Accelerating Structure

Manufacturing and Performance

with Emphasis on RDDS1

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0. Introduction
1. Fabrication of Disks
2. Assembly of Structure
3. Prospects
0. Introduction

- This presentation discusses on
  1. How we build X-band accelerating structures.
  2. Where we are.
  3. Where we are going.

- Specifically, we treat the issues above in conjunction with the work we have been doing on development of two prototype structures:
  DDS3 (done in 1997-99) and RDDSI (ongoing since 1998).

- Both DDS3 and RDDSI are variants of Damped-Detuned structures:
  ~ 1.8 m long
  ~ 61 mm OD

which consist of some 200 disks with I/O couplers, HOM couplers and cooling water tubing etc.
DDS3 @ SLAC Nov.'98
Introduction (continued)

As of ‘97 - ‘99

- OFHC copper disks are machined through several steps:
  - Initial cutting of disks out of bars
  - Roughing, heat-treatment, and mid-machining
  - Diamond turning

- Disks are cleaned with
  - Acid and/or ozone rinsing and drying.

- Stacking on a precision vee-block.

- Diffusion bonding
  - All 205 disks are bonded in one group
  - Actual bonding is done in two stages
    - 180 deg C once
    - 850 deg C second

- Brazing for attaching
  - Fundamental and HOM couplers
  - Cooling water tubing and jackets
1. Fabrication of Disks

Issues that have been noted since the early stage of R&D

- Dimensional tolerance is of the order of 0.5 - 1 μm
- All disks within a structure have different cavity dimensional parameters
- Effects of difference of the temperature during fabrication and operation period are taking into account in the design and manufacturing processes.
- Disk thickness is known to change during diffusion bonding (approx 0.5 μm / disk). This will have to be taken into account, also.

Hence, there is a serious Quality Control issue to be addressed, but so far we have been accumulating positive experiences
DISK NUMBER
NOTE 4

(8.74377)

65° .005°

Z

P.C.DΦC

4XØ0.75

4XØ2rm±0.050

4X1.50±0.02

8X3.00±0.015

Φ 0.06 A B C

Φ 0.02 A

Φ 0.06 A B C

h±0.02

61.000±0.001
We have so far learned -

- Very rigorous dimensional QC both at the contractor’s (roughing) and at KEK machine shop (final diamond turning).
  - CMM measurements, cross checked with those at SLAC.
  - “Form Talysurf” measurements

- Tuning and maintenance of the serbo gain control for feeding the work with the ultra-precision lathe.

- In-house checking of the exact dimension of the diamond tip.

Consequently -

- RDDS disks can be fabricated with satisfactory accuracy for our first prototype
  - Dimension measurements agree within $0(1 \, \mu m)$ at KEK and SLAC with respect to design.
  - Attained good control over the fundamental-mode resonant frequencies

- Feed-back/forward strategy on mech. fab vs RF QC is to be determined for RDDSI very soon.

Oversized byte, whose motion is controlled assuming nominal size.

Nominal byte whose motion is controlled with correct size.

Proper shape, as intended

Wrong shape

Spindle Axis
Description:  
Ser. No.:
Customer:

Element: PROFILE_CURV (2)
Department: MET-060

Form .......: 0.00192 Min. Deviat.: -0.00142
Lower Toler.: -0.00200 Max. Deviat.: 0.00050
Upper Toler.: 0.00200
Error Magnif.: 50
No. of points: 188

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2. Assembly of Structures

Requirement

- Vacuum-tight junctions between disks with approx 0.05 μm surface finish, without upsetting the smooth disk-to-disk relative alignment of O(a few) μm.

Solution

- Disks are bonded through two-step diffusion bonding technique after aligned on a single vee-block as a whole.
  (Exercises so far done in vacuum furnace environment)
- Couplers, etc are brazed onto the structure later.
We have so far learned -

Challenge

- A variety of issues that lead to upsetting the relative disk-to-disk alignment during the bonding process, e.g.
  - Mechanical stability.
  - Non-uniformity of temperature within the assembly.
  - Coexistence of copper (disks) and stainless steel material for holding them together.

Solution

- 2-stage diffusion bonding

  150 degC: while constraining the stack on a vee block.
  
  to create strong-enough bonding against perturbation up to O(a few x 10) kg,
  
  yet not vacuum tight.

  850 degC: while the stack being detached from the vee-block and self-suspended
  
  to compete the vacuum tight, mechanically sturdy bonding of disks.
Long rods (3) for holding the stacked cells

Oil Cylinder + protection cover (to be removed during DB)

Spring + holder blocks (to be removed during DB)

Ball bearing

Ceramic block with a positioning pin

Stacked cells

Long rods (3) for holding the weights

Ceramic block

Weights
3. Summary and Prospects

Status as of Spring, 1999

- We have reasons to be optimistic about fabrication quality of RDDS disks for our first prototype.
- Two-stage diffusion bonding technique developed for previous prototypes is applicable to RDDS.
- We expect to complete building the RDDS 1 model, and beam-test it within this year, 1999.

Prospects for the Future

- Focus items in the second and third RDDS prototypes (RDDS2 / 3) include -
  
  Refinement of RDDS electrical design.  
  Deeper understanding of high-power performance. 
  Increased emphasis on mass-manufacturability of the structure. 
  Integration of the structures and support for the RF system test.

- Important task: automating the production and QC processes of these structures in a mass / industrial scale.

- First step is to record and document all the detailed issues that were encountered during the prototyping, and assess them with “engineering” eyes. RDDS 1 experiences should give important inputs there.