PRESERVING MICROMETRE TOLERANCES THROUGH THE ASSEMBLY PROCESS OF AN X-BAND ACCELERATING STRUCTURE

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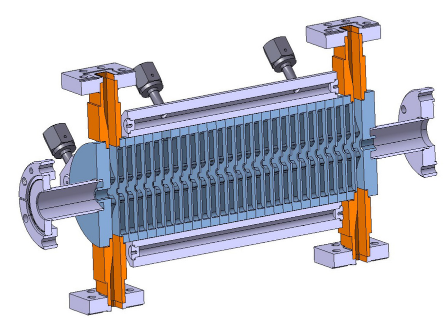
Introduction

LIC baseline accelerating structure stack is composed by a variable quantity of discs of the prototype being produced. The cavity formed by the disc represents the RF zone. The geometry of the disc depends on different parameters and each of these parameters contributes differently to satisfy the RF design. Sub-micrometre tolerances are needed to reach the accelerating gradient goal of 100 MV/m if no tuning is applied and if no temperature correction is allowed to the structure. However, the normal variability of the manufacturing processes makes that the disc presents discrepancies with respect to the nominal design. This paper aims at identifying the most critical design parameters through the means of a sensitivity analysis of the geometrical effects on the AS regular cells. For this purpose, six AS of two different prototypes are analysed: T24 N4 and N5 and TD26 N1 to N4.

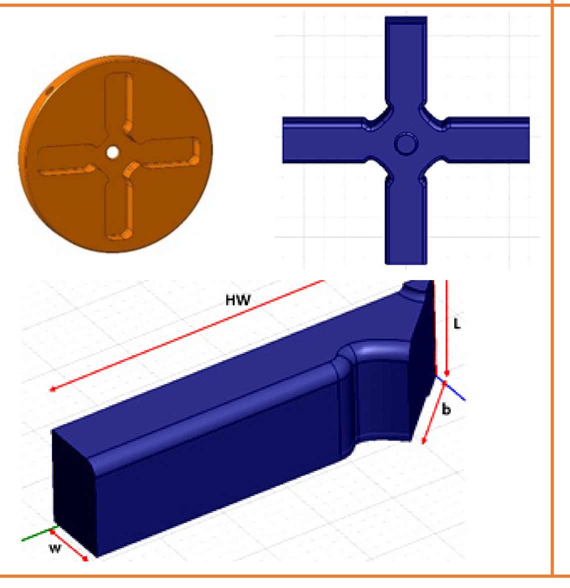
Geometry

TD26

26 tapered cells with integrated coupling cells

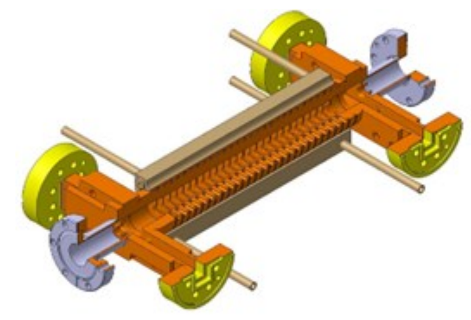


a iris aperture
b inner radius
L height
w width
HW represents length of the damping cell

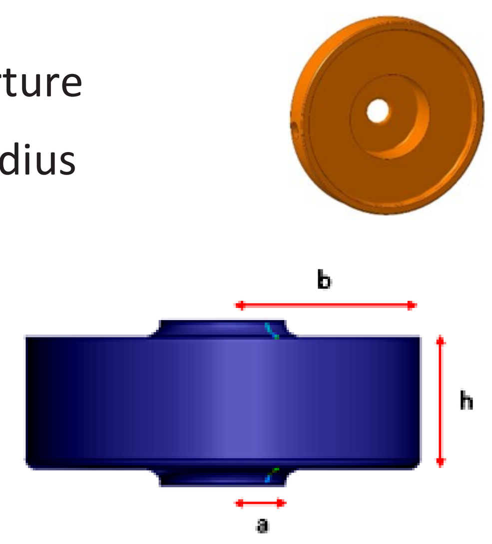


T24

24 undamped cells with a weak tapering of the irises

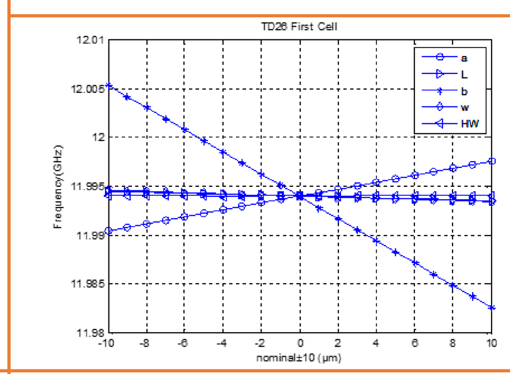
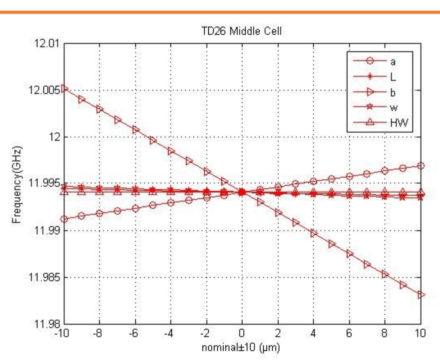
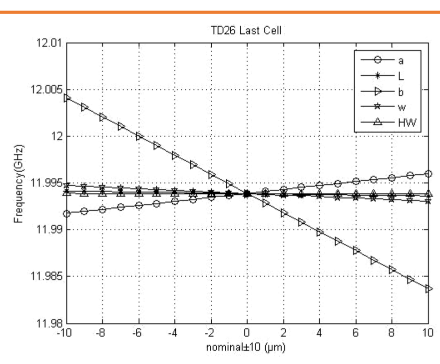
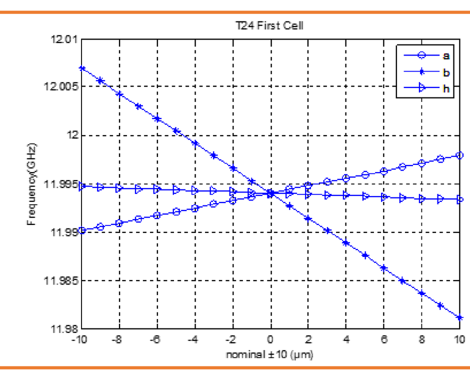
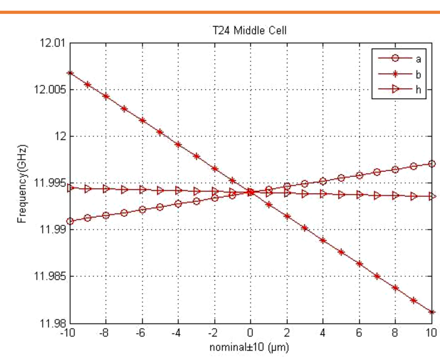
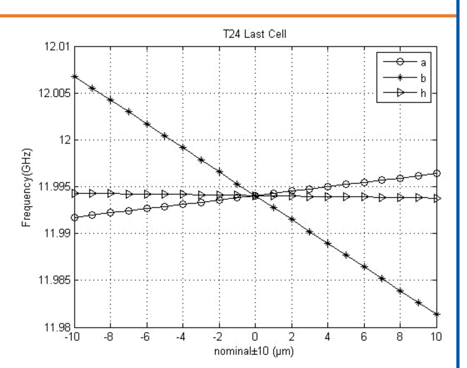


a iris aperture
b inner radius
h height



Sensitivity Analysis

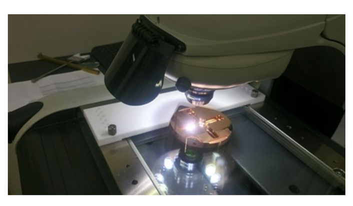
In a sensitivity analysis, each geometric parameter is varied slightly around the design value to determine the sensitivity of the return loss to that parameter. The results for both T24 and TD26 included the first, middle and last cells with ±10 µm interval around the nominal design value.

Measurements

Dimensional

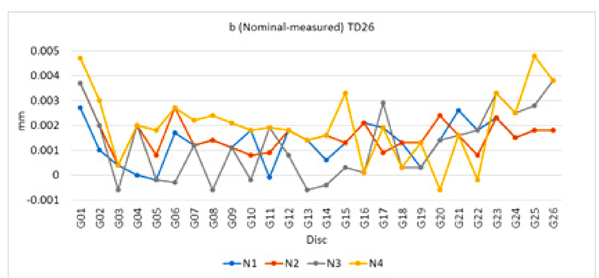
Optical



No contact
Repeatability 1 µm
Fast

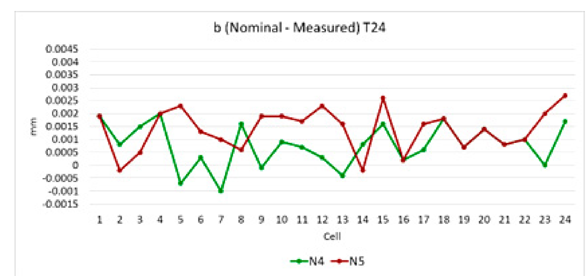
Accuracy 4 µm

TD26



b parameter was always smaller than nominal
Data range: N1- 2 µm, N2-3 µm, N3-4 µm, N4-5

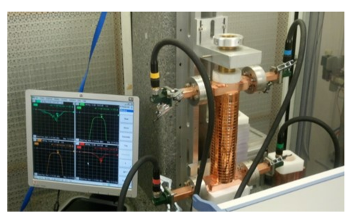
T24



b parameter was always smaller than nominal
Data range: N4– 4 µm, N5-3 µm

Frequency

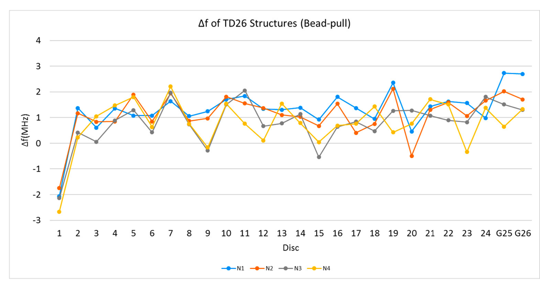
Bead-pull



Electric field distribution / Frequency deviations cell by cell

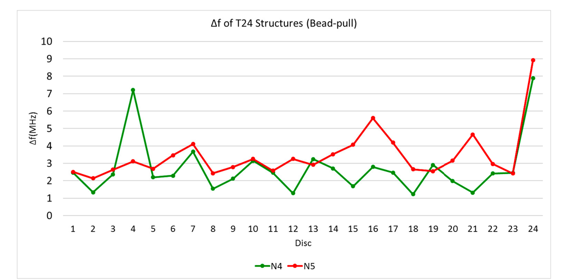
Affected by the lack of contact

TD26



Frequency deviation are uniform with reduced variability.

T24

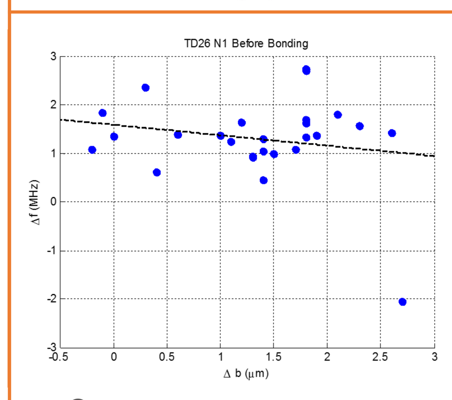


Frequency deviation are uniform with reduced variability.
An outlier is observed in cell 4 of N4 structure.

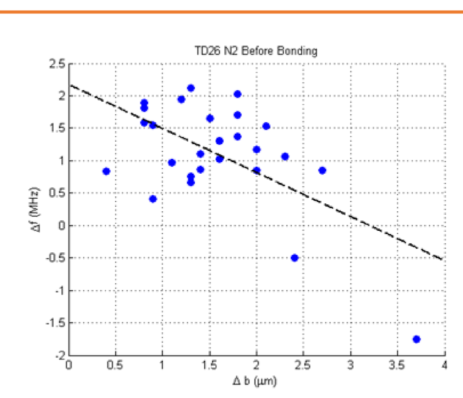
Correlation

Before Bonding

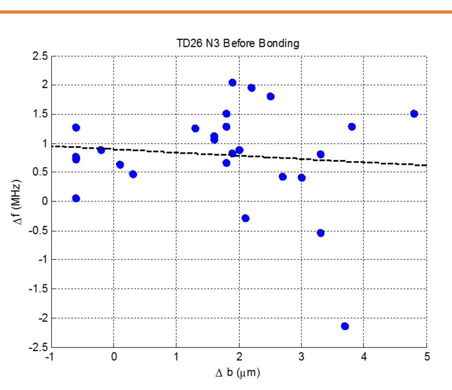
The linear correlation represents the strength of relationship between two different datasets and identified by a coefficient *r*. The coefficient value ranges from +1.0 (strong positive correlation) to -1.0 (strong negative correlation), being 0 no correlation at all.



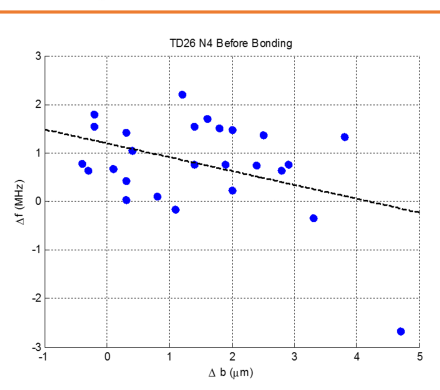
r=-0.193



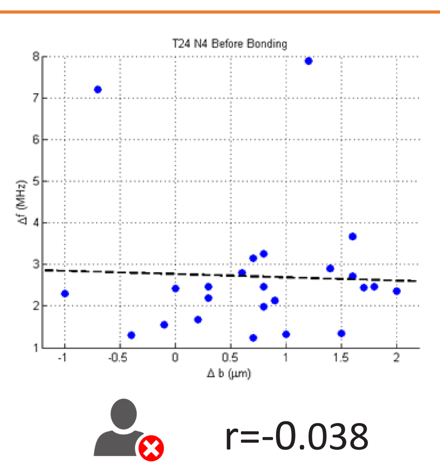
r=-0.59



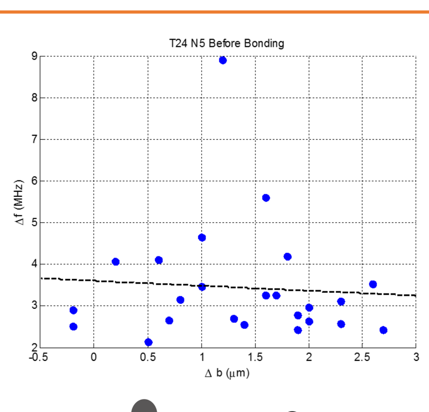
r=-0.09



r=-0.4



r=-0.038



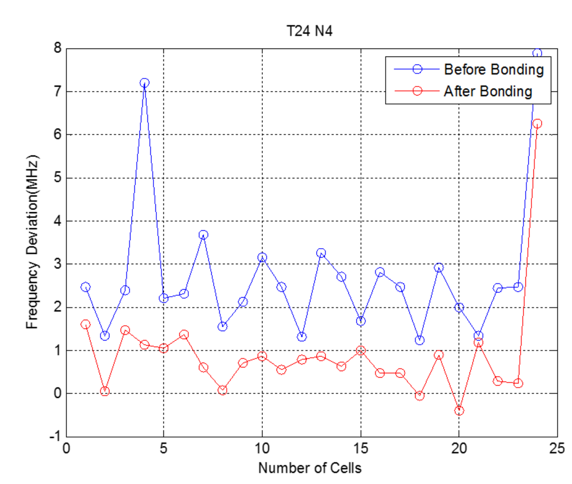
r=-0.069

Conclusions

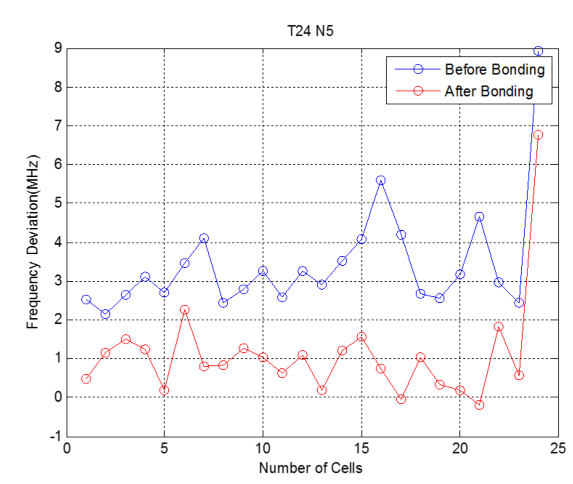
The sensitivity analysis found that, among several parameters, the inner radius ***b*** contributes the most to the frequency change for both prototypes. A negative correlation between the two factors was expected. Parameter ***b*** measurements of all the discs for both prototypes are homogenous with reduced variability (maximum data range 5µm). As seen from the correlation analysis, **before bonding there is no visible linear correlation except of TD26 N2 and N4**: both structures show negative moderate correlation. The lack of correlation may be the effect of the **low accuracy of the measurements processes**: the accuracy of the microscope is worse than the tolerances at stake; frequency deviations before bonding are affected by the mechanical contact of the disc stack. Both measurement processes have to be greatly improved in order to get reliable data. The b parameter measurement is now an important requirement for suppliers. Another possibility is that the data follows another type of correlation or the combined effect of more than one parameter.

Finally, there is evidence of a **geometry change in the cells after bonding** since there is a reduction of frequency deviation. Nevertheless, it is not possible to numerically assess the change due to the inaccessibility of the RF cavity. Other possible causes need to be further investigated.

After Bonding



Diameter: Not measured
Straightness: 15 µm



Diameter reduction: 7 µm
Straightness: 30 µm

On both structures there is a **reduction of the frequency deviation**. It is then clear that there has been a **change on the RF geometry** .