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OUTGASSING TEST OF AN AXON KAPTON RIBBON

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In this note we briefly report the outgassing measurement of a Kapton ribbon from Axon. The measurement method is described in detail in VACPISA 025.

1 - System performances

We performed a baking of the test chamber at 250 ^{0}C for several days achieving a final base pressure of ~10^{-10} mbar. The typical outgassing rate of the empty chamber is ~10^{-12} mbar l s^{-1} cm^{-2}.

The main components of outgassing after baking were H_2, H_2O, N_2/CO, CO_2. The internal surface of the chamber is 2500 cm^2.

2 - Measurement of the outgassing rate of Kapton ribbon

The experimental sample was a Kapton ribbon manufactured by Axon, France. The ribbon looked as a set of conductors inside two Kapton layers glued together. The ribbon was cleaned using an ultrasound bath of isopropyl alcohol for 40 minutes and a baking in air for some hours at 100 ^{0}C. The exposed surface was 6000 cm^2.

We monitored the evolution of outgassing (time is measured from beginning of the test through the whole paper):

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
82.75	15	6.7×10^{-6}	4.4×10^{-6}	4.6×10^{-5}
113	19	5.5×10^{-7}	1.9×10^{-7}	7.2×10^{-6}
131	15	1.9×10^{-7}	4.4×10^{-8}	2.9×10^{-6}

The mass spectrum after 113 hours is shown in Fig. 1.

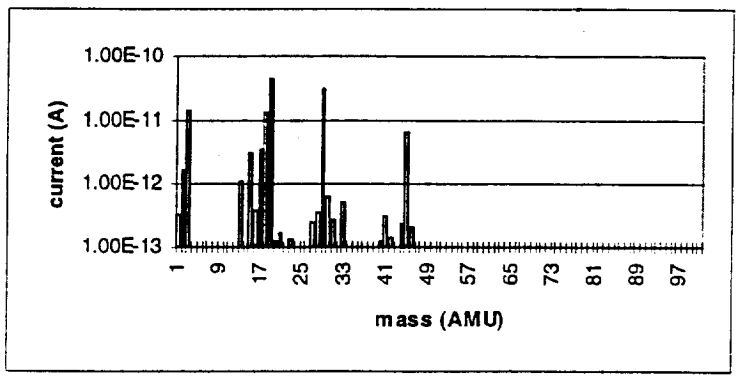

Fig. 1 Outgassing spectrum after 113 hours pumping at room temperature

We set temperature at 50 °C for 288 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
131.7	22	2.2×10^{-7}	5.2×10^{-8}	3.4×10^{-6}
132	56	9.7×10^{-7}	1.5×10^{-7}	1.6×10^{-5}
132.7	51	1.0×10^{-6}	1.6×10^{-7}	1.7×10^{-5}
133	54	1.1×10^{-6}	1.7×10^{-7}	1.9×10^{-5}
133.7	49	1.0×10^{-6}	1.8×10^{-7}	1.6×10^{-5}
134.5	54	1.2×10^{-6}	1.9×10^{-7}	2.0×10^{-5}
137.7	52	1.1×10^{-6}	1.8×10^{-7}	1.8×10^{-5}
155	52	5.5×10^{-7}	9.2×10^{-8}	9.2×10^{-6}
162.2	50	3.9×10^{-7}	6.8×10^{-8}	6.4×10^{-6}
178.8	48	3.4×10^{-7}	6.2×10^{-8}	5.6×10^{-6}
256.6	49	2.9×10^{-7}	4.8×10^{-8}	4.8×10^{-6}
280.6	52	2.9×10^{-7}	5.9×10^{-8}	4.6×10^{-6}
304.3	54	2.7×10^{-7}	5.5×10^{-8}	4.3×10^{-6}
326.8	55	2.8×10^{-7}	6.2×10^{-8}	4.4×10^{-6}
353.1	52	2.2×10^{-7}	4.2×10^{-8}	3.6×10^{-6}
418.8	50	2.3×10^{-7}	5.2×10^{-8}	3.6×10^{-6}

The mass spectrum after a few hours at 50 °C is shown in Fig. 2.

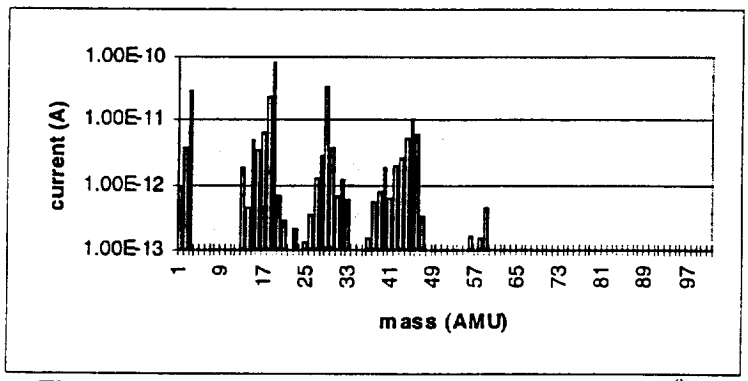

Fig. 2 Outgassing spectrum after a few hours at 50 °C

Some typical organic fragments (mainly at 41, 43, 45 AMU) appeared.

The fragments are still present after several tens hours at 50 °C (Fig. 3).

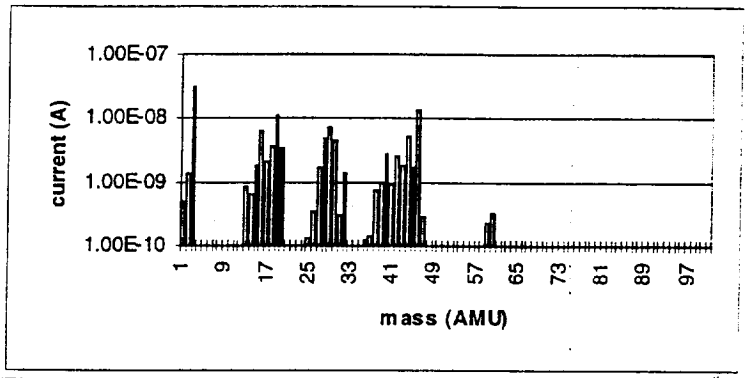

Fig. 3 Outgassing spectrum after several tens hours at 50 °C

We set temperature at 100 °C for 168 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
419	69	2.7×10^{-7}	5.0×10^{-8}	4.4×10^{-6}
419.25	100	4.0×10^{-6}	3.7×10^{-7}	7.3×10^{-5}
419.7	102	5.1×10^{-6}	5.2×10^{-7}	9.2×10^{-5}
420.2	106	7.4×10^{-6}	7.4×10^{-7}	1.3×10^{-4}
420.3	102	7.3×10^{-6}	8.1×10^{-7}	1.3×10^{-4}
450	101	6.1×10^{-6}	5.3×10^{-7}	1.1×10^{-4}
467.8	97	4.3×10^{-6}	7.3×10^{-7}	7.1×10^{-5}
496.3	97	2.5×10^{-6}	2.9×10^{-7}	4.4×10^{-5}
519.1	99	2.0×10^{-6}	2.1×10^{-7}	3.6×10^{-5}
586.8	100	1.5×10^{-6}	2.5×10^{-7}	2.5×10^{-5}

The mass spectrum after 48 hours at 100 °C is shown in Fig. 4.

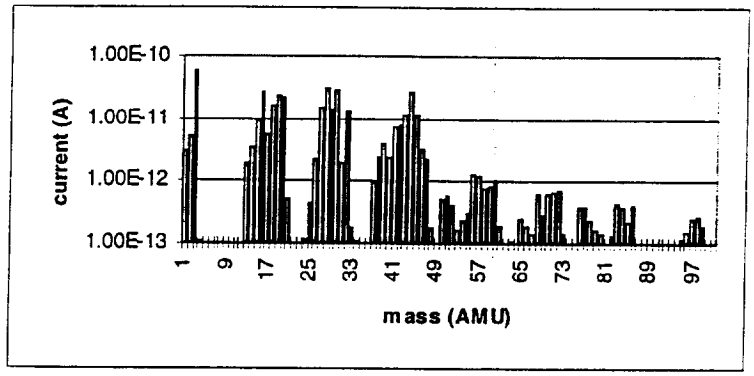

Fig. 4 Outgassing spectrum after 48 hours at 100 °C

The typical clusters centered at multiples of 14 AMU, typical of organic contamination, are evident. Some peaks with mass close to 100 AMU also appeared.

All fragments are still present after 168 hours at 100 °C, and some higher mass fragments have appeared (Fig. 5).

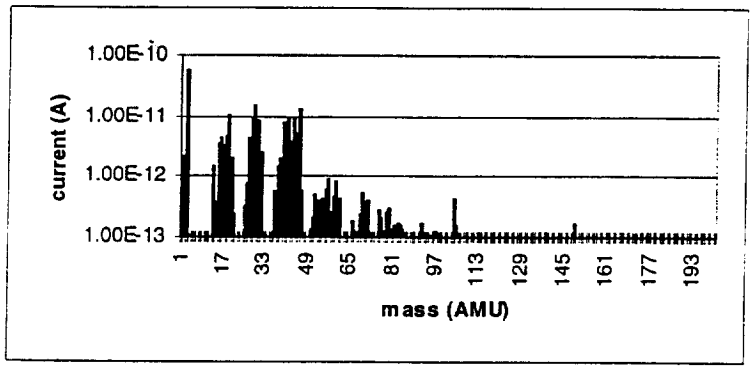

Fig. 5 Outgassing spectrum after 168 hours at 100 °C

We set temperature at 150 °C for 193 hours and monitored the evolution of outgassing:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
587.2	110	1.4×10^{-6}	1.6×10^{-7}	2.5×10^{-5}
587.8	143	1.1×10^{-5}	1.0×10^{-6}	2.0×10^{-4}
589	145	1.5×10^{-5}	1.8×10^{-6}	2.6×10^{-4}
589.25	150	1.6×10^{-5}	2.0×10^{-6}	2.8×10^{-4}
611.3	144	3.6×10^{-6}	4.0×10^{-7}	6.4×10^{-5}

611.9	143	3.3×10^{-6}	4.0×10^{-7}	5.8×10^{-5}
635.25	158	2.3×10^{-6}	3.4×10^{-7}	3.9×10^{-5}
659.5	157	1.1×10^{-6}	1.5×10^{-7}	1.9×10^{-5}
682	153	8.3×10^{-7}	1.4×10^{-7}	1.4×10^{-5}
753.7	144	8.5×10^{-7}	1.8×10^{-7}	1.3×10^{-5}
779.3	143	6.0×10^{-7}	1.6×10^{-7}	8.8×10^{-6}

The mass spectrum measured at beginning of heating at 150 °C is shown in Fig. 6.

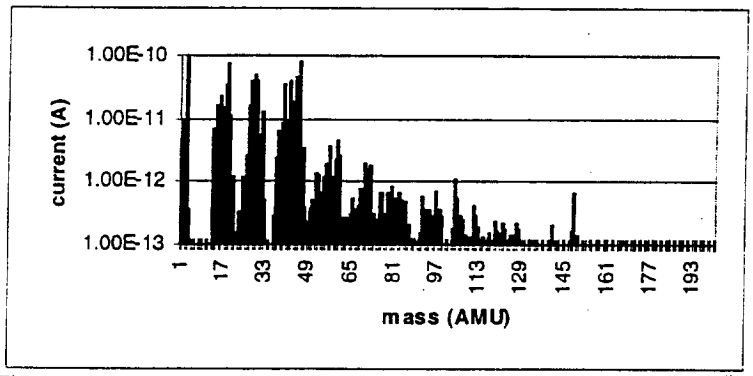

Fig. 6 Outgassing spectrum at beginning of heating at 150 °C

We note the typical organic fragments pattern mentioned above appeared again. There were still some fragments after 73 hours at 150 °C, as shown in Fig. 7, mainly at masses 41, 43, 45, 55 AMU.

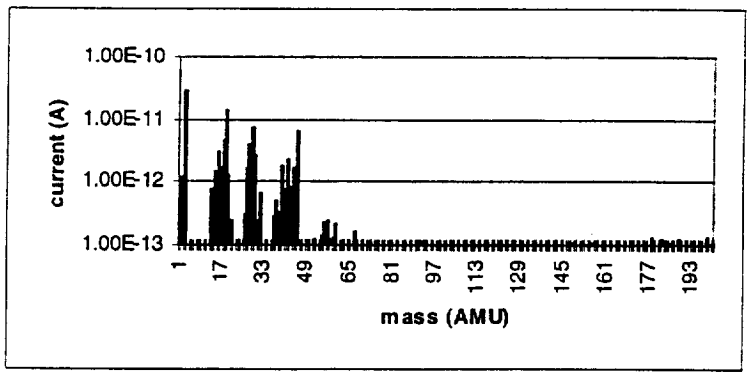

Fig. 7 Outgassing spectrum after 73 hours at 150 °C

We switched off the heating and we measured:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
786.4	38	2.2×10^{-8}	1.6×10^{-8}	1.2×10^{-7}
826.3	13	1.3×10^{-8}	1.0×10^{-8}	6.0×10^{-8}

The mass spectrum at 850.8 hours is shown in Fig. 8.

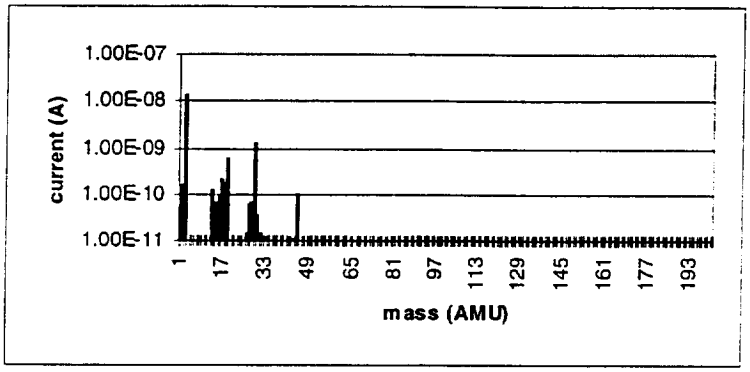

Fig. 8 Outgassing spectrum after the first thermal cycle

Since some organic contamination was present during the various steps in temperature, we checked if it had been removed by the thermal cycle. We heated the samples at 80 °C for 72 hours:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
994.4	77	1.7×10^{-8}	9.3×10^{-9}	1.5×10^{-7}

A spectrum taken at beginning of heating at 80 °C is shown in Fig.9.

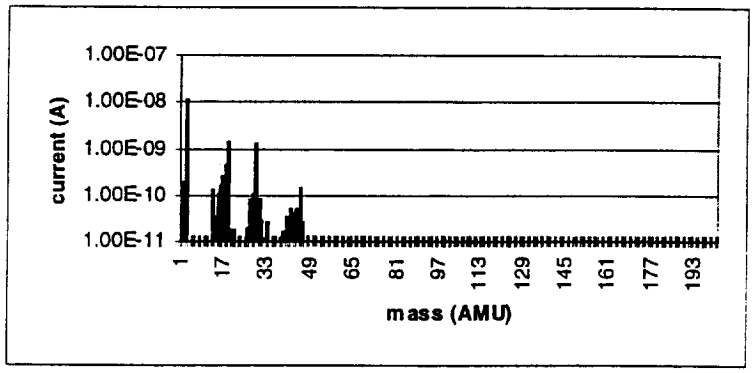

Fig. 9 Outgassing spectrum during the second heating at 80 °C

Some organic fragments at masses 41, 43 AMU appeared again.
We then heated the samples at 150 °C for 269 hours:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
995	145	5.9×10^{-8}	1.4×10^{-8}	9.0×10^{-7}
995.7	154	1.5×10^{-7}	2.8×10^{-8}	2.4×10^{-6}
1001.5	150	4.3×10^{-7}	6.6×10^{-8}	7.3×10^{-6}
1025.6	150	3.5×10^{-7}	6.2×10^{-8}	5.8×10^{-6}
1091.7	150	2.0×10^{-7}	4.2×10^{-8}	3.2×10^{-6}
1098	150	2.2×10^{-7}	5.0×10^{-8}	3.4×10^{-6}
1116.3	150	2.5×10^{-7}	4.7×10^{-8}	4.1×10^{-6}
1144	150	1.7×10^{-7}	4.1×10^{-8}	2.6×10^{-6}
1164.7	151	2.2×10^{-7}	4.3×10^{-8}	3.5×10^{-6}
1168.2	155	1.9×10^{-7}	3.8×10^{-8}	3.0×10^{-6}
1186.8	153	1.6×10^{-7}	3.3×10^{-8}	2.5×10^{-6}
1194	149	1.8×10^{-7}	4.0×10^{-8}	2.8×10^{-6}
1264.2	150	2.8×10^{-7}	7.3×10^{-8}	4.1×10^{-6}

A spectrum measured during the new heating at 150 °C is shown in Fig. 10.

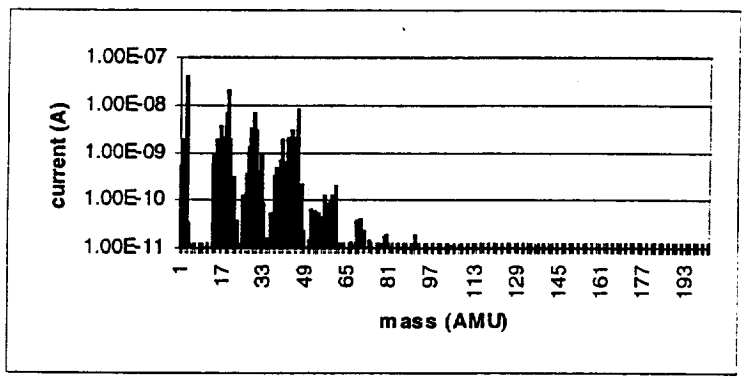

Fig. 10 Outgassing spectrum during the second heating at 150 °C

Some organic fragments, mainly at masses 41, 43 AMU, appeared again.
We switched off heating and we measured:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
1265.3	97	4.2×10^{-8}	2.2×10^{-8}	4.0×10^{-7}
1288	19	7.9×10^{-9}	5.6×10^{-9}	4.6×10^{-8}
1314	18	8.6×10^{-9}	6.2×10^{-9}	4.8×10^{-8}
1359.8	17	1.0×10^{-8}	7.4×10^{-9}	5.2×10^{-8}
1450.6	17	7.9×10^{-9}	5.2×10^{-9}	5.4×10^{-8}

A spectrum taken after cooling down is shown in Fig. 11.

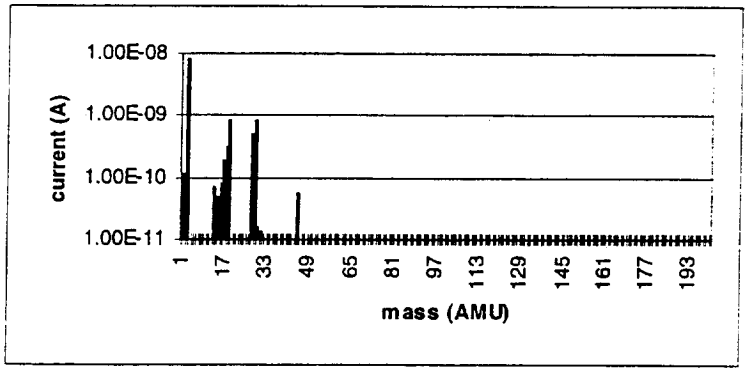

Fig. 11 Outgassing spectrum after the thermal cycles

The outgassing rate evolution is summarized in Fig. 12.

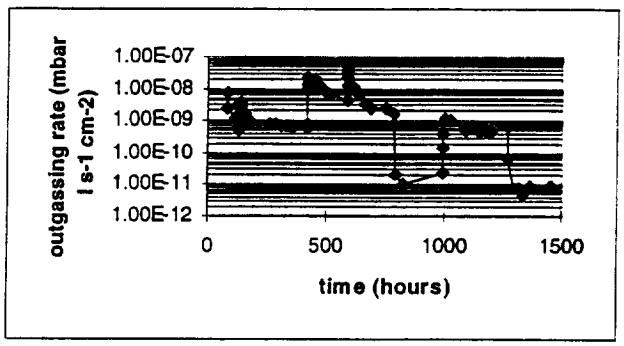

Fig. 12 Time evolution of the outgassing rate

3 - Discussion

The outgassing rate measured for the Kapton ribbon after the various thermal cycles was of the order of ~8×10^{-12} mbar l s^{-1} cm^{-2}. Several organic fragments appeared at the various steps of heating the sample, sometimes extending on the most part of the range of spectrometer. The various thermal cycles were not able to completely remove the organic contaminants, which appear again every time the material is heated again. The ribbon should not be baked in situ. The initial contribution at 45 AMU could be partly caused by the alcohol used for cleaning which is removed with difficulty due to the imperfect adherence of the ribbon layers. Part of this contribution and the other fragments cannot be explained by the isopropyl alcohol. Such fragments are not typical of pure Kapton insulation (see note VACPISA 036). The organic fragments which appear any time the ribbon is heated should be caused by the adhesives routinely used to glue the two layers of the ribbon and maybe for the external sides as well. Similar outgassing spectra were observed with the Kapton ribbon mono-layer sample provided by LIGO (see note VIR-TRE-PIS-3400-112). At the moment of test neither LIGO or VIRGO people were aware of the presence of the glue on the external side.