

Multipactor suppression with DC offset in coaxial RF FPC for SSR cavities

1/March/2023

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- **RF Fundamental Power Coupler (RF FPC)**
- **Role:** RF FPC is to supply RF power into cavity operating under ultra-low pressure, lower than 1E-9 mbar.
- **Characteristics**
 - Capacitive coupler (100 ohm coaxial)
 - One warm ceramic window
 - 2 K operation (from room temperature)
 - Two thermal intercepts (4 K, 40 K)
 - Fixed coupling: extremely over coupled (coupler beta > 1000) without beam loading
almost matched with beam loading (~1 mA)
 - DC bias: reduction and elimination of multipactor (MP) activation

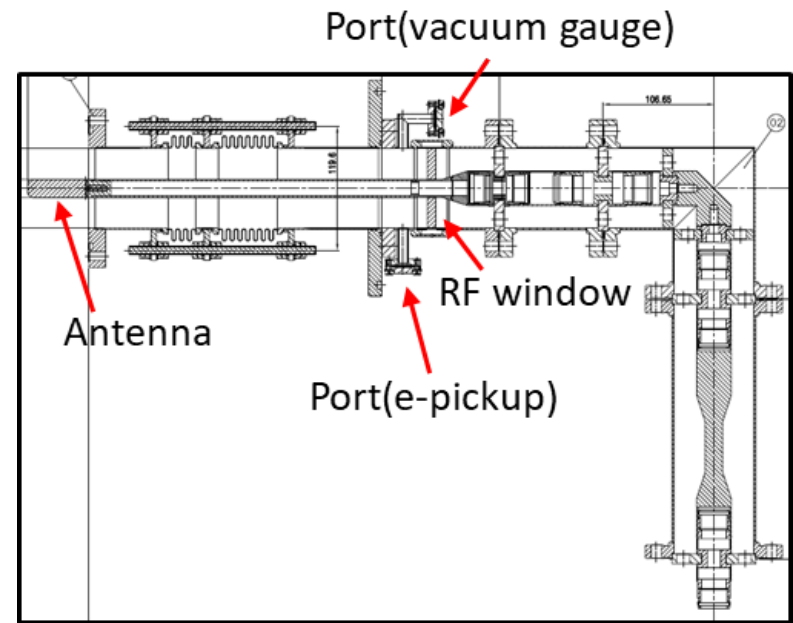
Input parameter (for SSR1)

Parameter	value
Operation frequency	325 MHz
Operation RF power	5 kW max.(margin: 25%)
Control bandwidth	± 30 Hz
External Q factor	5E6
Standard coaxial W/G	3-1/8 inch

Three sections: Antenna, RF window, T/L

- Antenna
 - Cold vacuum part, 100 ohm
 - Two thermal intercepts (4 K, 40 K), bellows
 - Outer: 316L, inner: copper
- RF window: 6 mm thickness Al₂O₃, without TiN
- T/L: Warm air side, 50 ohm

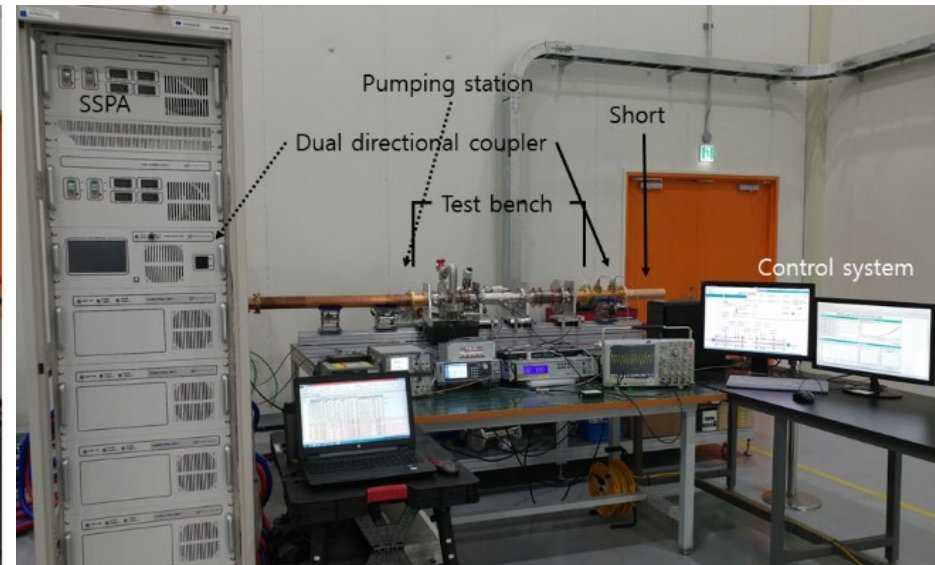
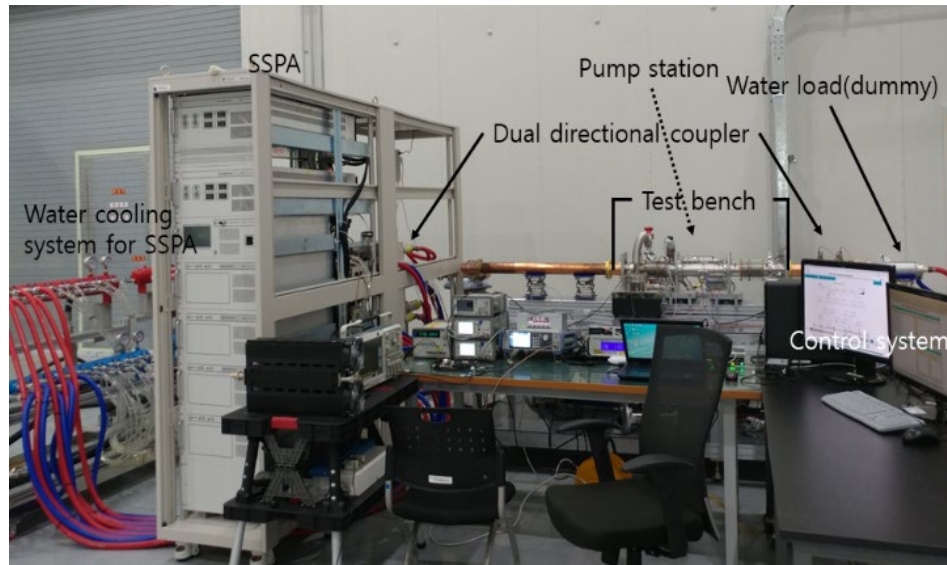
Side view of RF FPC



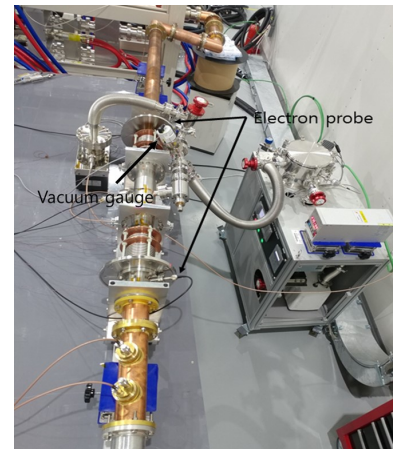
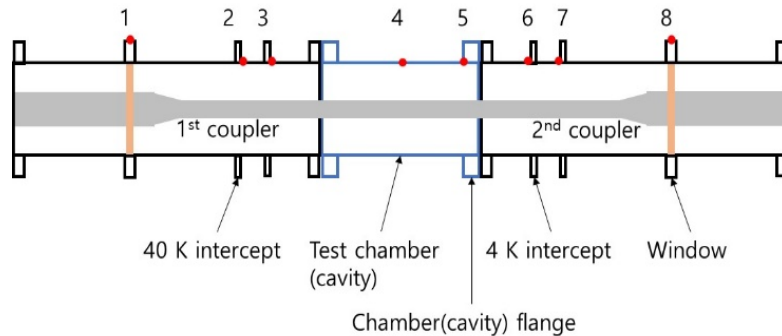
RF power experiment on test bench: setup

TW mode

SW mode

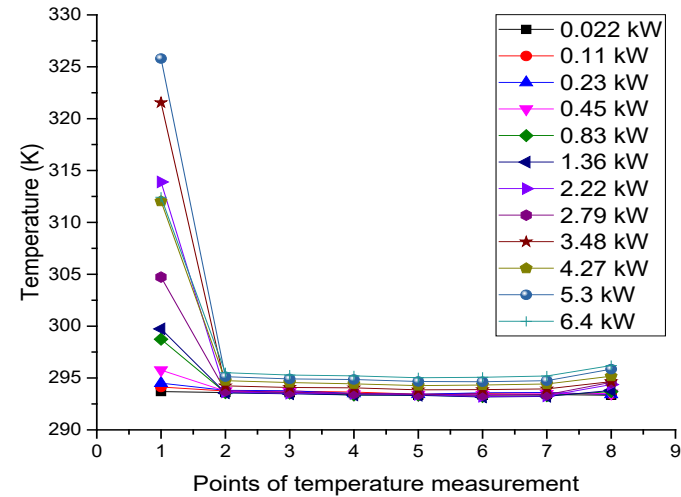
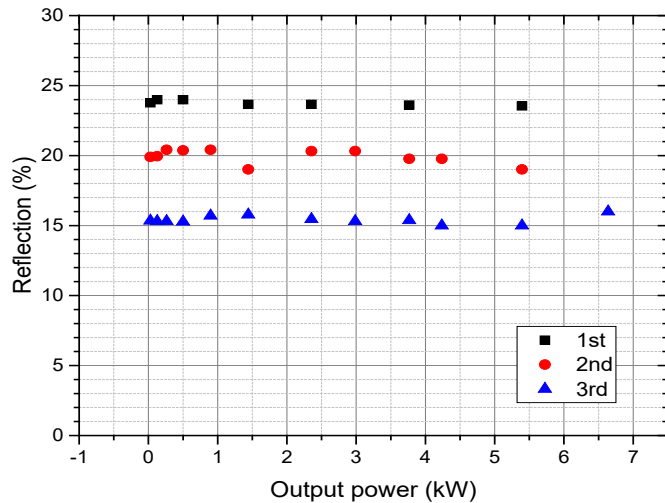


Diagnostic for interlock

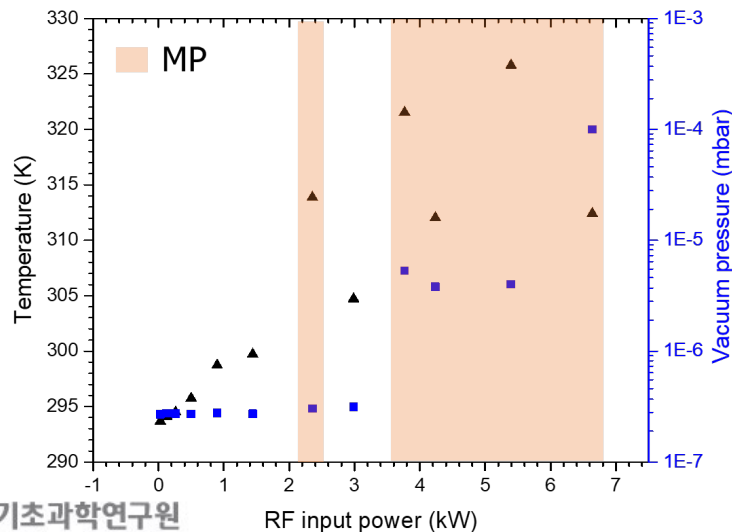


RF power experiment on test bench: results

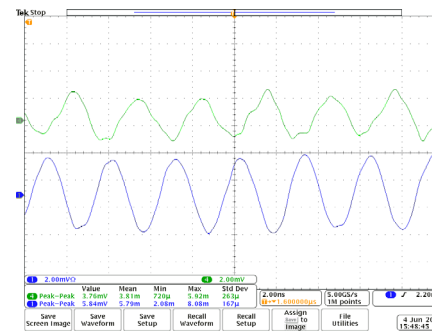
- RF reflection of the test bench (TW mode)
- Temperature variations (SW mode)



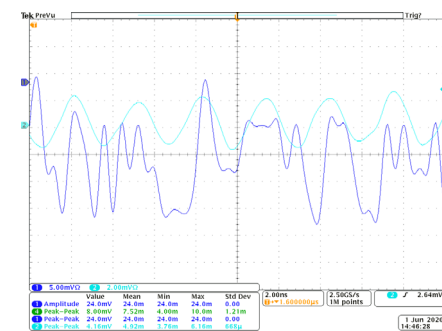
- Variation of max. temperature & vacuum pressure (SW mode)



- Signals of electron pickup probe

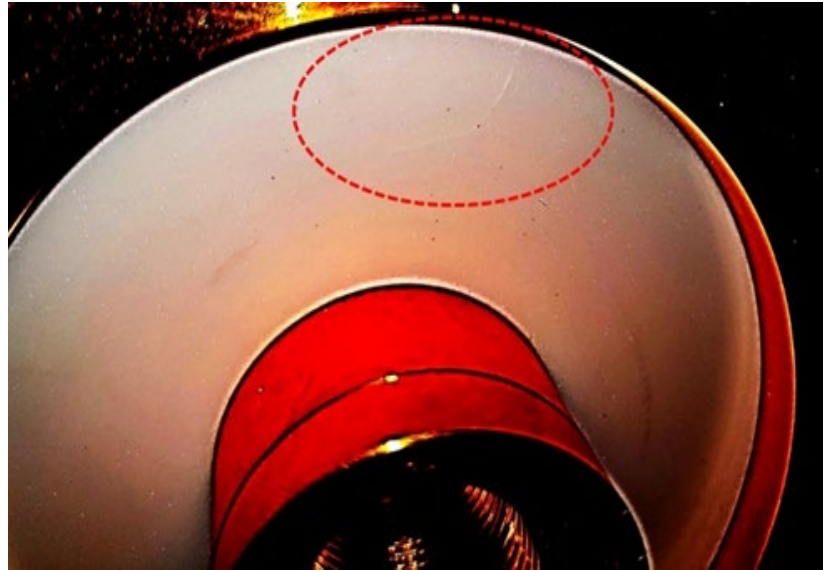


(Normal operation)



(MP activation)

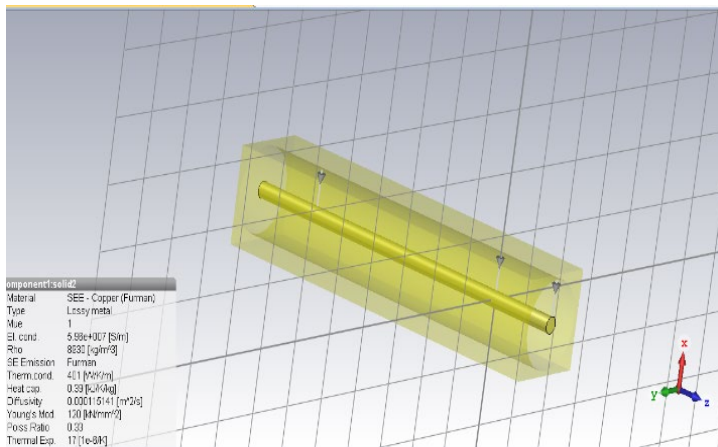
- Long term operation (TW mode)



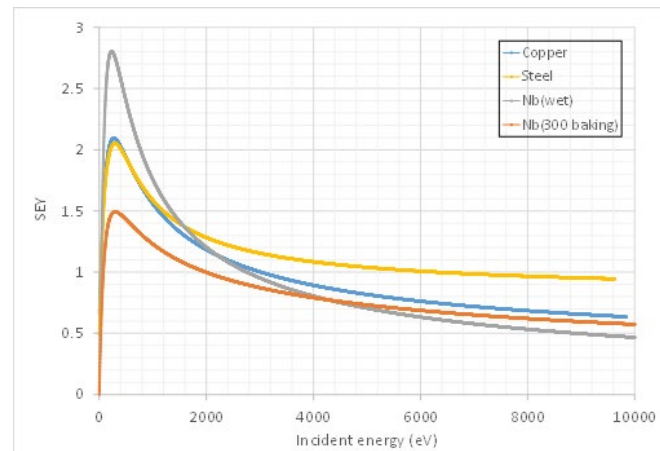
- More than 7 kW continuously in TW mode
- After one hour, a vacuum leakage occurred due to a crack in the RF window
- The temperatures were not saturated
- The temperature of RF window of the 1st coupler was increased to 375 K
-> w/o TiN coating (310 K, saturated with no vacuum leakage)

Numerical calculation & computing simulation for MP(w/o DC offset)

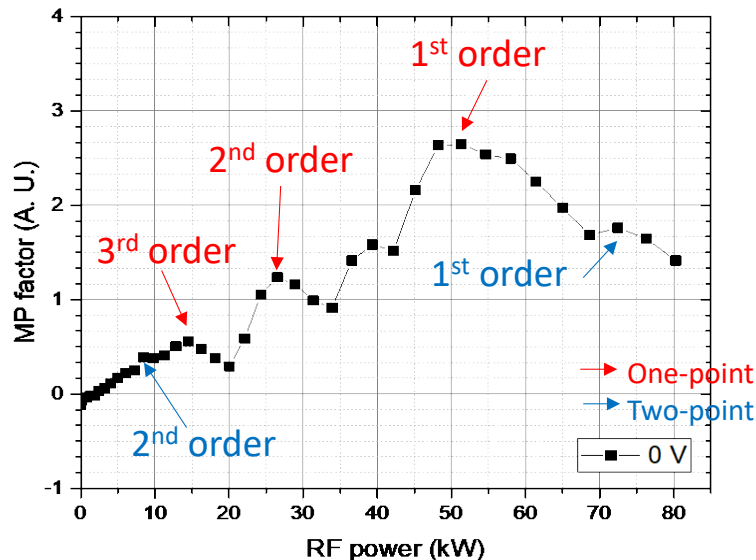
Modeling for MP simulation



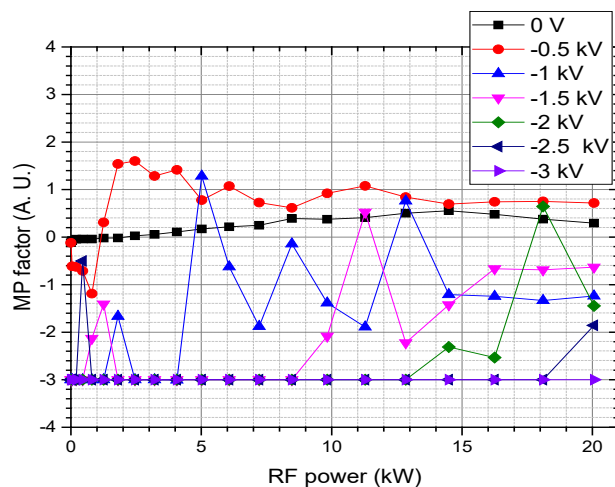
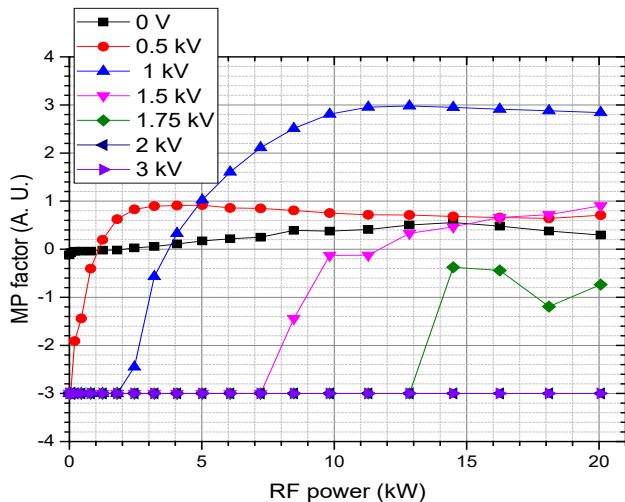
SEY curve



Simulation results of MP factor without DC offset (SW mode)



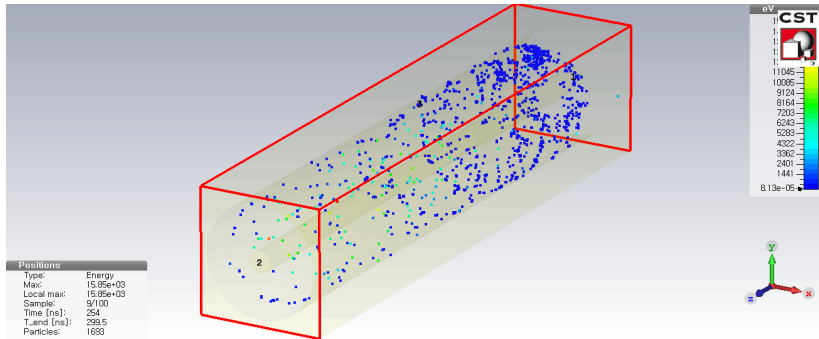
Computing simulation for MP: Results (w/ DC offset)



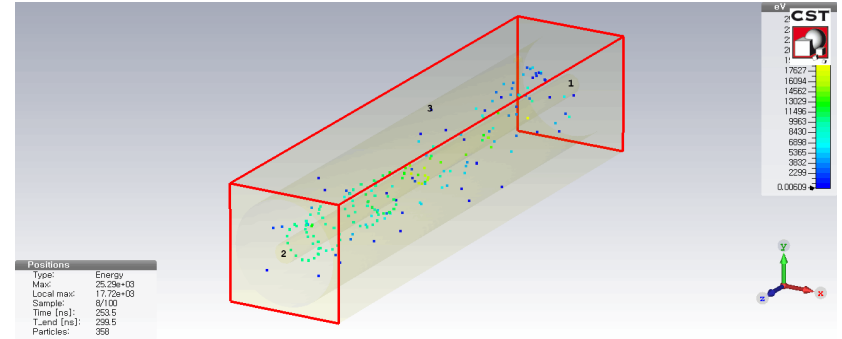
	0 kV	1.75 kV	-2.5 kV
0 ns			
1 cycle			
16 cycle			

- **DC bias with DC block**
 - long term operation(durability test): DC P/S, commercial components
- **Diagnostic for interlock**
 - vacuum gauge: limit $\rightarrow 1\text{E-}7$ mbar?
 - electron pickup probe: position
 - temperature sensor: limit T, $\Delta T/s$
- **Nominal power for SSR2: external Q**
 - cost for RF power system
 - RF control bandwidth

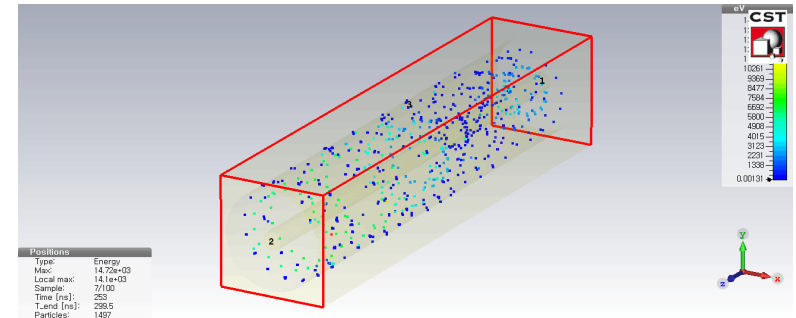
Computing simulation results of electron distribution (SW mode)



0 V

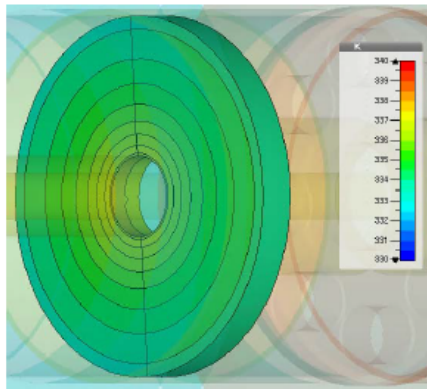
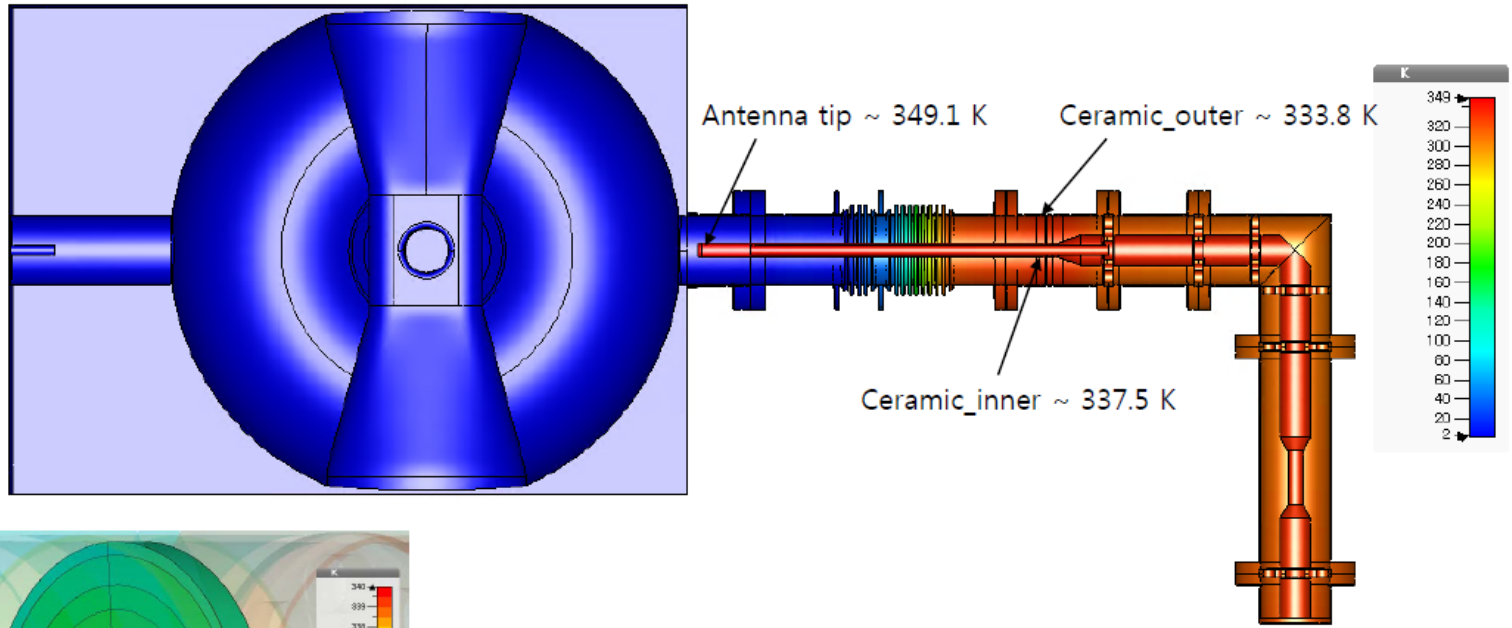


3 kV



-3 kV

Dynamic heat load and temperature distribution - 6 kW full reflection

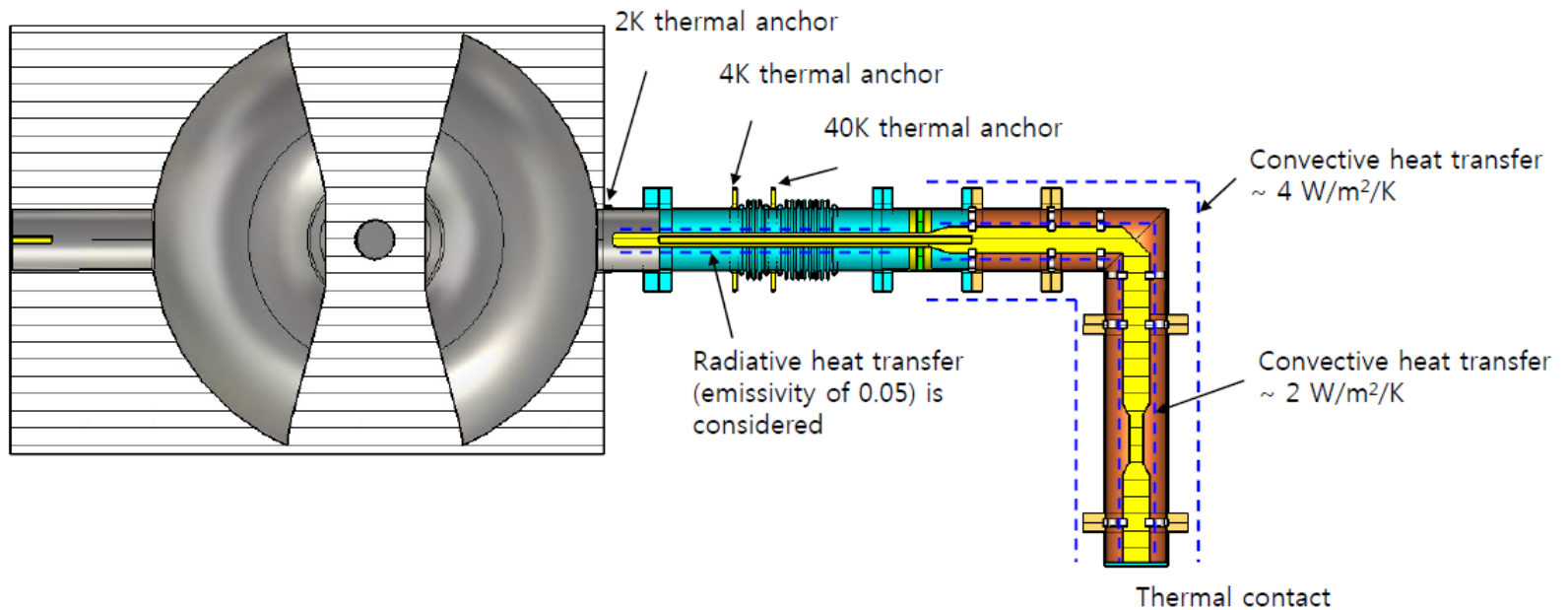


Temperature transition at ceramic window

		Static (0 kW)	Dynamic (6 kW)
Heat load [W]	2K anchor	0.08	1.10
	4K anchor	0.20	0.94
	40K anchor	0.48	0.76
	Total	0.76 (<2 W)	2.8 (<5 W)
Temperature [K]	Antenna tip	298.7	349.1
	Ceramic inner	298.7	337.5
	Ceramic outer	298.4	333.8

Coupler-Bend-Cavity-Thermal-Dynamic-20190408-1.cst

Thermal simulation setup



Conductive heat transfer through cryomodule wall and supporter is not considered.

실제 온도를 측정하여 simulation setup을 보정하는 과정이 필요함