CNRS *Centre National de la Recherche Scientifique*
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INSTALLATION OF A SECOND VACUUM CHAMBER FOR SMALL SAMPLES AND TEST OF A KAPTON RIBBON CABLE

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In this note we briefly report the results obtained on a Kapton ribbon sample from LIGO which could be used for Superattenuator cabling. In fact, the stiffness of a multi-conductor ribbon should be smaller than the stiffness of several coaxial cables. The measurement method is described in detail in VACPISA 025. The tests have been performed in a newly installed test apparatus for small samples.

1 - Experimental apparatus

We have installed a second system for the test of small samples. It consists of a vacuum chamber made of 304L stainless steel with a volume of 12.9 liters and an internal surface of 3200 cm^2. It is equipped with two CF200 ports to introduce the samples and four CF40 ports, two of them used for a Bayard-Alpert gauge and a residual gas analyzer. The sample chamber is separated from the pumping chamber by a diaphragm which reduces the effective pumping speed to S_e = 20 l/s N_2 equivalent at 20 °C. Two CF40 ports on the pumping chamber are connected to a Penning gauge and to the pumping system. The pump used is a 170 l/s turbo baked by a scroll.

2 - System performances

We performed a baking at 250 °C for 8 days and we got:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
after	33	3.5×10^{-9}	1.1×10^{-10}	6.8×10^{-8}

The main components of outgassing after baking were H_2, H_2O, N_2/CO, CO_2.

3 - Measurement of the outgassing flow of the Kapton ribbon

The sample was a multi-conductor ribbon cable manufactured by Flex Link, California which is planned for use in the cabling of the LIGO stacks. The exposed surface was 3102 cm^2. The sample was cleaned with an ultrasonic bath of acetone (according to LIGO group suggestion), then baked at 120 ^{0}C for 5 hours.

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)
1	33	2.8×10^{-6}	5.7×10^{-6}	6.1×10^{-4}
64.5	32	1.3×10^{-7}	1.7×10^{-8}	2.3×10^{-6}
70.5	33	1.5×10^{-7}	2.1×10^{-8}	2.6×10^{-6}
91.5	33	1.5×10^{-7}	2.0×10^{-8}	2.6×10^{-6}
114.5	33	1.3×10^{-7}	1.6×10^{-8}	2.3×10^{-6}

123	33	1.3×10^{-7}	1.6×10^{-8}	2.3×10^{-6}
137.5	33	1.1×10^{-7}	1.3×10^{-8}	1.9×10^{-6}
141	33	1.9×10^{-7}	2.6×10^{-8}	2.6×10^{-6}

The spectrum taken after 141 hours is shown in Fig. 1. There is an evident peak at mass 58.

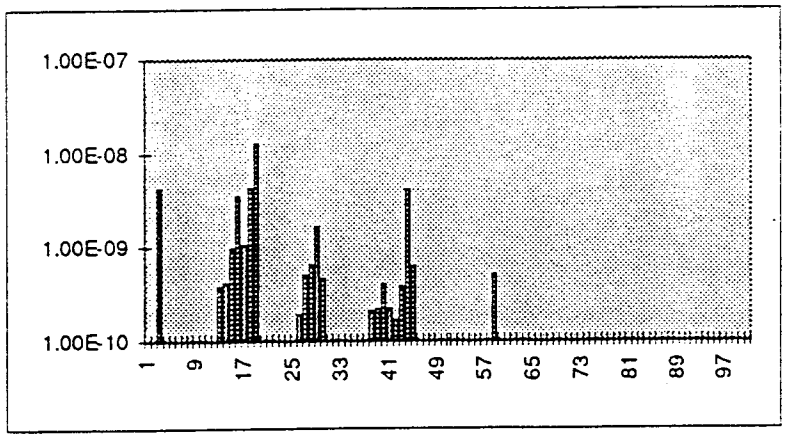

Fig. 1 Outgassing spectrum after 141 hours pumping at room temperature

We set temperature to 50 °C and monitored the evolution of outgassing:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
142	50	5.4×10^{-7}	7.5×10^{-8}	9.3×10^{-6}
143	50	5.7×10^{-7}	7.7×10^{-8}	9.5×10^{-6}
144.5	50	5.7×10^{-7}	7.9×10^{-8}	9.8×10^{-6}
160.5	50	6.5×10^{-7}	8.4×10^{-8}	1.1×10^{-5}
166.5	50	5.2×10^{-7}	6.8×10^{-8}	9.0×10^{-6}
167.5	50	5.7×10^{-7}	6.8×10^{-8}	1.0×10^{-5}
169.5	50	5.0×10^{-7}	6.7×10^{-8}	1.1×10^{-5}
237	43	2.9×10^{-7}	3.7×10^{-8}	5.1×10^{-6}
238	43	2.5×10^{-7}	3.0×10^{-8}	4.4×10^{-6}
241	43	2.6×10^{-7}	3.2×10^{-8}	4.6×10^{-6}
280.5	43	1.2×10^{-7}	1.3×10^{-8}	2.1×10^{-6}
286.5	43	1.6×10^{-7}	1.9×10^{-8}	2.8×10^{-6}
310	43	2.1×10^{-7}	2.5×10^{-8}	3.7×10^{-6}

The spectrum measured during 50 °C heating is shown in Fig. 2. The peak at mass 58 is still present and some low mass organic fragments around mass 30 and mass 40 have appeared. The last part of table was taken at a lower temperature due to a malfunctioning of the temperature controller.

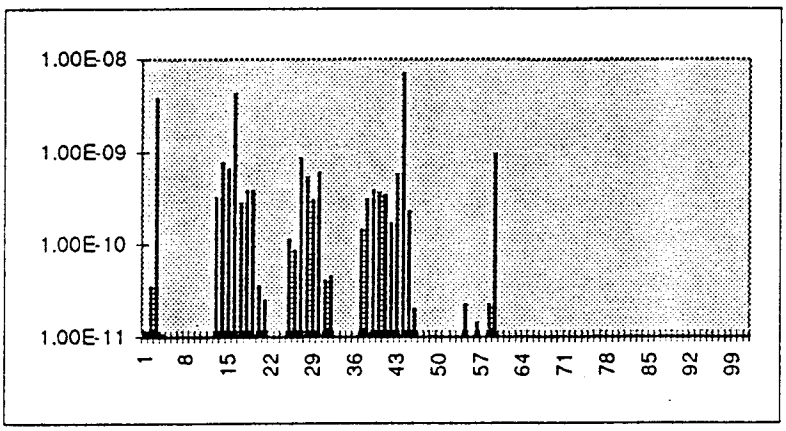

Fig. 2 Outgassing spectrum during heating at 50 °C

We replaced the temperature controller and set heating to 100 °C; we measured:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
311.75	100	1.6×10^{-4}	2.0×10^{-5}	2.8×10^{-3}
312	100	5.5×10^{-5}	6.8×10^{-6}	9.6×10^{-4}
312.5	100	2.7×10^{-5}	4.1×10^{-6}	4.6×10^{-4}
313.5	100	1.0×10^{-5}	1.4×10^{-6}	1.7×10^{-4}
329	100	2.5×10^{-6}	3.2×10^{-7}	4.4×10^{-5}
335	100	7.4×10^{-6}	1.0×10^{-6}	1.3×10^{-4}
400	100	4.0×10^{-7}	5.2×10^{-8}	7.0×10^{-6}
407	100	4.0×10^{-7}	5.4×10^{-8}	6.9×10^{-6}
409.5	100	2.4×10^{-7}	3.2×10^{-8}	4.2×10^{-6}
425	100	8.1×10^{-8}	1.1×10^{-8}	1.4×10^{-6}
431.75	100	8.0×10^{-8}	8.3×10^{-9}	1.4×10^{-9}

The spectrum measured after 431.75 hours is shown in Fig. 4. The outgassing spectrum characteristics are basically the same as above.

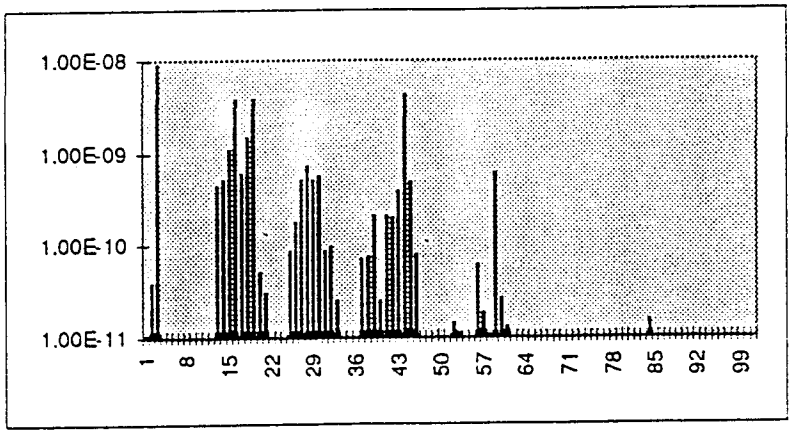

Fig. 3 Outgassing spectrum after 120 hours at 100 °C

We set temperature to 150 °C for a few hours:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
432	150	1.0×10^{-5}	1.6×10^{-6}	1.7×10^{-4}
432.25	150	5.6×10^{-6}	8.0×10^{-7}	9.6×10^{-5}
432.5	150	1.7×10^{-6}	2.5×10^{-7}	2.9×10^{-5}
433	150	2.3×10^{-6}	3.3×10^{-7}	3.9×10^{-5}
434	150	7.8×10^{-6}	1.1×10^{-6}	1.3×10^{-4}

The spectrum measured after 434 hours is shown in Fig. 4. A new peak at 84 is appeared.

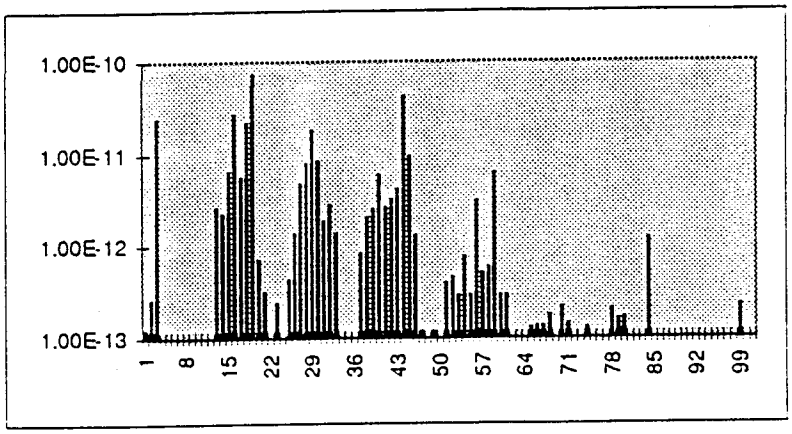

Fig. 4 Outgassing spectrum after 2 hours at 150 °C

We set temperature to 120 °C and we measured:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
449.5	120	4.3×10^{-7}	6.2×10^{-8}	7.4×10^{-6}
454.5	120	7.6×10^{-8}	1.3×10^{-8}	1.3×10^{-6}
456	120	4.3×10^{-8}	9.0×10^{-9}	6.8×10^{-7}
473	120	1.0×10^{-7}	1.6×10^{-8}	1.7×10^{-6}

The spectrum measured after 473 hours is shown in Fig. 5. It is quite similar to the one at 150 °C but with some reduction in the water contribution.

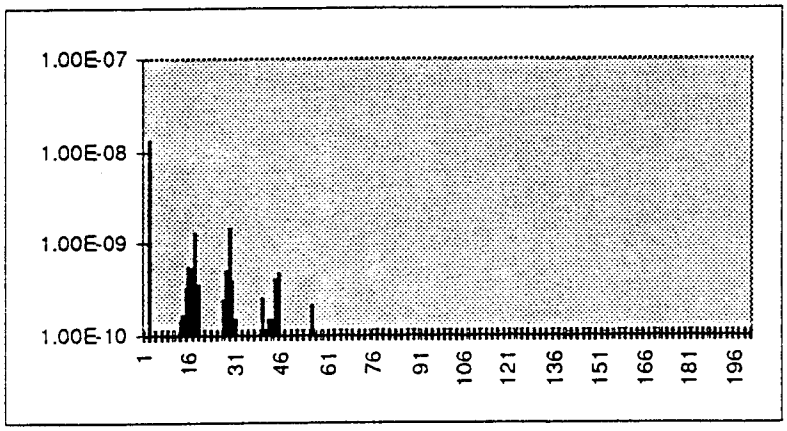

Fig. 5 Outgassing spectrum after 23.5 hours at 120 °C

We switched off the heating:

t(h)	T(°C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
481	32	2.4×10^{-8}	5.5×10^{-9}	3.7×10^{-7}
496.5	32	2.2×10^{-9}	9.2×10^{-10}	2.6×10^{-8}

The spectrum measured at the end of the test is shown in Fig. 6. There is no evidence of organic contamination.

The vertical time scale of the shown spectra is not the same because in some cases we used electron multiplier to increase sensitivity.

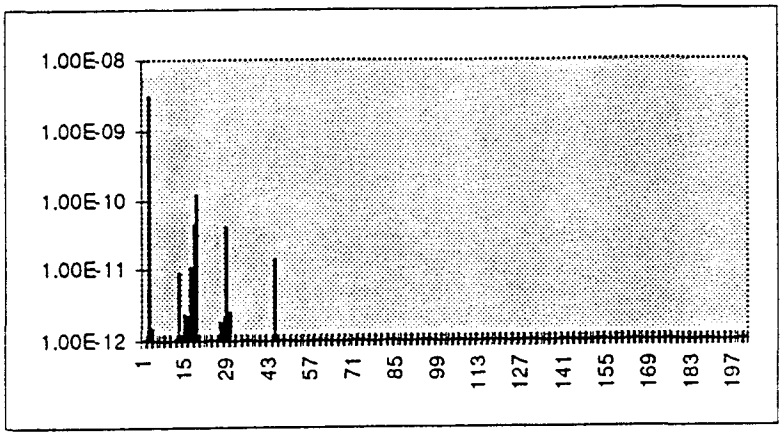

Fig. 6 Outgassing spectrum after the vacuum baking at 150 °C

The outgassing rate evolution is summarized in Fig. 7.

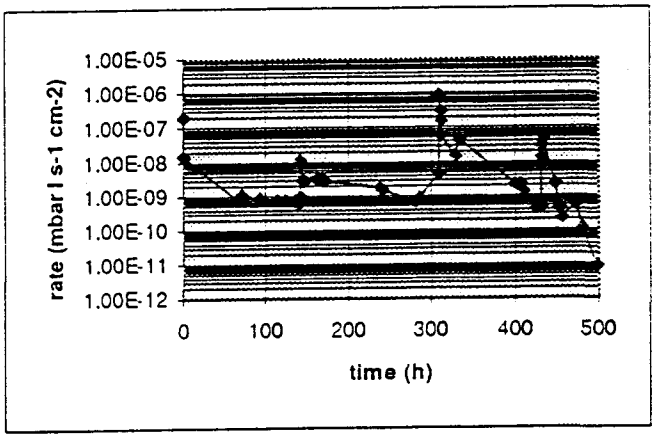

Fig. 7 Evolution of the outgassing rate of the Flex Link ribbon

4 - Discussion

The outgassing rate of the Kapton ribbon after the above thermal treatments, essentially vacuum baking at 150°C, was ~10^{-11} mbar l $s^{-1}cm^{-2}$. The recurrent peak at mass 58 can be explained with the acetone used for cleaning. Considering the measurements described in the note VACPISA 036 the organic fragments observed in the spectra above room temperature are not due to the cracking pattern of Kapton but to some organic contamination which has not been removed by cleaning. This could be due to the not

perfect mechanical conditions of the ribbon (e.g. surface scratches). We think that a different way of cleaning has to be addressed. In any case, the ribbons should not be baked in situ. We could not perform tests with current flowing due to lack of suitable electrical connectors.