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OUTGASSING RATE MEASUREMENTS OF SILICON CARBIDE

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Abstract

A C-band accelerating structure has a higher accelerating gradient than that of the S-band structure. It provides a good advantage of a shorter machine length. In order to effectively use RF power and for cost reduction, the accelerating structure should be as long as possible, however from vacuum point of view, a longer accelerating structure has worse vacuum performance as a shorter one.
We propose a 2 meters long RF structure, so the vacuum behavior of this one has to be checked .The cavity has also RF silicon carbide absorbers, and also if the vacuum property of the material is well known [1, 2] a test is necessary in order to characterize our samples in the better way, also because vacuum characteristics of the accelerating structure depends strongly from their outgassing rate.

Introduction

In order to measure out gassing rate of a material the known-conductance method has been used.
The schematic view is shown in fig.1; setting an upper limit for the outgassing rate of silicon carbide. A gas flow restriction interposed between a pump and a vacuum vessel reduces the 'useful' pumping speed.
The relation between the gas throughput Q and the vacuum pressure P is given by [3]:

$$\Delta P = \frac{Q}{S_{eff}}(1 - e^{-\frac{t}{\tau_p}})$$

Where τ_p is in general very small compared to the timescale of the measurement, so

$$\Delta P = (P_1 - P_2) = \frac{A_a q_a + A_s q_s}{S_{eff}} \qquad [1]$$

Where A_a, q_a and A_s, q_s are the surfaces area and specific outgassing rate of the vacuum vessel at pressure P_1 (background) and sample respectively.

In our case $S = 150\frac{l}{s}$, is the nominal vacuum speed of sputter ion pump, C is made by a thin hole of diameter 10mm and area $A = 0{,}78 cm^2$ giving a vacuum conductance in the order of $9\frac{l}{s}$.

The effective pumping speed S_{eff} seen by the vacuum vessel at pressure P1 is easily calculated:

$$S_{eff} = \frac{C \cdot S}{C + S} \cong 8{,}5\frac{l}{s}$$

In order to make more accurate measurements as possible, all the system has been vacuum–fired at 650°C for two days and baked out in situ at 180 °C for 24 hours .The same procedure applied also to silicon carbide samples, shown in fig.2. We put inside 16 pieces, total surface about $3{,}5 \cdot 10^3 cm^2$.

Assuming from literature [4, 5] an outgassing rate, for stainless steel, of about $2*10^{-14}\ mbar \cdot liter \cdot \sec^{-1} \cdot cm^{-2}$ and for inner vacuum area surface A_a about $10^3 cm^2$, the total outgassing from background $A_a q_a \cong 2*10^{-11}\ mbar \cdot liter \cdot \sec^{-1}$ is obtained.

At steady state pressure drop, $\Delta P = 4 \cdot 10^{-10} mbar$ has been measured, from equation [1], we obtain as upper limit for $A_s q_s \cong 3{,}3 \cdot 10^{-9}\ mbar \cdot liter \cdot \sec^{-1}$.

Total surface of silicon carbide is about $3{,}5 \cdot 10^3 cm^2$ so an outgassing rate of about $9 \cdot 10^{-13}\ mbar \cdot liter \cdot \sec^{-1} \cdot cm^{-2}$ is inferred. This is an upper limit because in our case the surface area of vacuum vessel at P1 and P2 are different, so ΔP probably is overestimated.

In principle we could make two set of measurements, one with the samples inside and one without, but it's very difficult to compare conditions in both trials, also adopting a particular procedure, for instance venting with liquid nitrogen.

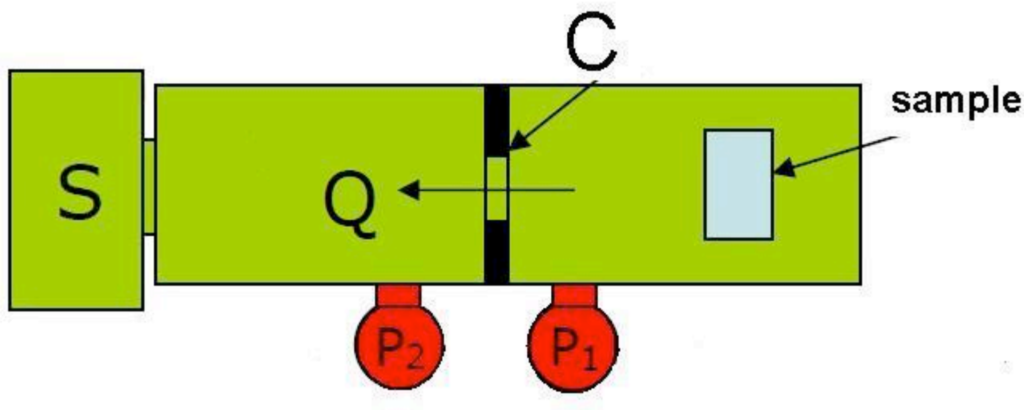

Figure 1: A schematic view of throughput method for measuring out gassing rate.

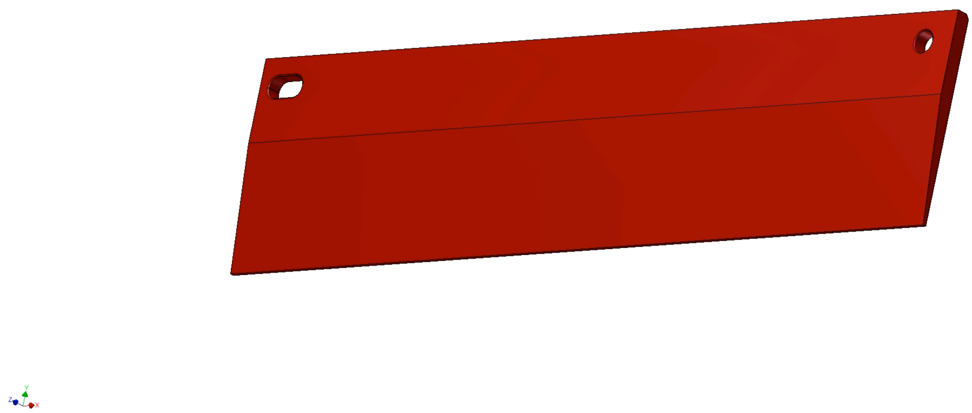

Figure 2: Silicon carbide absorber for C band accelerating structure.

Results and conclusions

The outgassing rate for silicon carbide samples has been measured using known-conductance method.
These results, agree, less than a factor 2 , with our previous simulation on a C-band vacuum pressure, when an outgassing rate for silicon carbide of $5*10^{-13}\ mbar \cdot liter \cdot \sec^{-1} \cdot cm^{-2}$ has been adopted and these data are also in good agreement with measurements done by others authors [4, 5].
To improve measurements probably we could develop a dedicated apparatus.
Silicon carbide is prepared by synthetic procedure and also if it is not designed for vacuum projects, after particular treatments (vacuum firing and bake out) its outgassing rate becomes compatible with UHV applications. Vacuum tests on assembled C-band structure are in progress in order to verify these statements and the definitive results will be provided in a forthcoming paper.

References

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