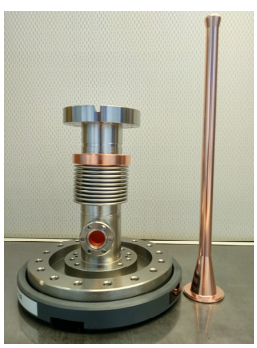

Figure 3: Cold external conductor and antenna.

Parameters are controlled during the overall manufacturing and samples are used continously to verify the reproductibility of results.

RRR value and thickness measurement on real part of couplers are regularly done to check that the process results are constants.

These measurements allow also having statistics on high rate of production [5].

Example of statistics on Copper coating on WIC is given in Fig. 4.

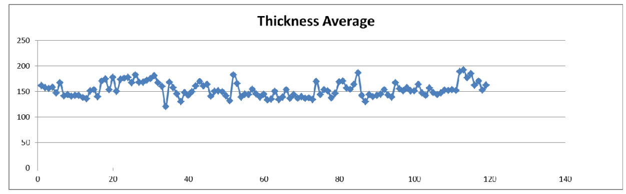


Figure 4: Thickness average on WIC.

Measurements are done on dedicated parts of components in order to know dispersion on pieces and average dispersion between components (this is done for the WEC, the CEC and the WIC), Fig. 5.

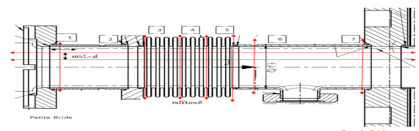

Figure 5: Example of position of Systematic Thickness Measurement.

### *RI Research Instruments*

At RI factory, the ceramics windows are prepared with a TiN coating of a thickness of 10 nm nominal.

Once the sub-assemblies from Thales are received at RI factory, a double check of quality, Fig. 6, is done on these sub-assemblies before EB welding is made for having the warm and cold part ready for final assembly of couplers.

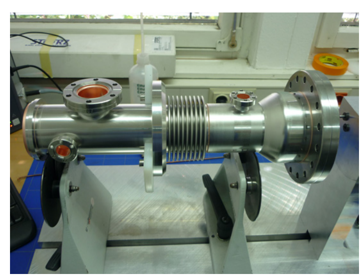

Figure 6: double check on copper coating quality at RI.

Then Warm Part and Cold part are cleaned in ISO 6 clean room, dried and assembled by pair on the transition waveguide in an ISO 4 clean room.

Once the assembly operation is finished, an RGA is done and the spectrum is recorded in order to observe the absence of unwanted material, like hydrocarbons. This is done while couplers are baked at 150°C in an oven, Fig. 7.




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Figure 7: Oven for RGA while couplers are baked in oven.

Then couplers are sent to the associated labs in the US for integration on cryomodules.

### *Overview On Coupler Production*

After a prototype phase where 8 couplers were delivered and accepted, serial production has started with the aim of having a full maximal rate of 4 couplers per week and taking into account the necessary ramp up of such program.

Even if production rate is lower than the one demonstrated during the full XFEL production stabilized phase, special care have to be considered when starting such a program (ramp up phase is mandatory to adjust every single individual parameter and having a shared full interpretation among all the parties involved in the program.

Figure 8 represents the overall production chart of sub-assemblies.

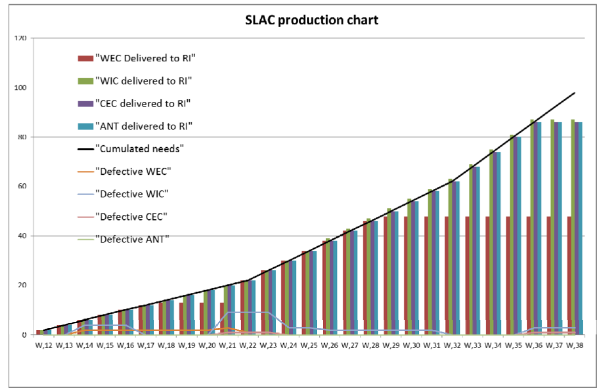


Figure 8: Overall production chart of sub-assemblies.

## CONCLUSION

LCLS-II production at Thales and RI Research Instrument is on progress at the schedule rate.

No major problems have been encountered during manufacturing phase (prototype and serial production). Main issues like the WIC thickness of 150 µm have been quickly and in time achieved. This is due to the high experience earned in the XFEL program and the continuity of such programs among them.

## ACKNOWLEDGMENT

We acknowledge all the people involved in the manufacturing of LCLS-II couplers especially workers involved in the manufacturing factories (at RI and Thales) for their involvement along the program.

We also acknowledge all the teams from SLAC, Jlab and Fermilab for the fruitful and constructive exchanges we have during this program.

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