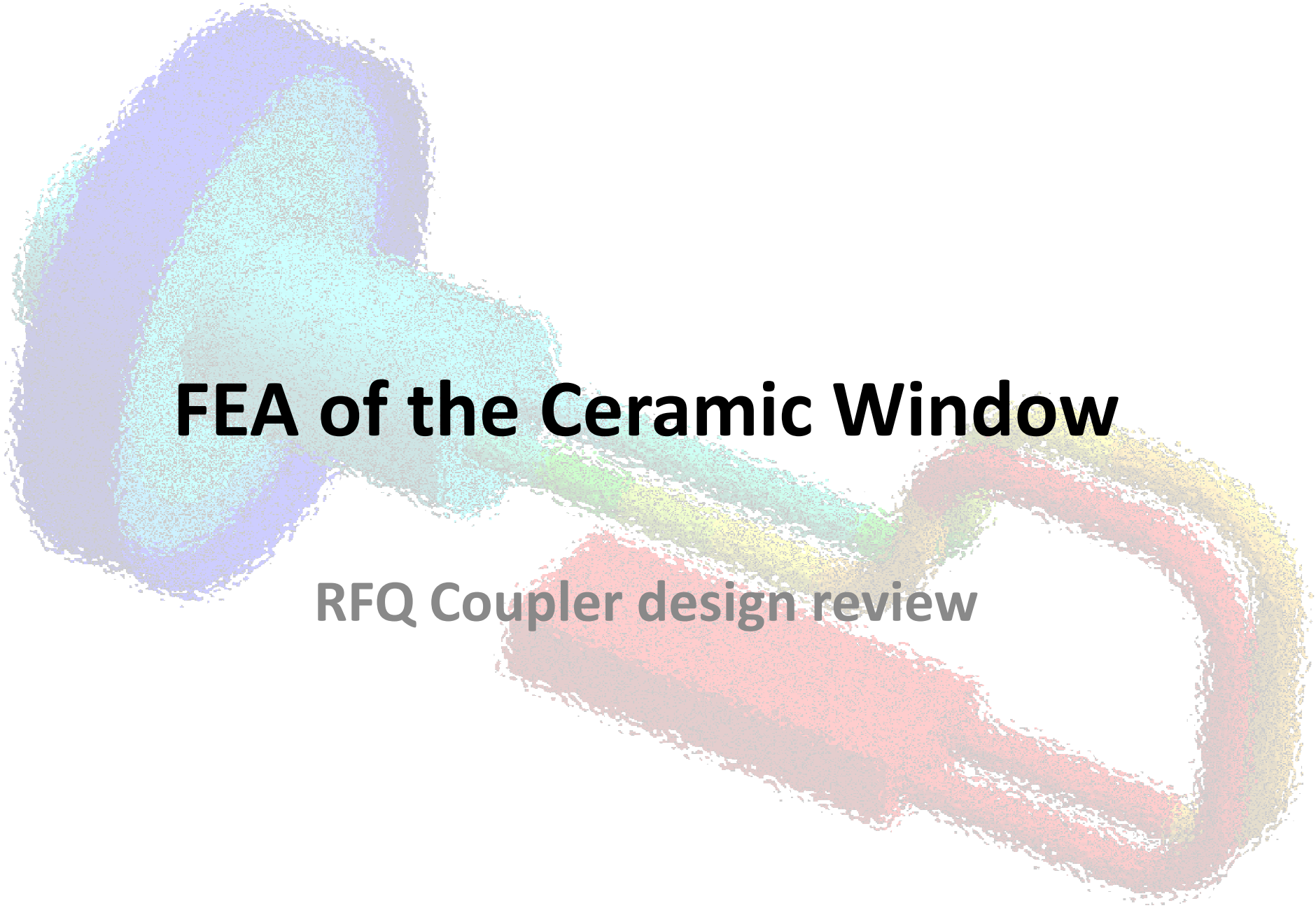


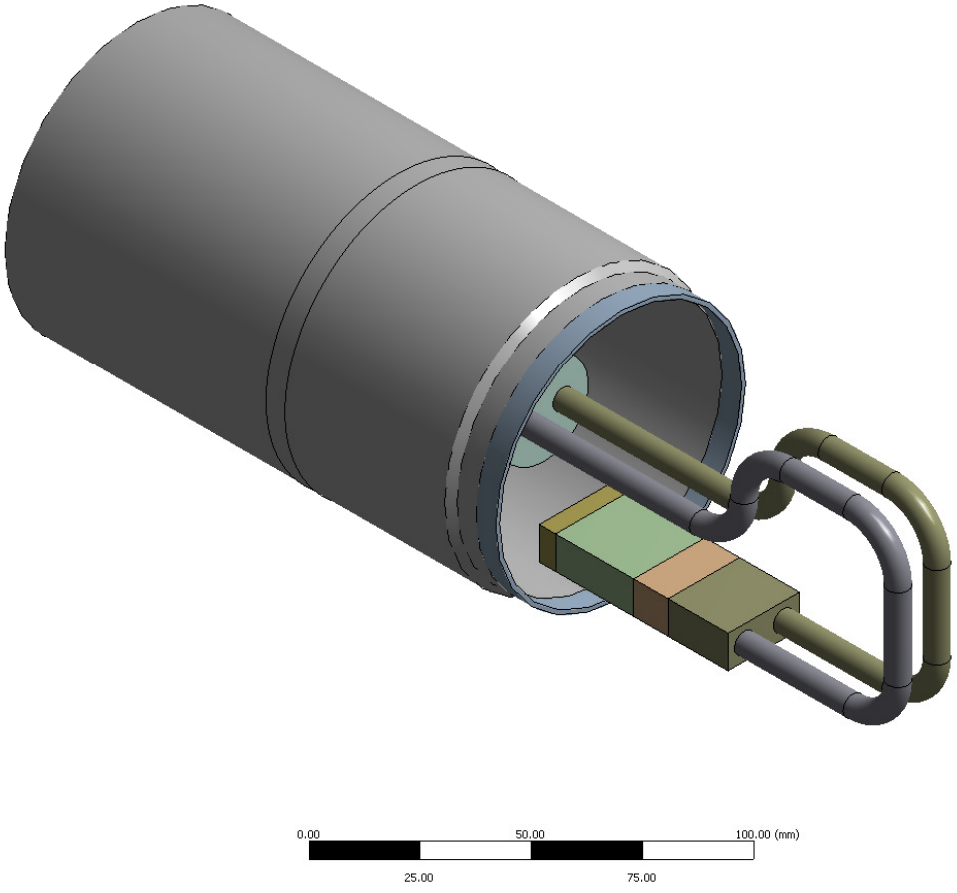
FEA of the Ceramic Window

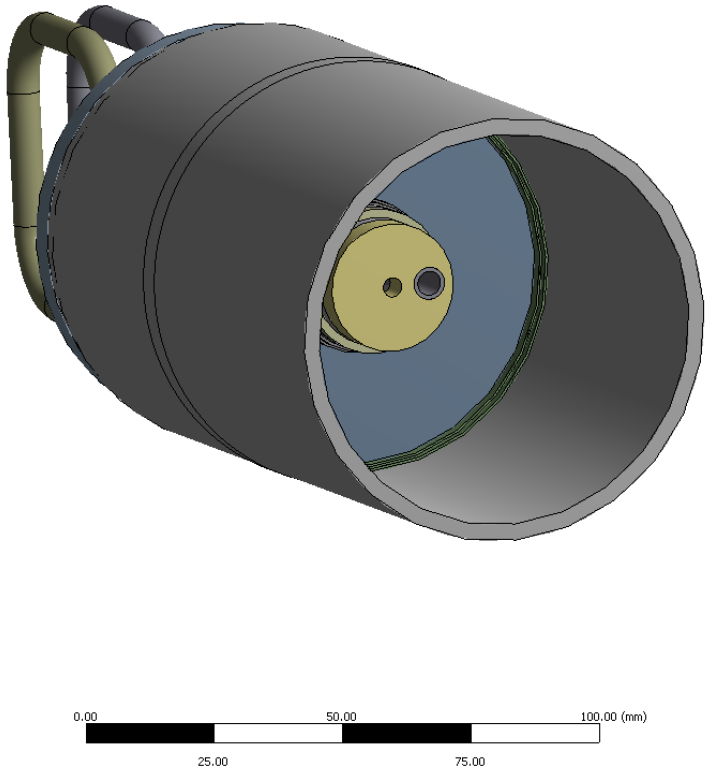
RFQ Coupler design review

Prepared by Valeri Poloubotko

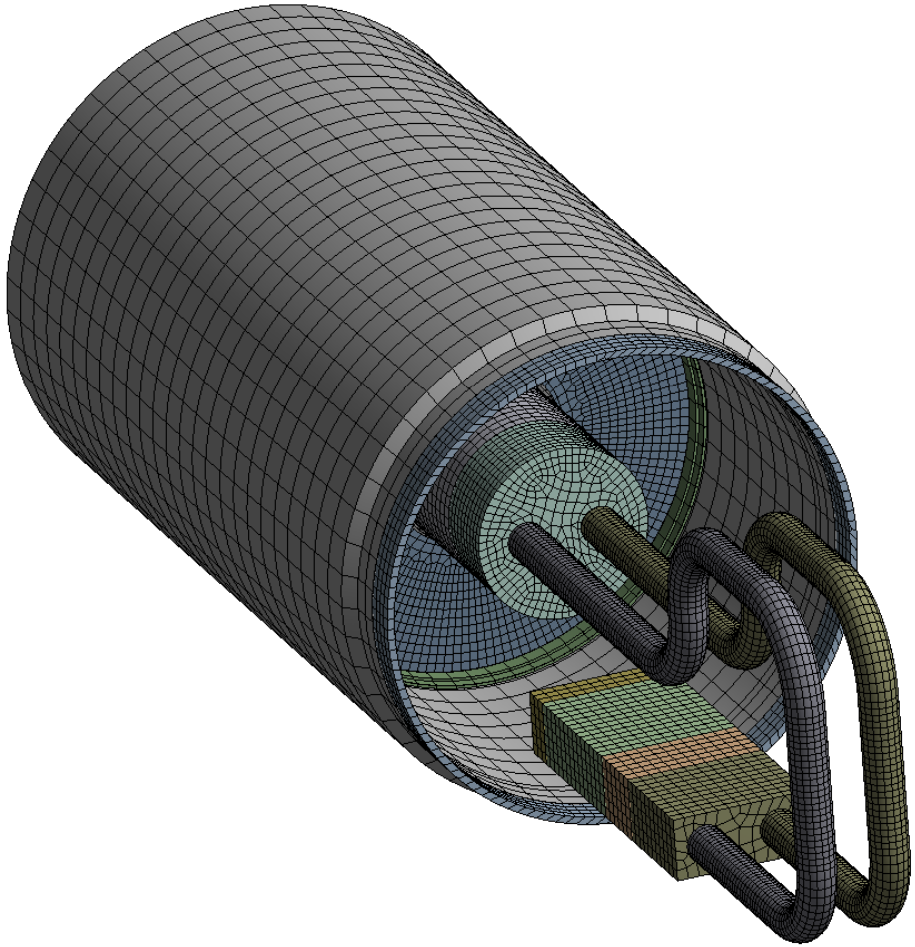
May 21, 2013

FEA Model of the Window Assembly



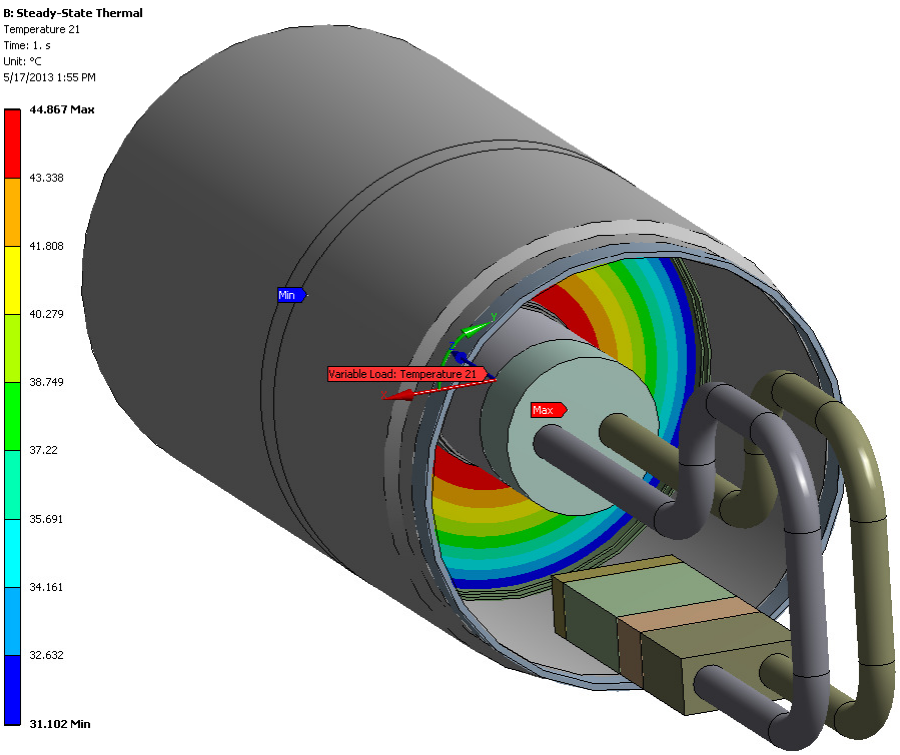


Meshing of the Window Assembly

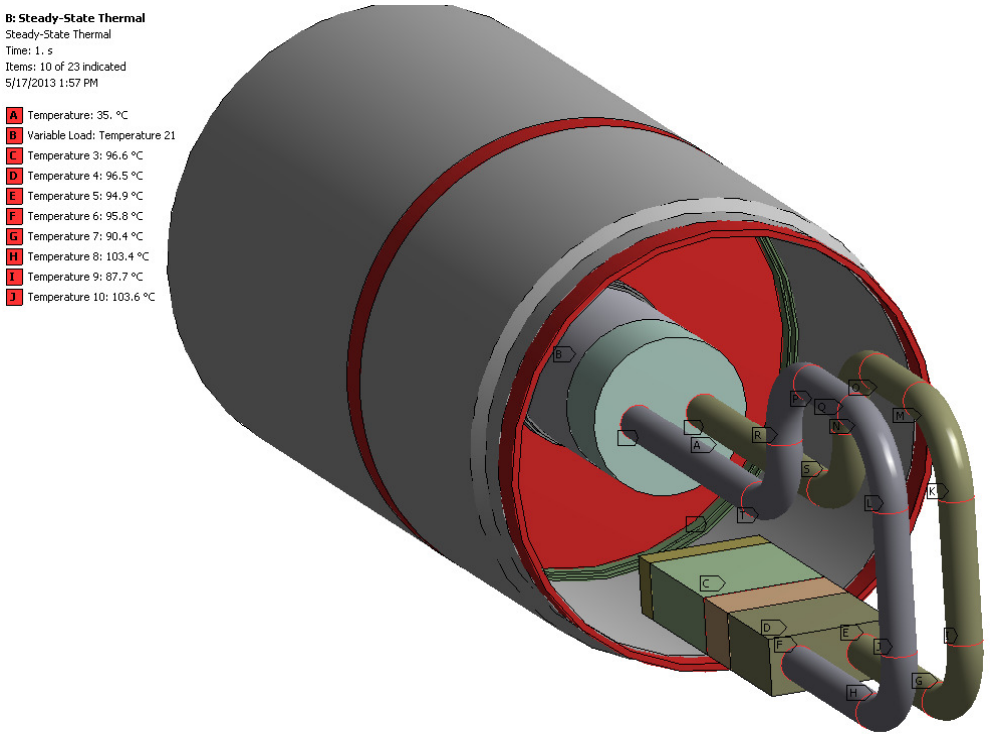


Multizone meshing with individual body sizing

DOE of the Window Assembly

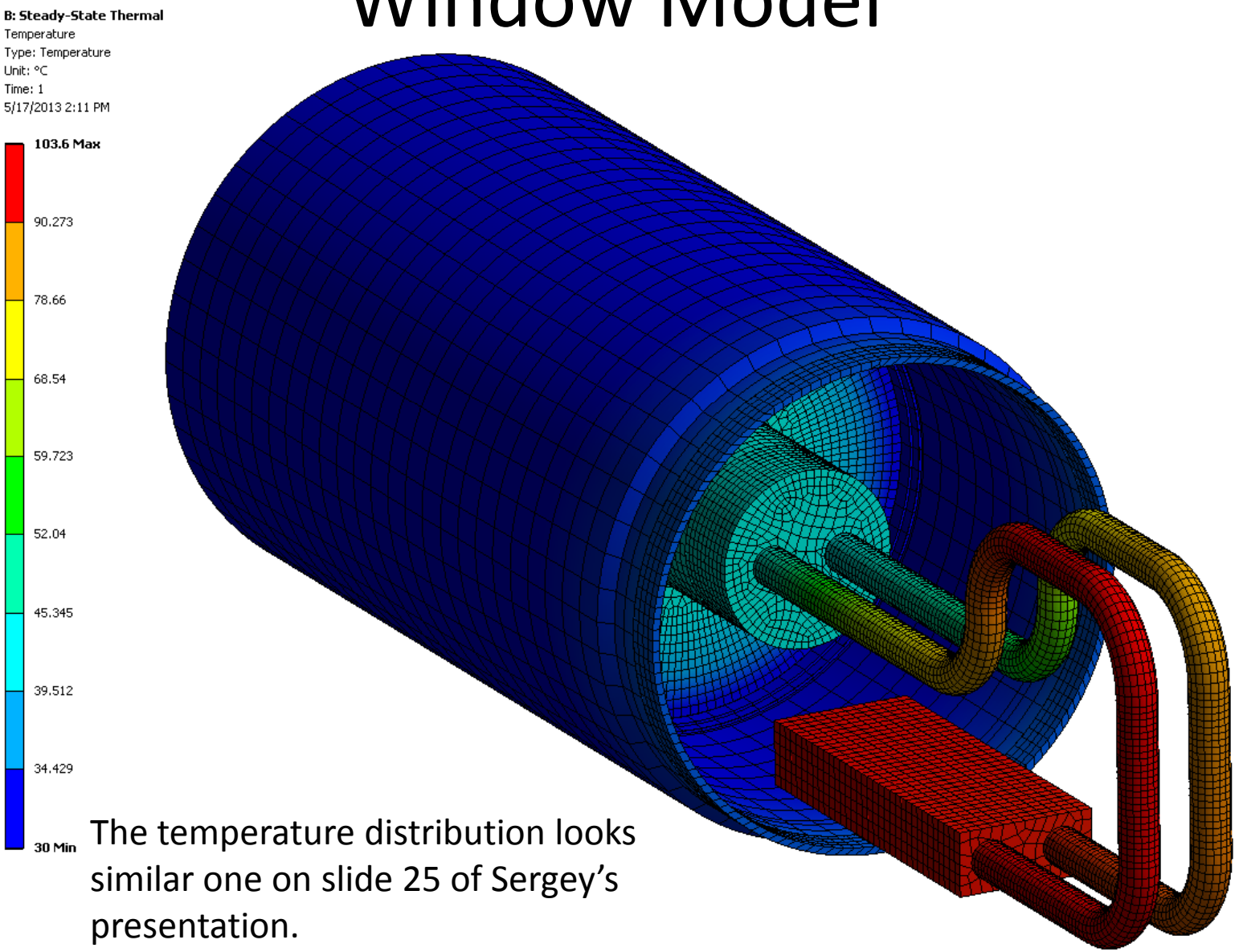


Polynomial (of power 4) temperature distribution in the ceramic window



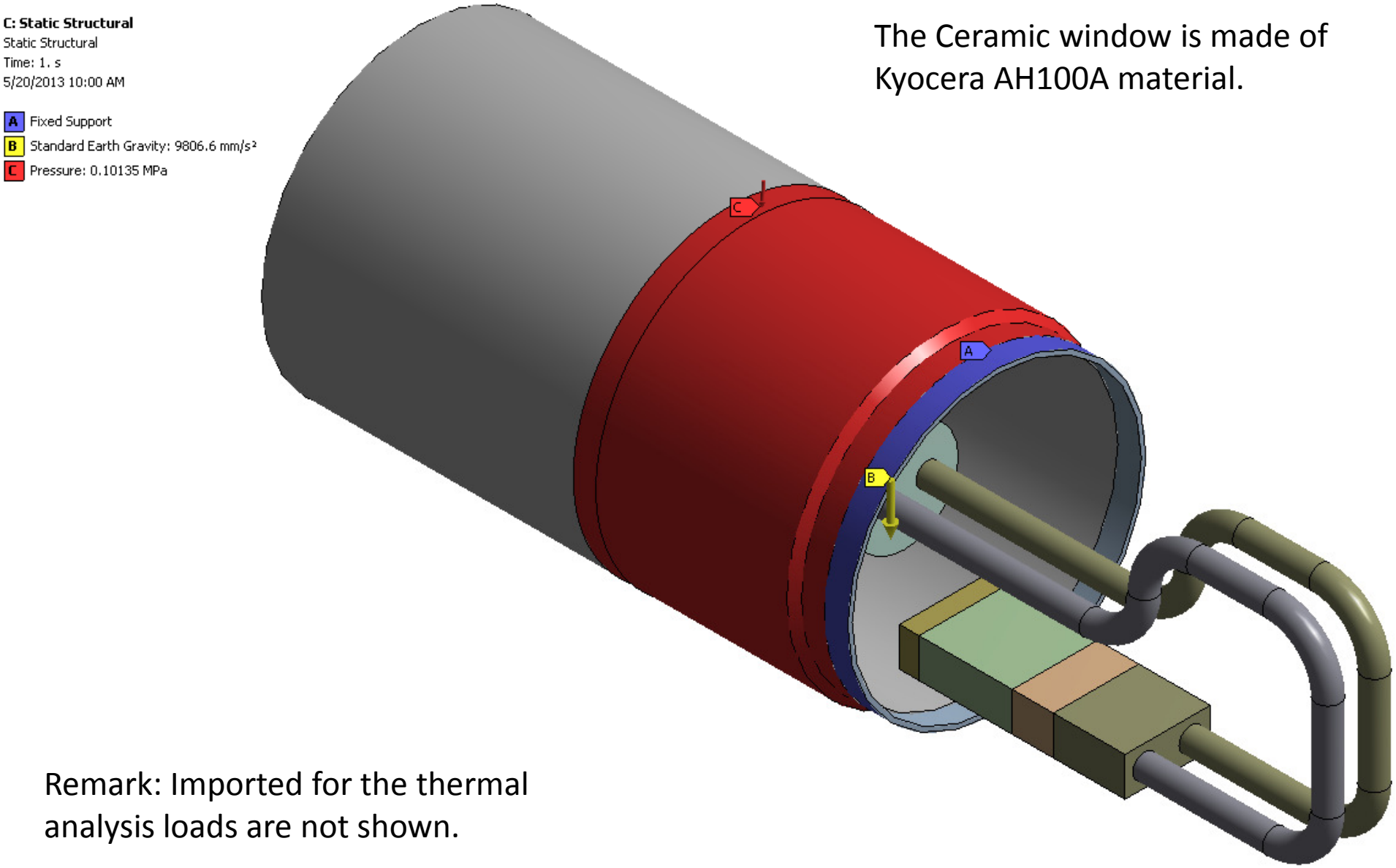
Temperature load in the model (slide 25 of Sergey's presentation)

Temperature Distribution in the Window Model



The temperature distribution looks similar one on slide 25 of Sergey's presentation.

Loads in the Structural Analysis



The Ceramic window is made of Kyocera AH100A material.

Remark: Imported for the thermal analysis loads are not shown.

Window Ceramics

CoorsTek *Amazing Solutions.*®

Properties*		Units	Test	Porcelain	Steatite	Cordierite	Mullite	Alumina AD-85 Nom. 85% Al_2O_3	AD-90 Nom. 90% Al_2O_3	AD-94 Nom. 94% Al_2O_3	AD-96 Nom. 96% Al_2O_3	FG-995 Nom. 98.5% Al_2O_3	AD-995 Nom. 99.5% Al_2O_3	AD-998 Min. 99.8% Al_2O_3
Density		gm/cc	ASTM-C20	2.40	2.78	2.05	2.80	3.42	3.60	3.70	3.72	3.80	3.90	3.92
Crystal Size	Average	MICRONS	THIN-SECTION	–	–	–	10	6	4	12	6	6	6	6
Water Absorption		%	ASTM-373	0	0	9.50	0	0	0	0	0	0	0	0
Gas Permeability		–	–	0	0	–	0	0	0	0	0	0	0	0
Color		–	–	WHITE	BEIGE	YELLOW	TAN	WHITE	WHITE	WHITE	WHITE	WHITE	IVORY	IVORY
Flexural Strength (MOR)	20° C	MPa (psi x 10^3)	ASTM-F417	130 (19)	140	55	170 (25)	296 (43)	338 (49)	352 (51)	358 (52)	375 (54)	379 (55)	375 (54)
Elastic Modulus	20° C	GPa (psi x 10^6)	ASTM-C848	104 (15)	110	40	150 (22)	221 (32)	276 (40)	303 (44)	303 (44)	350 (51)	370 (54)	370 (54)
Poisson's Ratio	20° C	–	ASTM-C848	–	–	–	–	0.22	0.22	0.21	0.21	0.22	0.22	0.22
Compressive Strength	20° C	MPa (psi x 10^3)	ASTM-C773	590 (86)	–	–	550 (80)	1930 (280)	2482 (360)	2103 (305)	2068 (300)	2500 (363)	2600 (377)	2500 (363)
Hardness		GPa (kg/mm^2)	KNOOP 1000 gm	5.9 (600)	–	–	7.4 (750)	9.4 (960)	10.4 (1058)	11.5 (1175)	11.5 (1175)	13.7 (1400)	14.1 (1440)	14.1 (1440)
		R45N	ROCKWELL 45 N	60	57	–	70	73	75	78	78	82	83	83
Tensile Strength	25° C	MPa (psi x 10^3)	ACMA TEST #4	–	–	–	–	155 (22)	221 (32)	193 (28)	221 (32)	248 (36)	262 (38)	248 (36)
Fracture Toughness	K(I c)	Mpa $m^{1/2}$	NOTCHED BEAM	2	–	–	2	3 - 4	3 - 4	4 - 5	4 - 5	4 - 5	4 - 5	4 - 5
Thermal Conductivity	20° C	W/m K	ASTM-C408	5.0	2.5	1.6	3.5	16.0	16.7	22.4	24.7	27.5	30.0	30.0
Coefficient of Thermal Expansion	25-1000° C	1X 10^{-6}/°C	ASTM-C372	4.9	9	3.4	5.3	7.2	8.1	8.2	8.2	8.2	8.2	8.2
Specific Heat	100° C	J/kg*K	ASTM-E1269	–	–	–	950	920	920	880	880	880	880	880
Thermal Shock Resistance	ΔTc	°C	❶	–	100	350	300	300	250	250	250	200	200	200
Maximum Use Temperature		°C	NO-LOAD COND.	1400	1200	1200	1700	1400	1500	1700	1700	1700	1750	1750
Dielectric Strength	6.35mm	ac-kV/mm (ac V/mil)	ASTM-D116	–	–	–	9.8 (248)	9.4 (240)	8.3 (210)	8.3 (210)	8.3 (210)	8.7 (220)	8.7 (220)	8.7 (220)
Dielectric Constant	1 MHz	25° C	ASTM-D150	5.9	–	–	6.0	8.2	8.8	9.1	9	9.6	9.7	9.8
Dielectric Loss (tan delta)	1 MHz	25° C	ASTM-D150	0.0024	–	–	0.002	0.0009	0.0004	0.0004	0.0002	0.0002	0.0001	< 0.0001
Volume Resistivity	25° C	ohm-cm	ASTM-D1829	–	10^{13}	10^{12}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}	> 10^{14}
	500° C	ohm-cm	ASTM-D1829	–	10^8	10^6	4 x 10^5	4 x 10^8	4 x 10^8	4 x 10^9	4 x 10^9	2 x 10^{10}	2 x 10^{10}	2 x 10^{10}
	1000° C	ohm-cm	ASTM-D1829	–	–	–	–	–	5 x 10^5	5 x 10^5	1 x 10^6	2 x 10^6	2 x 10^6	2 x 10^7
Impingement		–	❷	–	–	–	–	1.00	0.45	0.52	0.50	0.48	0.47	0.47
Rubbing		–	❷	–	–	–	–	1.00	0.36	–	0.60	–	–	–

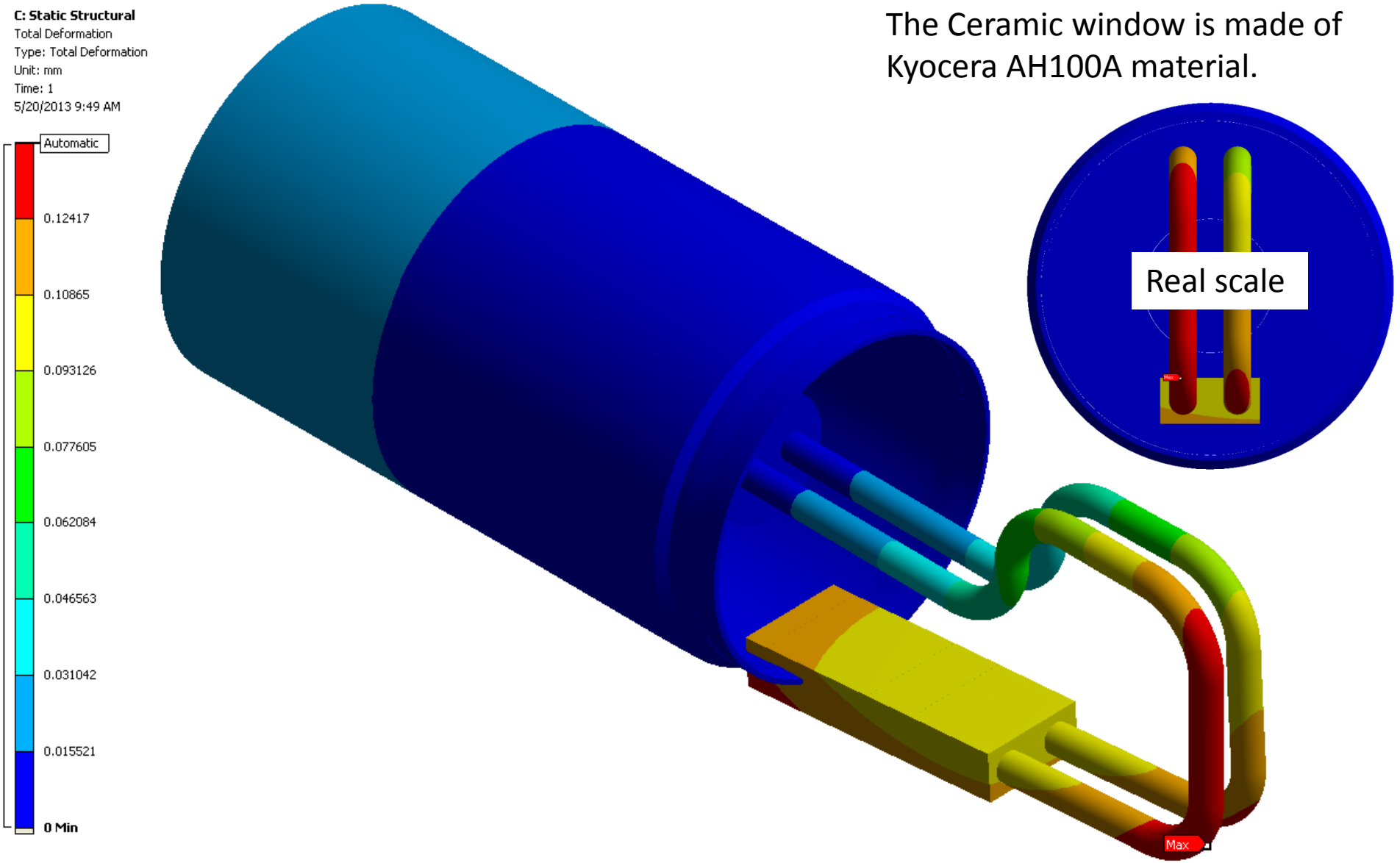
Window Ceramics

MATERIAL PROPERTIES for Antenna

KYOCERA

ITEMS	UNIT	CUSTOMER' s REQUEST	PROPOSED CERAMIC MATERIAL	
KYOCERA MATERIAL No.	--	--	A479B	AH100A
APPLICATION	--	--	RF EQUIPMENT	HIGH VOLTAGE
METALLIZATION	--	Mo/Mn + Ni Plating	Mo/Mn+ Ni Plating Ag-Cu-Ti + Ni Plating	Ag-Cu-Ti +Ni Plating
BRAZING ATMOSPHERE	--	NO REQUEST	N2/H2 VACUUM	VACUUM
BRAZING MATERIAL	--	NO REQUEST	Ag-Cu / Cu / Au-Cu	Ag-Cu
Al2O3 PURITY	%	99.5MIN.	99.8	97
SEE Coefficient (Max.)	—	NO REQUEST	11.5	5.7
FLEXUAL STRENGTH	*MPa*	NO REQUEST	300	359
YOUNG'S MODULUS	*GPa*	NO REQUEST	370	386
POISSON'S RATIO	—	NO REQUEST	0.23	0.25
VOLUME RESISTIVITTY	*Ohm*cm*	NO REQUEST	$>10^{14}$	$>10^{14}$
DIELECTRIC CONSTANT (1MHz)	—	9.8 +0.2/-0.4	9.9	10.9
Tan Delta (@1MHz)	*($\times10^{-4}$)*	*$<10^{-4}$ at R.oom Temperature*	0.4 (@8GHz) circular cavity	2X (10GHz)
CTE	*$\times10^{6}$/deg C*	NO REQUEST	7	7.4
THERMAL CONDUCTIVITY	*W/(mK)*	NO REQUEST	29	24

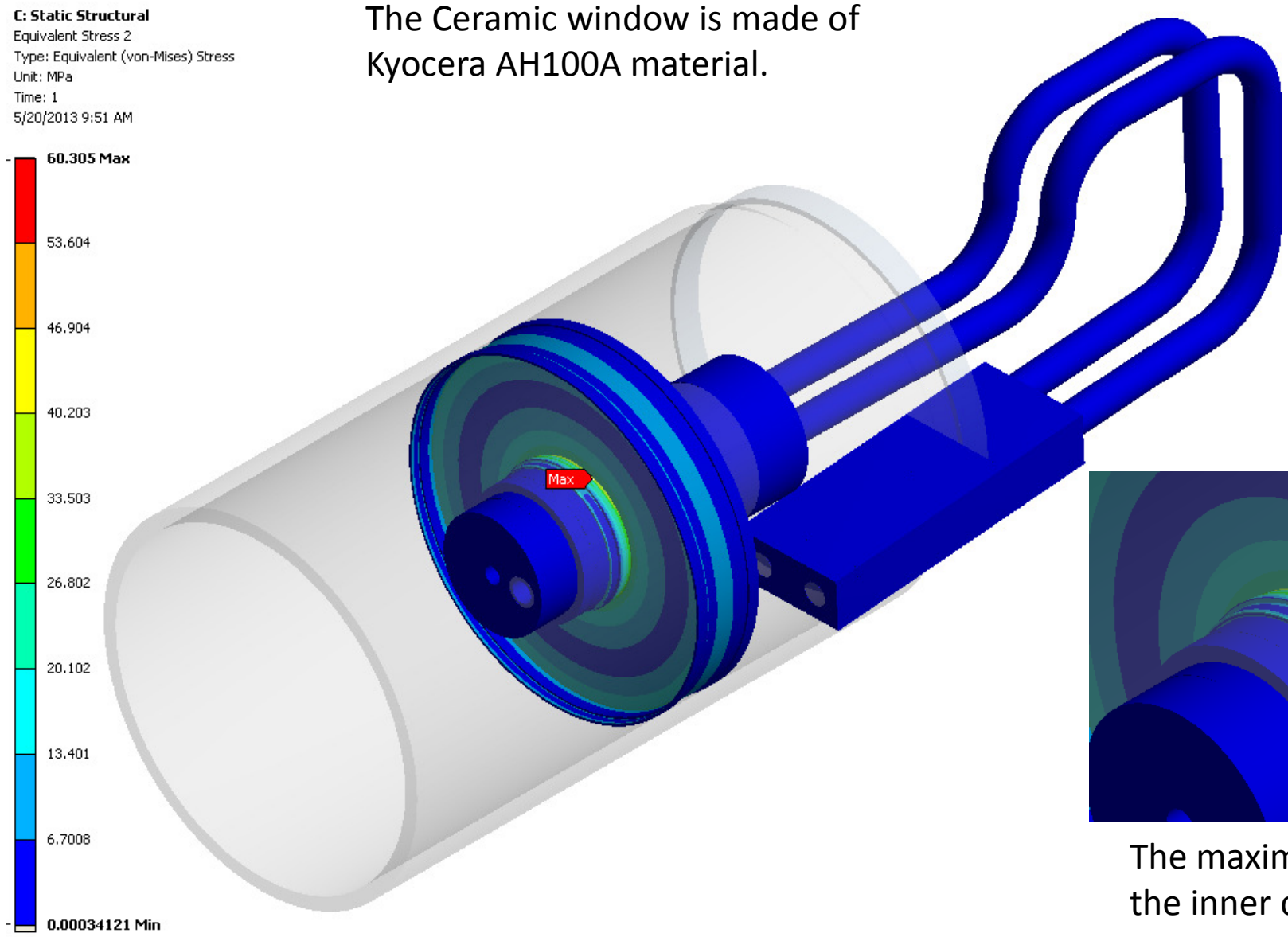
The Model Deformation

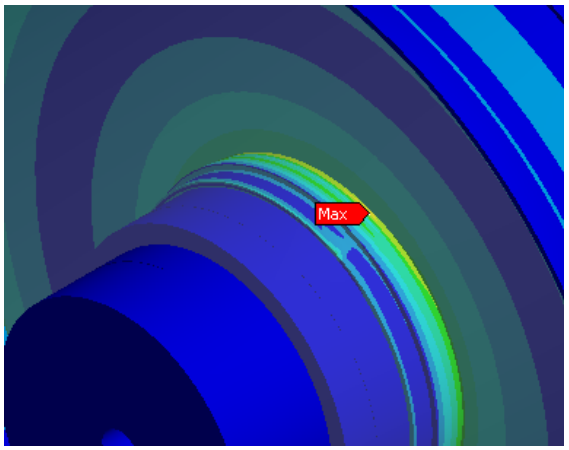


The Ceramic window is made of Kyocera AH100A material.

Equivalent Stress in the Model

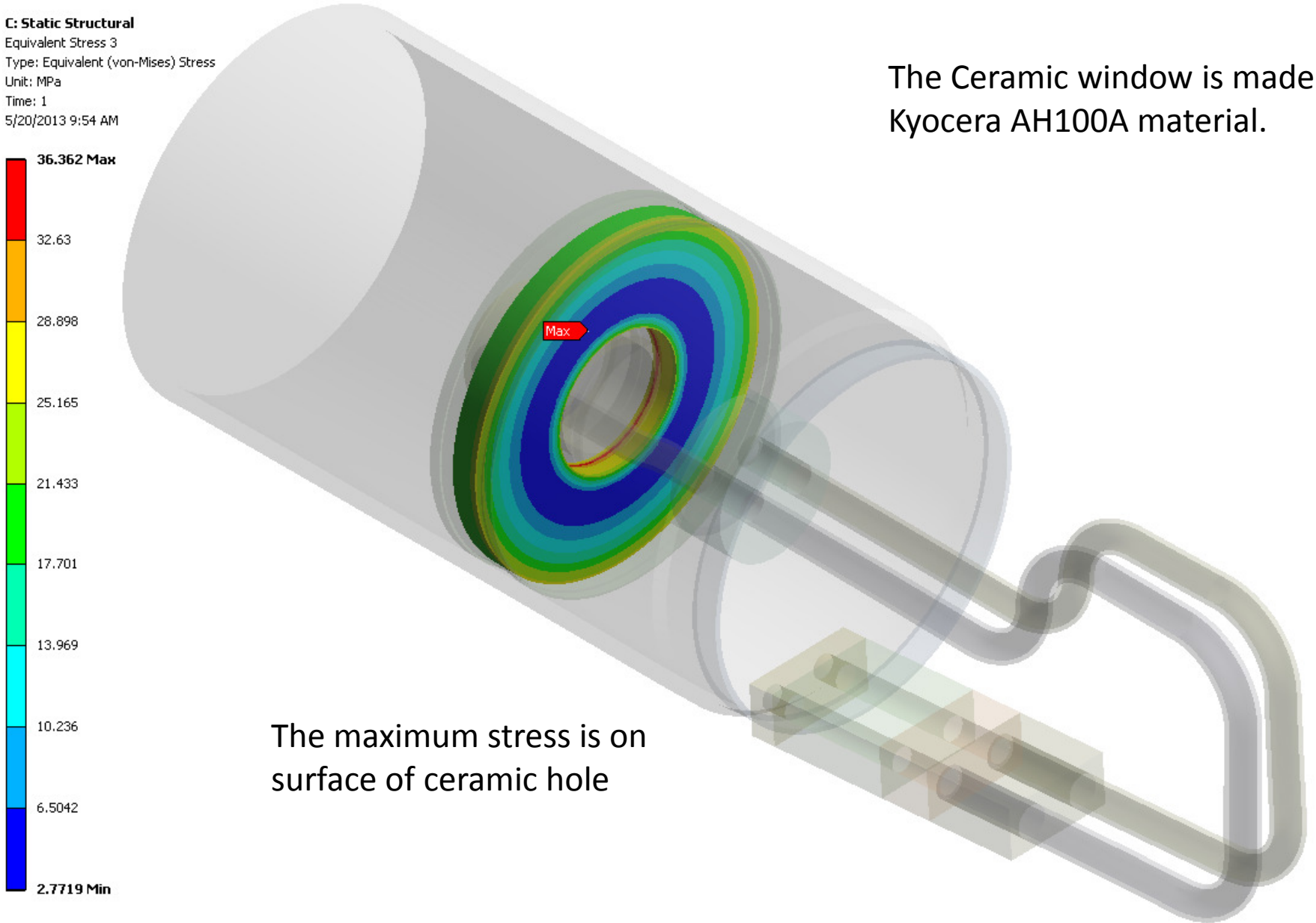
The Ceramic window is made of Kyocera AH100A material.





The maximum stress in the inner copper sleeve

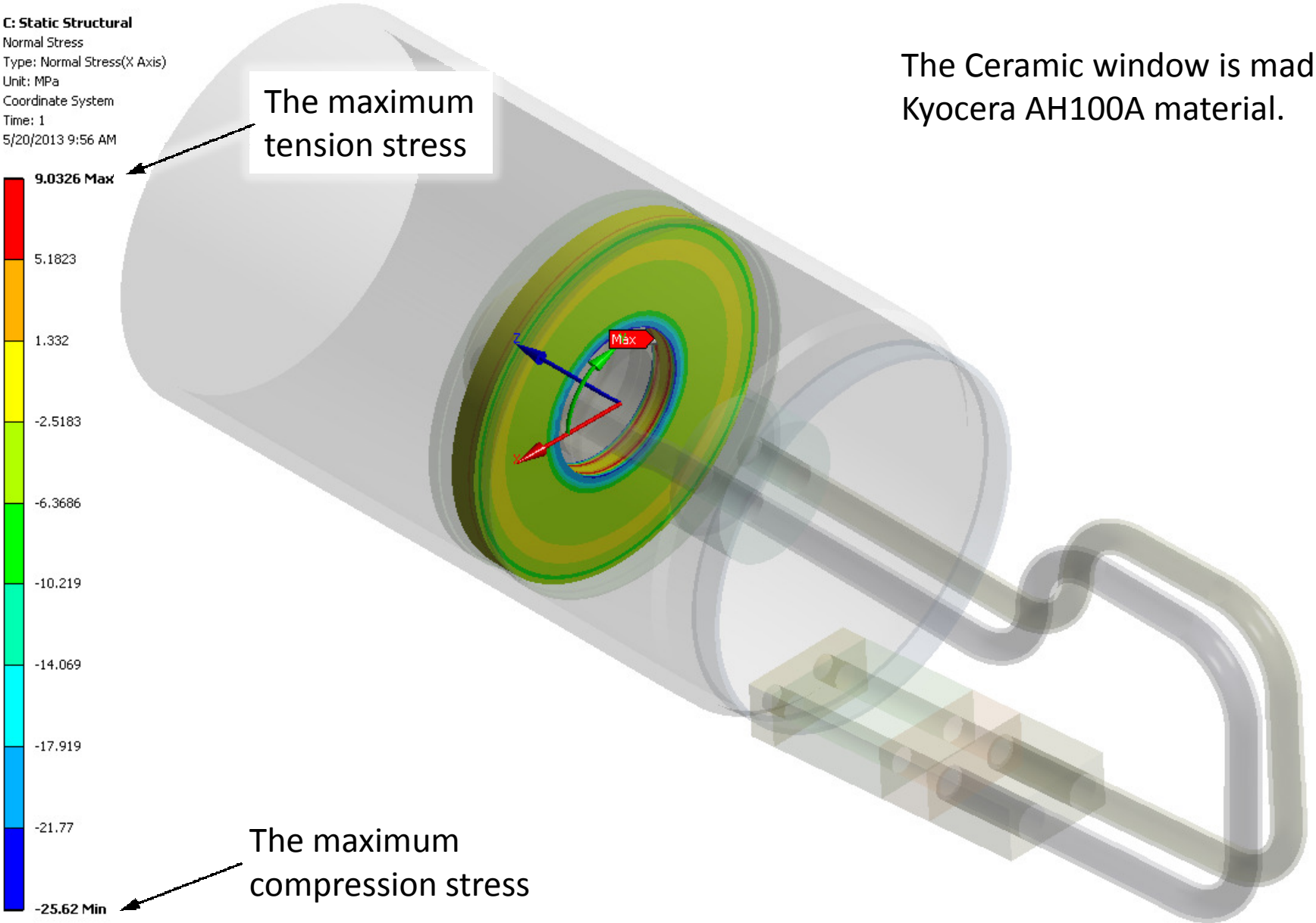
Equivalent Stress in the Ceramic Window



The Ceramic window is made of Kyocera AH100A material.

The maximum stress is on surface of ceramic hole

Radial Stress in the Ceramic Window



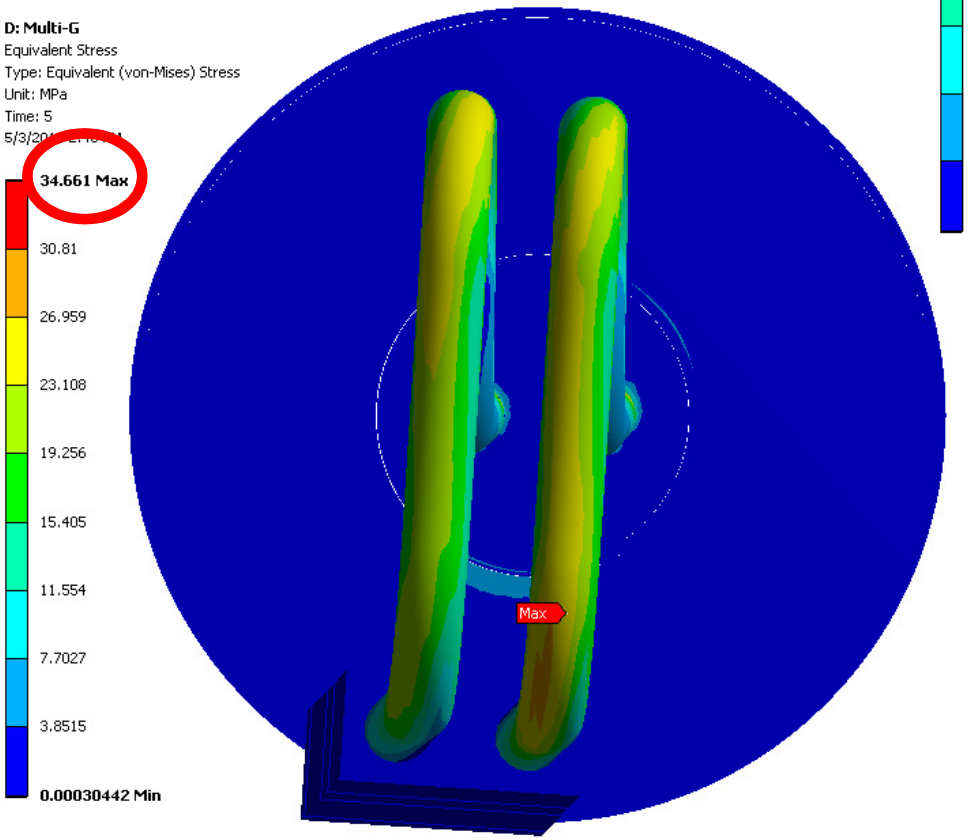
The maximum tension stress

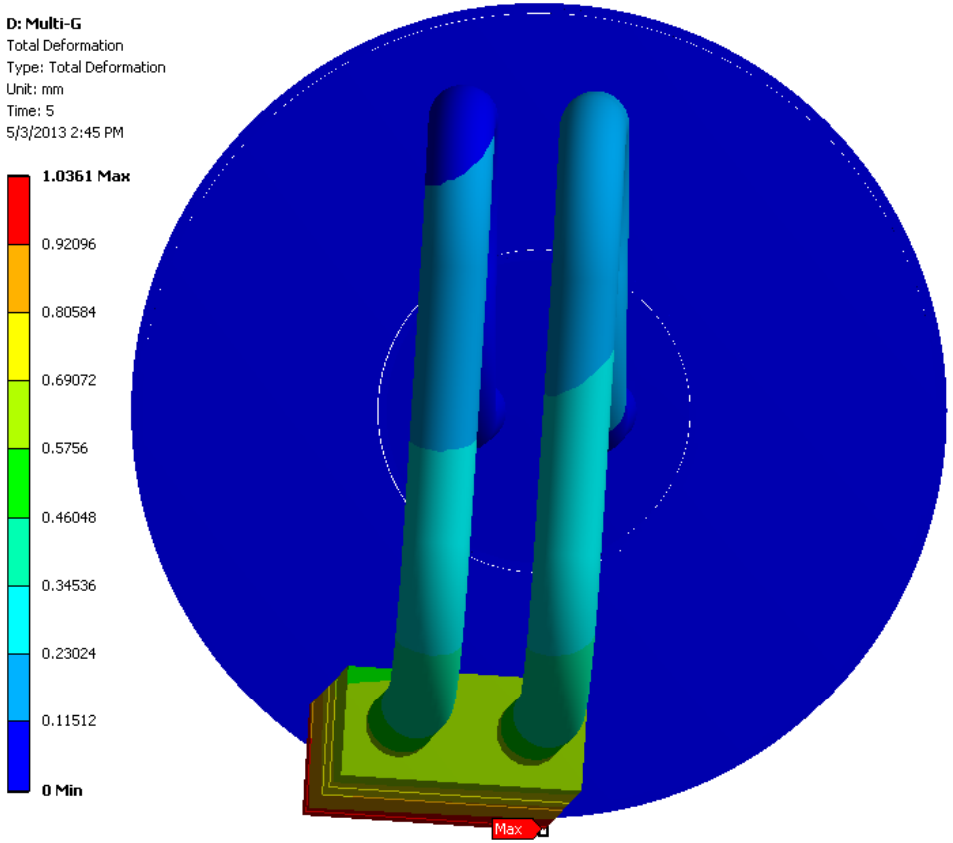
The maximum compression stress

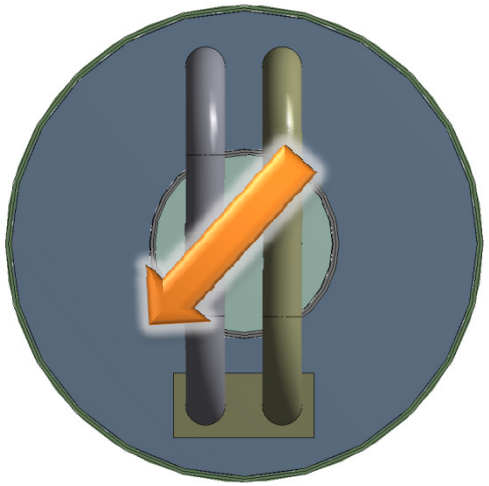
The Ceramic window is made of Kyocera AH100A material.

Coupler Transportation

The Ceramic window is made of Kyocera AH100A material.



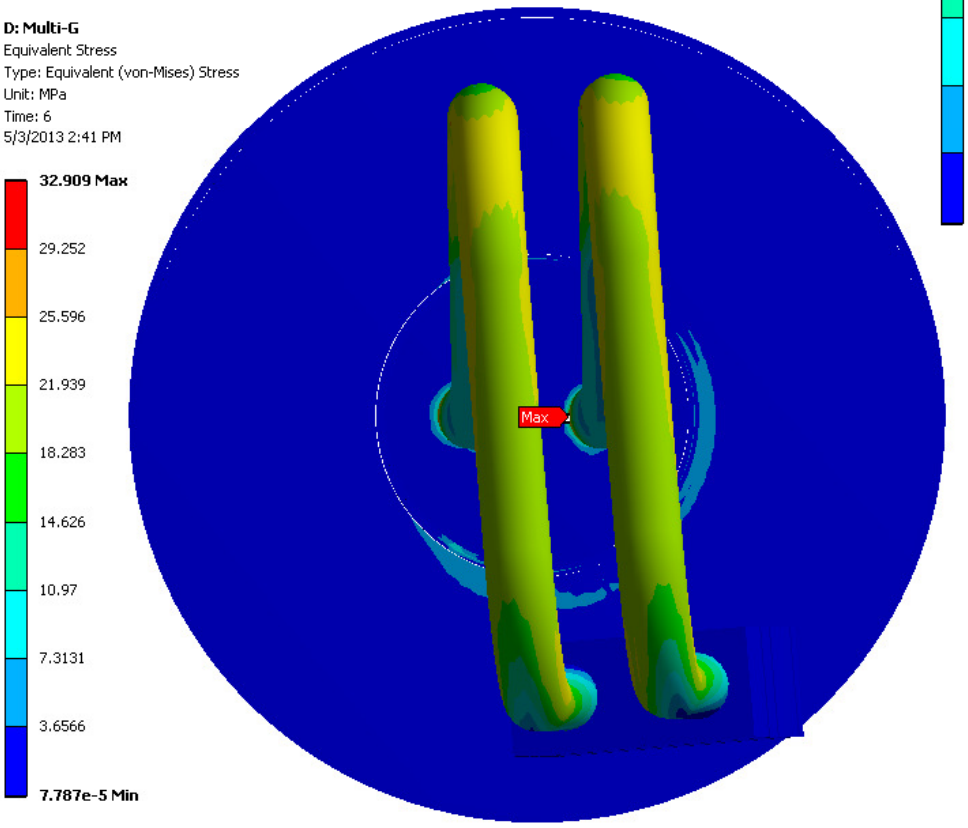


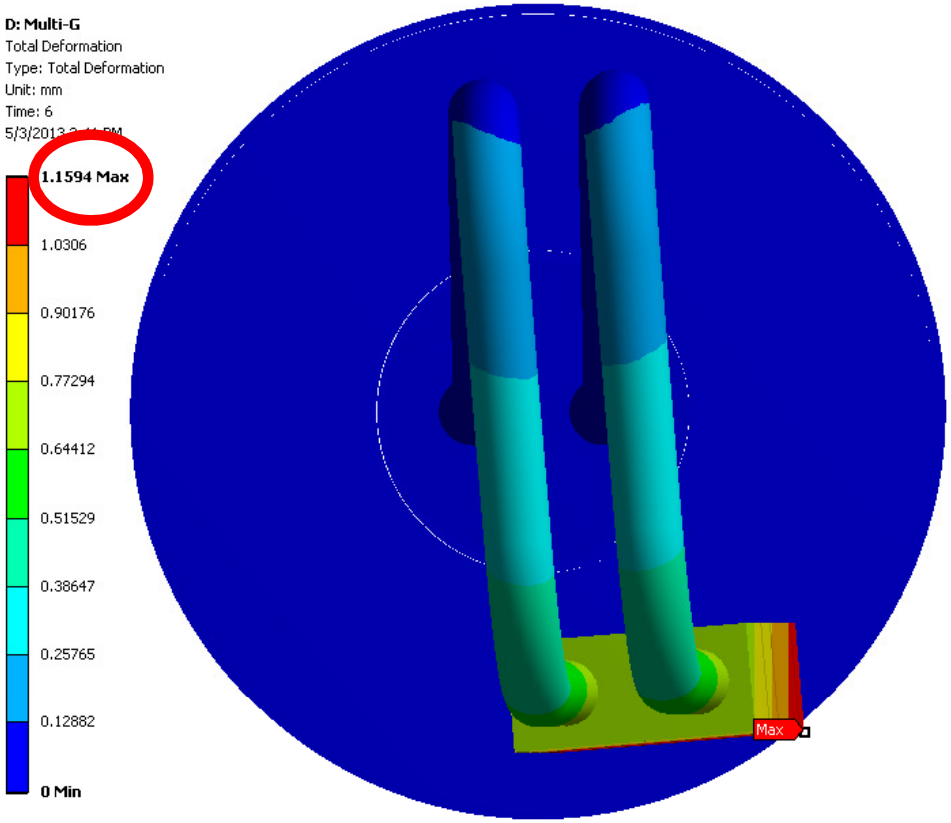


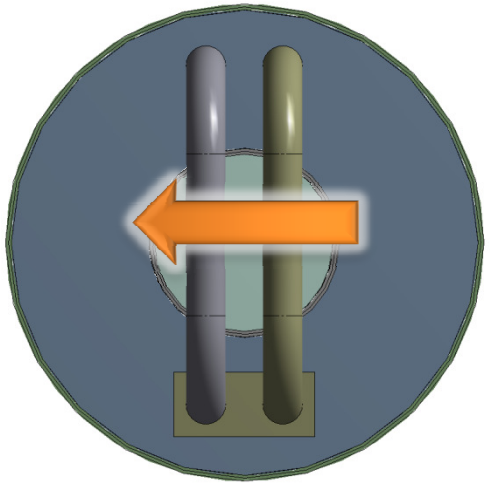
10G load

Coupler Transportation

The Ceramic window is made of Kyocera AH100A material.







10G load

Thank you

Prepared by Valeri Poloubotko

May 21, 2013