Diamond turning of RDDSI disks

Contents:

1. Detailed description of fabrication of RDDSI disks.

2. Some issues remained to be studied.
Procedure for RDDS1 disks machining

1. Roughmachining
   Makes blanks from copper bar by band saw.
   Turning with over size of 40 μm.
   Grinding both sides.
   Make one of them as a datum.
   Improvement of flatness.
   Milling to final dimension.

2. Annealling
   Purpose is stress releasing.
   Vacuum at 500°C for 2 hours.

3. Hand lapping of one side
   Purpose is removing scratches.
   At #800 sandpaper on the optical flat.
   Time is about 30 seconds for 1 disk.
   (Time was reduced by Grinding)

4. Intermediate turning

5. Final turning
 Intermediate turning

Functions of intermediate turning
  1. Reduce the tool damage at final turning.
  2. Improvement of flatness.

Cutting condition
  Cutting with over size of 10 \( \mu \text{m} \).

  Rotation speed 2800rpm
  Cutting speed 40mm/min then 27mm/min
  Cutting depth 6 \( \mu \text{m} \)
  Tool Single crystal diamond tool
  Chuck Vacuum chuck
  Process time -1 5min/1 disk
Final turning

Processes in Final turning

O. Measurement of tool radius.

1. Daily process

2. Based on RF measurement of previously machined disks, "2b" dimensions can be modified for the fabrication of later days.

3. After fabrication of all disks, flatness and thickness of all of the disks were measured.

Cutting condition

<table>
<thead>
<tr>
<th>Process</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation speed</td>
<td>2800rpm</td>
</tr>
<tr>
<td>Cutting speed</td>
<td>40mm/min then 27mm/min</td>
</tr>
<tr>
<td></td>
<td>(3mm/min at cavity area)</td>
</tr>
<tr>
<td>Cutting depth</td>
<td>4 μm + 4 μm+ 2 μm</td>
</tr>
<tr>
<td>Tool</td>
<td>Single crystal diamond tool</td>
</tr>
<tr>
<td>Chuck</td>
<td>Vacuum Chuck</td>
</tr>
<tr>
<td>Process time</td>
<td>~30min/1 disk</td>
</tr>
</tbody>
</table>
Typical turning process in a day

CD : Cut dummy disks measure “OD” adjust tool position.

FF : Temperature of the previous disk just after cutting was input to NC for the following disk, if changed a lot.

Check “OD” just after cutting.
If it indicates a drift to run over 0.75 μm, the tool positioning reference in radial direction was changed.

TC : Checking diamond tool by microscope.

Cut Input Side
8 disks
Chuck input side on vacuum fixture with ±0.3 μm centering.

Cut Output Side
8 disks

START

CD

Turning

FF

Turning

FF

TC

Lunch

CD

END
Evaluation of diamond tool radius

\[ \Delta t(45) = \Delta br(\sqrt{2} - 1) \] (1)

The maximum separation between these two lines is related to error of tool radius \( \Delta br \) as shown (1).
Measurement of OD

After final cut of INPUT SIDE (over cut 2 µm)

After final cut of OUTPUT SIDE
Flatness of disks

Typical interferogram pattern

Histogram of flatness
Some issues remained to be studied.

1. Parallelism
   Some of the disks were out of tolerance.

   Need more study

2. Concentricity error
   Some of disks showed 2 \( \mu \text{m} \) concentricity.

   Need more study

3. Tool wear

   We need to understand the mechanism of the tool wear.

   1. Intermittent cutting due to alignment notch.
   2. Cutting of corner where rough machining stage surface remains.

   Need more study
Parallelism of standard disks

RDDS1
Component of normal vector \((nx, ny)\)
representing a surface w.r.t the other surface

Histogram of parallelism

Some of the disks were out of tolerance
Concentricity measurement

Residual from circular fitting
(Measurement by Form Talysurf)

Angular distribution of the step
Cutting edges of diamond tools

New tool

Tool wear
Total pass length of each tool for fabrication of all RDDS1 disks
Future subject

1. Production of disks for prototype is established.

2. Some issues such as parallelcity and concenticity should.

3. Studies toward longer tool life should be performed.

4. Reducing the time for cutting process should be studied.