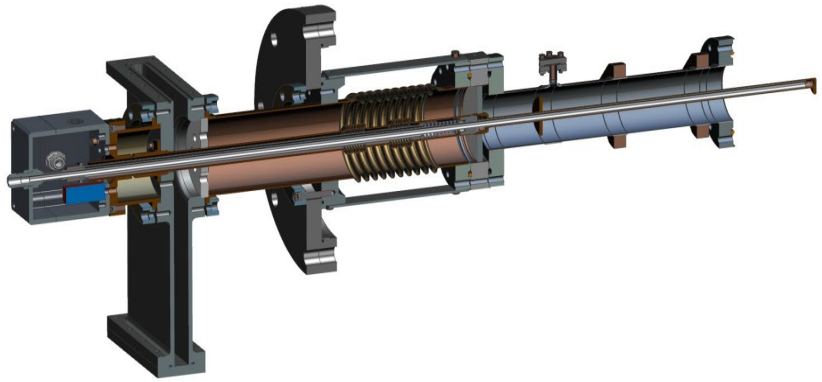
RF Power Couplers

Rajesh Kumar- SPC IIFC-RF Couplers

14 July2022

Status of RF Power Couplers

325 MHz Coupler under development
(20 kW, full reflection for all phases)



650 MHz Coupler under development
(50 kW, full reflection for all phases)

2 Nos of 325 MHz Couplers are to be delivered to FNAL under IIFC

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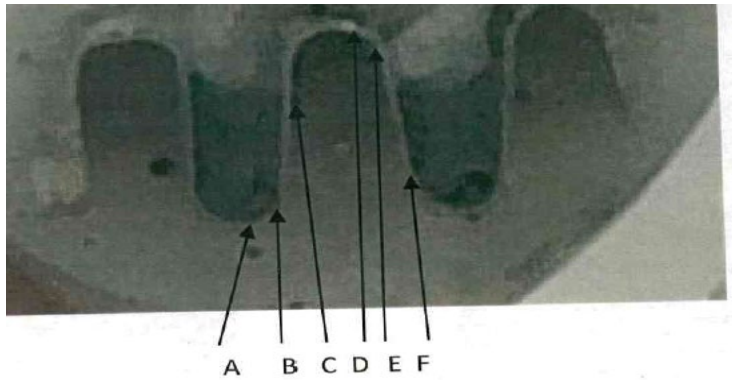
Indian accelerator program will need higher power levels (Both CW and pulsed)
50 kW for 325 MHz SSR and 150 kW for 650 MHz cavities

•Status of bellow's copper plating

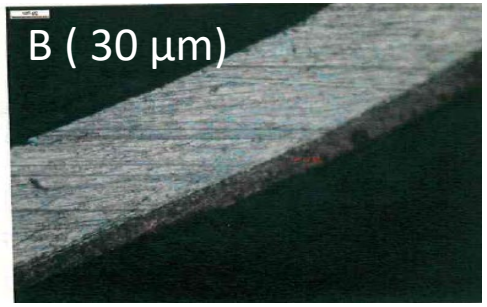
-Outer conductor SS bellow's copper plating thickness is between 10- 70 microns.

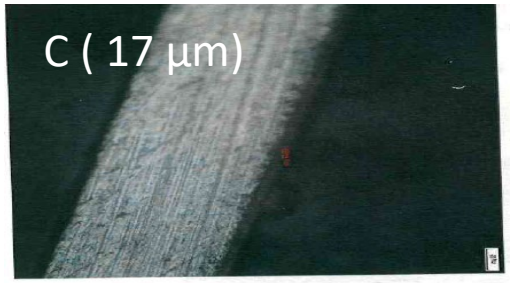
- Inner conductor SS bellow's copper plating thickness is between 15 – 47 microns.

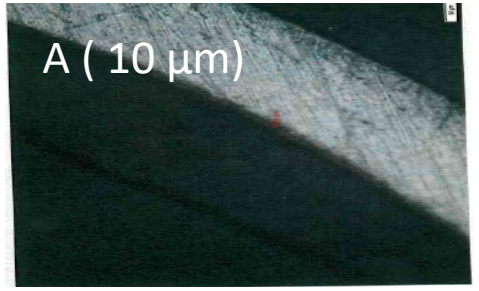
- Plating of bellows for 650 MHz and 325 MHz coupler prototypes is in progress. Further trials are in progress to bring the uniformity to with in 10-40 microns.



Sample of outer conductor bellow







Optical microscope images of copper coated samples

Summary of Bellow Cu Plating Tests

Plating parameters	Specifications	Test Results
Plating quality		OK
Adhesion- ASTM B571 Bend Test		Completed-OK
Peel test- ASTM B571		Completed-OK
Plating * (RRR)	RRR range to be 10-100	Not done
Surface roughness	Ra < 1.6 microns	OK
Thickness	20 +- 5 microns**	10-70 microns
Vacuum Bake out	350 F (176 deg. C)	OK
Thermal Cycle (high)	400 deg. C	OK
Thermal Cycle (low)	-196 deg. C	OK

- **Status of cold part brazing**

-Ceramic to copper collars are brazed and have passed the vacuum tests.

- Brazing of antenna parts to ceramic is completed.

- Joining of cold part outer conductor to Flange is completed. Plating of outer conductor is in progress.

-Discoloration of alumina is observed.

-Ceramic discs will be used for masking the cold part assembly during further brazing operations.

Trial on 3 inch disc
(325 MHz coupler)

Trial on 4 inch disc
(650 MHz- Prototype B)

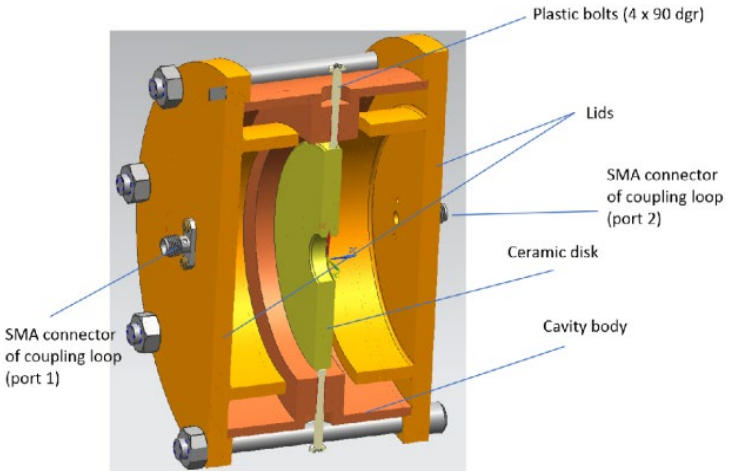
- **Status of Alumina discs**

- Alumina discs for 325 MHz (old design) and 650 MHz Prototype B coupler were procured from Indian Vendor- CUMI. The loss tangent was measured at FNAL and later at BARC. It was in the range of 1E-4 to 2E-4.
- However, discs procured recently from CUMI has shown poor loss tangent (5.7E-4 to 7.5E-4). Hence, those discs were rejected.

-Coorstek has not responded to recent emails for supply of metallized discs.

- Kyocera discs may be restricted under export control
- FNAL will be providing 3 inch and 4 inch metallized alumina discs of required loss tangent (better than 1e-4)

Alumina loss tangent measurement set-up at BARC



Set-up model provided by FNAL

Alumina loss tangent measurement set-up developed at BARC

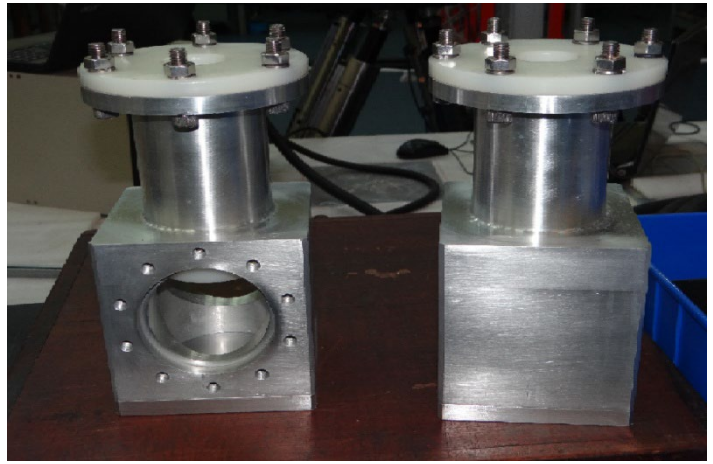
6 mm disc

Disk no	CST simulation result	BARC measurement
4” Disk #1	fo=2.384GHz Qcer=12262 δ=1e-4	fo=2.3544GHz Qcer=7100 δ=1.72e-4
4” Disk #2	fo=2.384GHz Qcer=12262 δ=1e-4	fo=2.3541GHz Qcer=6000 δ=2.2e-4

8 mm disc

Disk no	CST simulation result	BARC measurement
4” Disk #1	fo=2.149GHz Qcer=11492 δ=1e-4	fo=2.053GHz Qcer=2012 δ=5.74e-4
4” Disk #2	fo=2.149GHz Qcer=11492 δ=1e-4	fo=2.055GHz Qcer=1502 δ=7.49e-4

Fabrication status of 325 MHz Couplers



Coaxial transition junction box

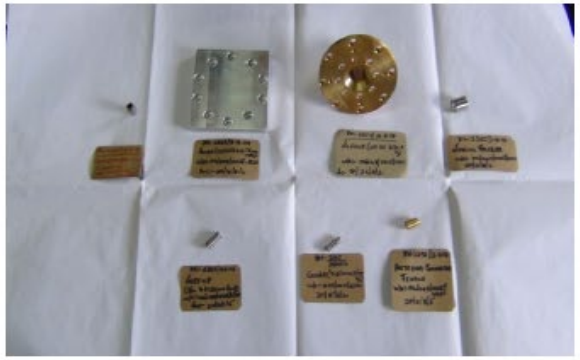
Coaxial transition outer conductor

Instrumentation box

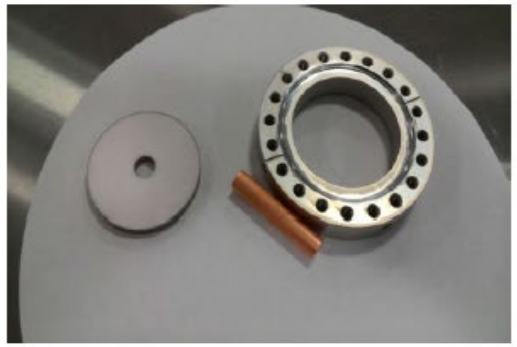
Prototype brazed cold part of coupler

Fabrication status of 325 MHz Couplers

Fabricated SS Parts



Aluminium and copper parts



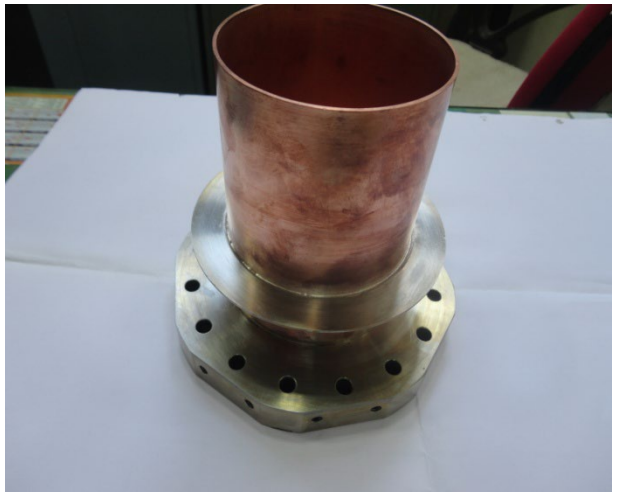
Cold coupler parts

Alumina disc after brazing

Coupler test stand tested upto 30 kW

Status of 650 MHz Coupler

650 MHz Outer conductor Extension
(Bellow EM shield design)

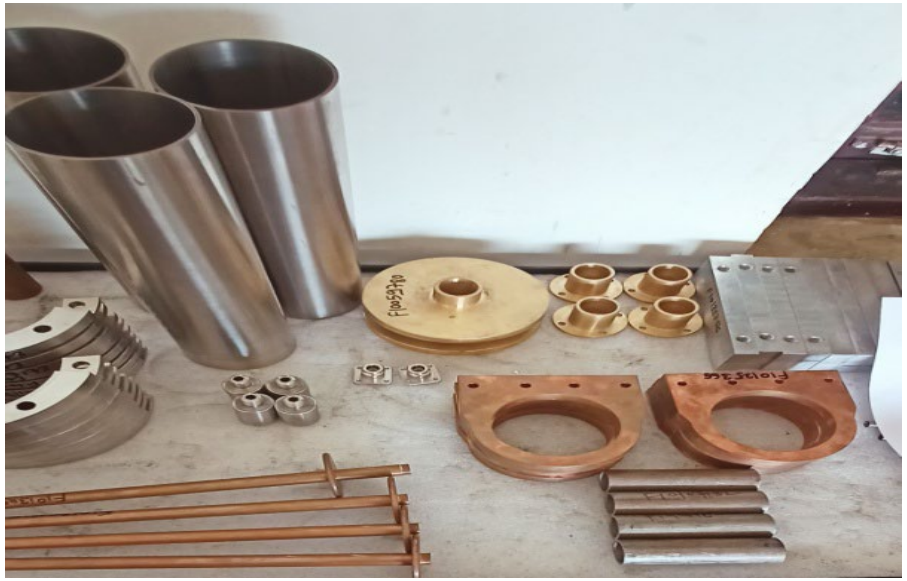


650 MHz Outer conductor with Flanges

Inner conductor antenna

Alumina disc after brazing to copper sleeves
(discoloration observed)

Status of 650 MHz Coupler contd.



Ceramic, inner conductor , Outer conductor, antenna and other coupler parts

Summary

- Machining of 325 MHz couplers (old design) is completed. Brazing and joining operations are pending.
- Machining of 650 MHz coupler parts including the incoming waveguide is completed. Final brazing step of cold part and alumina disc coloration are issues which are being resolved.

Following areas need attention:

- Requirement of clean room during manufacturing and later during coupler's life cycle
- Assembly , Storage, transportation requirements for Couplers before and after various tests (Warm test bench, HTS, Cryomodule etc.)

Thanks