

SCT end-cap module - Materials

Peter Kodyš^{a1}

^aIPNP, Charles University, Prague, Czech Republic

1 Material Of Components Setting In Athena Framework

1.1 Basic Material Mixtures

There is set of materials using for building of real end cap SCT modules. Following tables contain using obvious usual names of materials, elements of material and their part by volume and by mass in %. In tables is also mass of average atom. Basic source of mass of materials is [1].

¹peter.kodyš@mff.cuni.cz

Glass D263 Schott GmbH				
Material	vol %	Element	vol %	mass %
SiO2	64.1	Si	21.37	27.43
B2O3	8.4	B	3.36	1.66
Al2O3	4.2	Al	1.68	2.07
Na2O	6.4	Na	4.27	4.48
K2O	6.9	K	4.60	8.22
ZnO	5.9	Zn	2.95	8.82
TiO2	4.0	Ti	1.33	2.92
Sb2O3	0.1	Sb	0.04	0.22
		O	60.40	44.17
Summa			100.00	100.00
		Average atom:	21.88	

Table 1: Glass D263 based of information from manufacturer Schott GmbH, mainly used for dummy far detectors of short middle modules as mechanical stabilization and for fun-inns between detectors and hybrid chips.

Kapton (polyimid)			
Element		vol %	mass %
C	22.0	56.41	69.11
H	10.0	25.64	2.64
N	2.0	5.13	7.33
O	5.0	12.82	20.92
Summa	39.0	100.00	100.00
		Average atom:	9.80

Table 2: Kapton (polyimid) as a basic material of hybrid flex with 5 layers of Cu.

1.2 Detector Materials

Detector material using for building of real end cap SCT modules was silicon with some covers and alumina strips and interconnected with alumina bonds. Only middle short module contain next material used for far dummy detector from glass as mechanical stabilization of module.

1.3 Sub-Spine Materials

Sub-spine material was aluminum nitride with main function of mechanical stabilization of module. All types have sub-spines on hybrid side and on far side and except inner type also in middle of detectors. Next function of sub-spines is conductive interconnection of backplanes of detectors for sharing of bias voltage (used conductive glue for this).

Adhesive, screen epoxy, araldite 2011, plastic (phenol epoxies C6 H6 O)			
Element		vol %	mass %
C	6.0	46.15	76.57
H	6.0	46.15	6.43
O	1.0	7.69	17.00
Summa	13.0	100.00	100.00
		Avarage atom:	7.24

Table 3: Epoxy (call also as adhesive, screen epoxy, araldite 2011, plastic) is phenol epoxy C6 H6 O

EotiteP102, AIT (electrically conducting glues, epoxy + silver)			
Element		vol %	mass %
C	6.0	44.55	49.88
H	6.0	44.55	4.19
O	1.0	7.43	11.07
Ag	0.5	3.47	34.86
Summa	13.5	100.00	100.00
		Avarage atom:	10.73

Table 4: EotiteP102 or AIT is conductive glue contained from epoxy and silver

Elastosil (silicone rubber, Si H2)			
Element		vol %	mass %
Si	1.0	33.33	93.30
H	2.0	66.67	6.70
Summa	3.0	100.00	100.00
		Avarage atom:	10.03

Table 5: Elastosil is silicon rubber contain from Si and H

FR4 (epoxy and glass in the ratio 44:56 by volume)				
Material	Part %	Element	vol %	mass %
Epoxy	44.0	C	20.31	15.80
		H	20.31	1.33
		O	3.38	3.51
Glass	56.0	Si	11.97	21.77
		B	1.88	1.32
		Al	0.94	1.64
		Na	2.39	3.56
		K	2.58	6.52
		Zn	1.65	7.00
		Ti	0.75	2.32
		Sb	0.02	0.18
		O	33.83	35.06
		Summa		
		Avarage atom:	15.44	

Table 6: FR4 is a composition of epoxy and glass

Sn/Pb			
Element		vol %	mass %
Sn	1.0	50.00	36.42
Pb	1.0	50.00	63.58
Summa	2.0	100.00	100.00
		Avarage atom:	162.96

Table 7: Sn/Pb composite

AlN (aluminium nitride)			
Element		vol %	mass %
Al	1.0	50.00	65.83
N	1.0	50.00	34.17
Summa	2.0	100.00	100.00
		Avarage atom:	20.49

Table 8: AlN (aluminium nitride) used for sub-spines made

Al2O3			
Element		vol %	mass %
Al	2.0	40.00	52.92
O	3.0	60.00	47.08
Summa	5.0	100.00	100.00
		Avarage atom:	20.39

Table 9: Al2O3

Detectors - material summary						
	Outer	Middle long	Middle short			Inner
Material	Weight [g]	Weight [g]	Weight [g]	mass %	vol %	Weight [g]
Silicon	10.53	10.41	5.34	49.89	43.68	4.12
Glass D263	0.00	0.00	5.36	50.11	56.32	0.00
Summa	10.53	10.41	10.70	100.00	100.00	4.12

Table 10: Detectors material description - especially middle short type with far glass dummy for mechanical stabilization.

Detectors - summary of all materials			
	Middle short		
Element	Weight [g]	mass %	vol %
Si	6.81	63.64	55.71
B	0.09	0.83	1.89
Al	0.11	1.04	0.95
Na	0.24	2.25	2.40
K	0.44	4.12	2.59
Zn	0.47	4.42	1.66
Ti	0.16	1.46	0.75
Sb	0.01	0.11	0.02
O	2.37	22.14	34.02
Summa	10.70	100.00	100.00

Table 11: Summary of all materials in middle short type of EC SCT modules.

Sub-spines - material summary			
	Outer	Middle long and short	Inner
Material	Weight [g]	Weight [g]	Weight [g]
AlN	2.04	1.80	0.91

Table 12: Summary of materials for sub-spines for all type of modules

Sub-spines - all materials				
		Outer	Middle long and short	Inner
Material	Element	Weight [g]	Weight [g]	Weight [g]
AlN	Al	1.34	1.19	0.60
	N	0.70	0.62	0.31
Summa		2.04	1.80	0.91

Table 13: All materials for sub-spines for all type of modules

1.4 Spine Materials And Other Residuals

Spine material was set to TPG (well thermal conductive carbon). Because there is many components (e.g. washers, wire bonds, glue, fan-ins) which are not part of hybrid or other components defined for Athena framework, we add they to spine material. Those additional are mainly on the ends of spine so we just distribute their mass to whole spine volume.

1.5 Hybrid Material

Hybrid material collect also material close hybrid except mounting pin and female screw for final mounting to discs.

1.6 Module Summary

Just brief summary of module material.

References

- [1] SNOW, S. W., WEIDBERG, A. (2005): *The Radiation Length of SCT Endcap modules*, ATLAS internal note, in preparation, now in <http://www.hep.man.ac.uk/atlas/radlen/index.html> cited on July 24, 2005, CERN, Geneva
- [2] BROKLOVÁ, Z., CORNELISSEN, T., GONZALEZ, S., GORFINE, G., DOLEŽAL, Z., ESCOBAR, C., KODYŠ, P., ŘEZNÍČEK, P. (2005): *SCT end-cap module description in Athena framework*, ATLAS internal notes, in preparation, CERN, Geneva
- [3] BROKLOVA, Z. ET AL. (2004): *SCT Simulation Website* [online] <http://ific.uv.es/~cescobar/simulation.html> cited on June 25, 2004

Spine with other materials - material summary				
		Outer	Middle long and short	Inner
Material	Element	Weight [g]	Weight [g]	Weight [g]
Carbon	C	2.8088	2.6436	1.3266
AlN	Al	0.5707	0.5695	0.5580
	N	0.2963	0.2956	0.2897
Elastosil	Si	0.0279	0.0288	0.0282
	H	0.0020	0.0021	0.0020
Araldite	C	0.0394	0.0380	0.0372
	H	0.0033	0.0032	0.0031
	O	0.0088	0.0084	0.0083
Aluminium	Al	0.1189	0.1147	0.1124
Araldite	C	0.0039	0.0038	0.0037
	H	0.0003	0.0003	0.0003
	O	0.0009	0.0008	0.0008
FR4	C	0.0580	0.0559	0.0548
	H	0.0049	0.0047	0.0046
	O	0.0129	0.0124	0.0122
	Si	0.0799	0.0770	0.0755
	B	0.0048	0.0047	0.0046
	Al	0.0060	0.0058	0.0057
	Na	0.0131	0.0126	0.0123
Glass D263	K	0.0239	0.0231	0.0226
	Zn	0.0257	0.0248	0.0243
	Ti	0.0085	0.0082	0.0080
	Sb	0.0006	0.0006	0.0006
	O	0.1287	0.1240	0.1215
	Si	0.2384	0.2298	0.2252
	B	0.0144	0.0139	0.0136
	Al	0.0180	0.0174	0.0170
	Na	0.0390	0.0376	0.0368
	K	0.0714	0.0689	0.0675
	Zn	0.0766	0.0739	0.0724
	Ti	0.0254	0.0245	0.0240
	Sb	0.0019	0.0019	0.0018
O	0.3839	0.3701	0.3627	
Aluminium	Al	0.0019	0.0018	0.0017
Araldite	C	0.4745	0.4504	0.2454
	H	0.0398	0.0378	0.0206
	O	0.1053	0.1000	0.0545
Summa	0	5.7387	5.4905	3.8604

Table 14: Spine with other materials - all materials

Spine with other materials - summary of all materials									
Element	Outer			Middle long and short			Inner		
	Weight [g]	mass %	vol %	Weight [g]	mass %	vol %	Weight [g]	mass %	vol %
C	3.38	58.98	63.97	3.19	58.13	63.31	1.67	43.20	51.29
Al	0.72	12.47	6.02	0.71	12.92	6.26	0.69	18.00	9.51
N	0.30	5.16	4.80	0.30	5.38	5.03	0.29	7.50	7.64
Si	0.35	6.03	2.80	0.34	6.11	2.85	0.33	8.52	4.33
H	0.05	0.88	11.33	0.05	0.88	11.36	0.03	0.79	11.23
O	0.64	11.16	9.09	0.62	11.22	9.17	0.56	14.51	12.93
B	0.02	0.34	0.40	0.02	0.34	0.41	0.02	0.47	0.62
Na	0.05	0.91	0.51	0.05	0.91	0.52	0.05	1.27	0.79
K	0.10	1.66	0.55	0.09	1.68	0.56	0.09	2.33	0.85
Zn	0.10	1.78	0.36	0.10	1.80	0.36	0.10	2.50	0.55
Ti	0.03	0.59	0.16	0.03	0.59	0.16	0.03	0.83	0.25
Sb	0.00	0.05	0.00	0.00	0.05	0.00	0.00	0.06	0.01
Summa	5.74	100.00	100.00	5.49	100.00	100.00	3.86	100.00	100.00

Table 15: Spine with other materials - material elements summary

Spine with other materials - material summary									
Material	Outer			Middle long and short			Inner		
	Weight [g]	mass %	vol %	Weight [g]	mass %	vol %	Weight [g]	mass %	vol %
Carbon	2.81	48.94	53.09	2.64	48.15	52.44	1.33	34.37	40.80
AlN	0.87	15.11	9.60	0.87	15.76	10.06	0.85	21.96	15.28
Elastosil	0.03	0.52	0.68	0.03	0.56	0.73	0.03	0.78	1.11
Araldite	0.05	0.90	1.61	0.05	0.90	1.63	0.05	1.26	2.48
Aluminium	0.12	2.07	1.00	0.11	2.09	1.01	0.11	2.91	1.54
Araldite	0.01	0.09	0.16	0.00	0.09	0.16	0.00	0.13	0.25
FR4	0.37	6.39	5.40	0.35	6.44	5.46	0.35	8.98	8.30
Glass D263	0.87	15.14	9.02	0.84	15.26	9.13	0.82	21.27	13.86
Aluminium	0.00	0.03	0.02	0.00	0.03	0.02	0.00	0.05	0.02
Araldite	0.62	10.80	19.43	0.59	10.71	19.36	0.32	8.30	16.35
Summa	5.74	100.00	100.00	5.49	100.00	100.00	3.86	100.00	100.00

Table 16: Spine with other materials - material summary

Hybrid - all materials		
Material	Element	Weight [g]
Cu	Cu	2.202
CC	C	1.820
Si	Si	0.784
Kapton	C	0.556
	H	0.021
	N	0.059
Adhesive	O	0.168
	C	0.568
	H	0.048
Al2O3	O	0.126
	Al	0.215
Plastic	O	0.191
	C	0.133
	H	0.011
Sn/Pb	O	0.029
	Sn	0.154
AlN	Pb	0.270
	Al	0.090
EotiteP102	N	0.047
	C	0.049
	H	0.004
AIT	O	0.011
	Ag	0.034
	C	0.018
scr. Epoxy	H	0.001
	O	0.004
	Ag	0.012
Summa	C	0.027
	H	0.002
	O	0.006
		7.662

Table 17: Hybrid material - all elements in detail

Hybrid - all materials			
Summary	Weight [g]	mass %	vol %
Cu	2.20	28.74	7.39
C	3.17	41.38	56.27
Si	0.78	10.24	5.95
H	0.09	1.15	18.58
N	0.11	1.38	1.61
O	0.54	7.00	7.14
Al	0.31	3.98	2.41
Sn	0.15	2.02	0.28
Pb	0.27	3.52	0.28
Ag	0.05	0.61	0.09
Summa	7.66	100.00	100.00

Table 18: Hybrid matrial - all elements summary

Hybrid - all materials			
Material	Weight [g]	mass %	vol %
Cu	2.20	28.74	7.39
CC	1.82	23.76	32.30
Si	0.78	10.24	5.95
Kapton	0.80	10.50	17.49
Adhesive	0.74	9.67	21.83
AI203	0.41	5.31	4.25
Plastic	0.17	2.26	5.11
Sn/Pb	0.42	5.54	0.55
AIN	0.14	1.79	1.42
EotiteP102	0.10	1.28	1.95
AIT	0.04	0.46	0.70
scr. Epoxy	0.04	0.46	1.04
Summa	7.66	100.00	100.00

Table 19: Hybrid matrial - all materials summary

Summary table of materials in module (all in gramms)									
Component	Material	Outher		Middle		Short Middle ^a		Inner	
		Real	Athena	Real	Athena	Real	Athena	Real	Athe
Detectores	Silicon	10.53	10.53	10.41	10.41	10.70	10.70	4.12	4.1
Hybrid	Composite (Tab 17, 18, 19)	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.6
Spine	Composite (Tab 14, 15, 16)	2.81	5.74	2.64	5.49	2.64	5.49	1.33	3.8
Subspine	AIN	2.04	2.04	1.08	1.08	1.08	1.08	0.91	0.9
Others	Composite (Tab 14, 15, 16)	2.93	0.00	2.85	0.00	2.85	0.00	2.53	0.0
Module		25.97	25.97	25.37	25.37	25.66	25.66	16.56	16.5

^aFar detector is sett to glass dummy.

Table 20: Comparing of materials in different types of modules in real measurement[1] and in Athena simulation framework