Chapter 10.3

**GNP Chemical-Mechanical Polisher**

(gnpcmp - 582A)

1.0 **Title**
G&P Technology POLI-500 DC Chemical-Mechanical Polisher

2.0 **Purpose**
The G&P Technology POLI-500 DC System is a chemical-mechanical polisher primarily used for polishing aluminum and copper films on 4" wafers. Polishing 6" wafers will be available when 6" wafer carrier is available. Members need to discuss other material and/or substrate size requests with staff.
The system processes wafers serially with manual loading and unloading of each wafer. The chemical-mechanical polishing process uses the combination of chemical and mechanical polishing to planarize wafer surfaces.

3.0 **Scope**
This manual describes how to set up and operate the GNP chemical-mechanical polisher for polishing aluminum and copper films.

4.0 **Applicable Documents**
Revision History
CMP Process Characterization Report 1999

5.0 **Definitions & Process Terminology**
Head1- Polishing head
Head2- Conditioning head
Table- Where pad mounted on platen.
Wafer carrier- Where wafer is mounted for polishing and never should be dry.
Slurry- Polishing chemical which is diluted with D. I. water and other solution.

6.0 **Safety**
All lab members’ slurries have to be approved by Nanolab manager before use. Slurries may contain hazardous materials which require special disposal procedure.
Wafer carrier must soak in DI water at all time.
Water must be dripping at all time to keep pad wet.

7.0 **Statistical/Process Notes**
N/A

8.0 **Available Process, Gases, Process Notes**
**Machine parts**
The tool consists of a polishing pad on the table, polishing swing arm and diamond conditioning swing arm. The polishing swing arm holds the wafer in the wafer carrier, which includes a black foam pad underneath the wafer. The wet wafer is held on the wafer carrier by surface tension.
**Process Notes**

The polishing arm can exert force up to 5 psi. The polishing arm is connected to the arm spindle and the eccentric wheel, which controls the lateral travel of the arm across the pad during polishing. The travel is set by adjusting polishing arm reference center to table platen center.

The polishing pad is mounted onto the polishing table. The pad, (we are currently using an IC1010 stacked composite pad) is made of a porous material adhered to a stiff back structure. If the pad ever dries out, the residual slurry will stick in the pad fibers and destroy the pad. You will also scratch your wafer if you try to run it again. It is critical that the wafer carrier pad and the polishing pad are never dry.

The conditioning arm is used to condition (brush) the pad on the table during or in preparation for wafer polishing. This arm automatically retires after polishing is completed.

The slurry consists of DI water, KOH, ~ 200 nm diameter silicon dioxide particles. When the slurry dries it is difficult or impossible to remove, so it is important that all wafer surfaces stay wet until they are properly cleaned.

9.0 **Equipment Operation**

9.1 Enable the gnpcmp (Figure 1) on the Hydra.

9.2 Turn on circuit breaker switch (Figure 2) on right side panel of gnpcmp.

9.3 The machine should have D. I. H2O dripping on pad at all time.

9.4 Release EPO button.

9.5 Press green power on button.

9.6 Stick slurry line 1 or line 2 into your own premixed slurry bottle. Make sure water pump and slurry pump are on. Adjust to slurry flow rate as you wish, but return to default setting when you are done (See figure 3).

9.7 Dry backside of diamond conditioning head (Figure 5).

9.8 Use both hand, insert diamond conditioning head backside onto head2 and align alignment pins onto head2 pin slots, push up and turn left until pins go into the slotted positions. Use Allen wrench under the system to tighten the conditioning head on head2.

9.9 Press Manual Screen button (Figure 6).

9.10 Condition the pad:

► Set up conditioning parameters as follow:

► Table: 30 rpm

► Head2: 30 rpm

► Polishing Time: 30 sec. (usually this is enough conditioning time to prepare for a uniform polishing preparation.)

► D. I. : On

► OSCII: On

► Head1: Up

► Head2: Down

► Table: On

► Head2: On

► Press Manual Start button: conditioning arm moves and onto the table to condition the pad. When the conditioning ends, it will return to the initial stage.
► Rinse polishing pad and conditioning head with D. I. water hose. Use brush to brush pad while table is turning (press table “ON” and “Manual Start” for table to turn).
► When conditioning is done. Loosen conditioning head with Allen wrench.
► Remove conditioning head, clean it and place it on the left side of the machine.

9.11 Remove wafer carrier (Figure 4) from water container.
9.12 Check if black foam area on wafer carrier is clean. If not, use D. I. spray gun to clean it off. Center wafer on black foam center part of wafer carrier. Press wafer in, twist and turn wafer to get rid of excess water. Wafer is held on by surface tension only.
9.13 Wipe dry the back side of the wafer carrier with texwipes.
9.14 Use both hand, align the pins on the wafer carrier to head1 pin slots. Push up and turn left until alignment pins are locked in position.

9.15 Process your wafers:
► Set up the polishing parameters (Figure 7) as follow:
► Table: 60 rpm (rotate speed can be change in increment of 10 rpm.)
► Head1: 60 rpm (rotate speed can be change in increment of 10 rpm.)
► Pressure: 80 g/cm2 or higher (pressure is change in increment of 20 g/cm2.)
► Polishing Time: 30 sec. (this time is process dependent, usually ≤ 5 minutes.)
► D. I.: Off
► OSCII: Off (Turn OSCII “ON” to center head1 between the center of pad and the right table rim position and then stop the OSCII.)
► Table: On
► Head1: On
► Slurry1: On
► Slurry2: Off
► Head1: Down
► Head2: Up
► Note: Wafer carrier and platen velocity can be adjusted up to ~200 rpm and they can rotate at the various speed. Pressure can set up between 80 ~ 500 g/cm2 for 8” wafers. Polishing Time can be longer than ~999 sec, but it will not be displayed. The gauge on the back of the machine (Figure 8) shows some number which is related to the pressure that apply to the backside of the wafer carrier. When there is no pressure applied to the wafer carrier while the wafer is in contact with the pad, it reads 1.40 on the digital read out; but when there is pressure applied to the backside of the wafer carrier, the reading goes up.

9.16 After polishing is finish, the cmp will go back to initial stage. Rinse the wafer and wafer carrier immediately after head1 stops: Remove wafer carrier with wafer first and then rinse the wafer and wafer carrier. Remove wafer carefully on wafer carrier, rinse the wafer and wafer carrier again. Store wafer carrier back in its storage container and fill it with water. Make sure there is enough water to cover it.

9.17 Repeat the conditioning and polishing procedure as above for each wafer you want to polish.
9.18 When finish polishing, purge the slurry lines: Remove slurry1/slurry2 tube and place it in a container full of D. I. water. Press slurry1/slurry2 button until all slurry are removed in the slurry line.

9.19 Thoroughly rinse and clean off all surfaces - dried slurry is difficult or impossible to clean! Always keep the surfaces clean which include the conditioning head, wafer carrier, pad, platen and the bowl where the slurry spins off. The provided brush can use to clean the pad with plenty of water. Use the brush to clean the pad thoroughly while the table is turning and the D. I. water is dispensing.

9.20 MAKE SURE the WHOLE table is covered with water and water is dripping continuously on the pad.

9.21 Press power off.

9.22 Turn off circuit breaker

9.23 Disable gnpcomp on hydra.

9.24 See Chapter 10.2 on how to use CMPWC in conjunction with CMP to clean your wafers.

10.0 Troubleshooting

10.1 I forgot to put a wafer on the chuck before starting a recipe. What do I do?

Press Manual Stop button on the screen.

10.2 There is no water dripping on the pad. Is this a problem?

YES -- if the pad ever dries out it must be replaced. The pad is expensive, plus it takes time for the staff to replace it. Make sure water is dripping on the pad to keep it wet at all time!

10.4 Helpful Suggestions

10.4.1 Local Non-uniformity

Many users complain about non-uniformity, which is really Within Die Non Uniformity (WIDNU), not within wafer non-uniformity.

Local non-uniformity occurs because of the uneven distribution of patterns to be planarized (up areas) and non-planarized patterns (down areas) within the die. This non-uniformity is reproduced everywhere on the wafer, and is really a matter of design. What I did to trick this was that I included dummy structures on my design to roughly get a uniform distribution of Up and Down areas (~ 50%). I got way better results than what I did with previous designs.

But it is still not enough, since I do not have a hard etch stop. So, at this point, other parameters to play with are the speed of the pad, and the pressure applied. Basically, each design requires a little trimming of the recipe to minimize WIDNU. I can improve that by modifying the recipe a little.

10.4.2 Within Wafer Non-Uniformity

Pressure is a very efficient parameter when within wafer uniformity is critical. Less pressure, however, produces a lower removal rate but does provide better uniformity. Minimum down force for polish is 80 g/cm².

10.4.3 Monitoring

For any monitoring purpose, I would advise to just run blanket removals on Al or Cu, and measure uniformity to assess the machine is operating as expected.

11.0 Figures & Schematics
12.0 Appendix

Planarization of Al

Using the proprietary Cabot A7100 alumina based slurry with the following recipe planarization uniformity on a 6” wafer is ~ 0.3% and the etch rate is ~ 130 nm/min.

Five minutes of conditioning:

<table>
<thead>
<tr>
<th>GNPCMP parameters</th>
<th>Table on</th>
<th>Oscil on</th>
<th>Head1 off</th>
<th>Slurry1 off</th>
<th>Slurry2 on</th>
<th>Head1 on</th>
<th>Oscil on</th>
<th>Head2 on</th>
<th>Slurry1 on</th>
<th>Slurry2 on</th>
<th>Pressure</th>
<th>Head2 down</th>
<th>Head1 down</th>
<th>Manual Start on</th>
<th>Manual Stop off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table on</td>
<td>40 rpm</td>
<td>Oscil on</td>
<td>35 rpm</td>
<td>Slurry1 off</td>
<td>Slurry2 on</td>
<td>35 rpm</td>
<td>Oscil on</td>
<td>35 rpm</td>
<td>Slurry1 on</td>
<td>Slurry2 on</td>
<td>100 g/cm²</td>
<td>Head2 down</td>
<td>Head1 down</td>
<td>Manual Start on</td>
<td>Manual Stop off</td>
</tr>
<tr>
<td>Polishing time</td>
<td>340 sec</td>
<td>Oscil on</td>
<td>340 sec</td>
<td>Slurry1 on</td>
<td>Slurry2 on</td>
<td>340 sec</td>
<td>Oscil on</td>
<td>340 sec</td>
<td>Slurry1 on</td>
<td>Slurry2 on</td>
<td>90 sec</td>
<td>Head2 down</td>
<td>Head1 down</td>
<td>Manual Start on</td>
<td>Manual Stop off</td>
</tr>
</tbody>
</table>

(Slurry2 is connected to DI-H₂O)

Planarization

<table>
<thead>
<tr>
<th>GNPCMP parameters</th>
<th>Table on</th>
<th>Oscil on</th>
<th>Head1 on</th>
<th>Slurry1 on</th>
<th>Slurry2 on</th>
<th>Pressure</th>
<th>Head2 down</th>
<th>Head1 down</th>
<th>Slurry1 on</th>
<th>Slurry2 on</th>
<th>Polishing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table on</td>
<td>30 rpm</td>
<td>Oscil on</td>
<td>30 rpm</td>
<td>Slurry1 on</td>
<td>Slurry2 on</td>
<td>80 g/cm²</td>
<td>Head2 down</td>
<td>Head1 down</td>
<td>Slurry1 on</td>
<td>Slurry2 on</td>
<td>90 sec</td>
</tr>
</tbody>
</table>

(By lab convention Slurry1 line is for alumina based slurries and the Slurry2 line is for silica based slurries.)
For this recipe, slurry line 1 is connected to the Cabot A7100 and slurry line 2 is connected to DI-H₂O.

To clean the wafer of all alumina grit, wash it with DI-H₂O from the nearby deck hose, then wipe it with a PVA sponge soaked with dilute (10%) NH₄OH. Next, put the wafer in the same dilute NH₄OH for 10 minutes. Finally, ultra-sound in DI-H₂O for 1 minute.

Planarization of Ni

Besides the pad conditioning, there are two steps to this recipe. First, chemical/mechanical planarization using an alumina based Eminess Ultra-Sol 200A slurry (user supplied) with the Dow IC1000 pad underneath. Second, a purely mechanical polish to minimize the micro-cracks using a Polytex black pad (user supplied) and a silica based Logitech SF1 slurry (user supplied). Post-CMP Ni height uniformity was ~ 0.1%. The etch rate is ~ 110 nm/min. The problem of micro-scratch roughness can be improved by repeating the mechanical polishing of step three in the recipe below.

Five minutes of conditioning:

**GNPCMP parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table on</td>
<td>40 rpm</td>
</tr>
<tr>
<td>Head1 off</td>
<td>35 rpm</td>
</tr>
<tr>
<td>Head2 on</td>
<td>35 rpm</td>
</tr>
<tr>
<td>Pressure</td>
<td>100 g/cm²</td>
</tr>
<tr>
<td>Polishing time</td>
<td>340 sec</td>
</tr>
</tbody>
</table>

(note Slurry2 is connected to DI-H₂O)

Planarization

**GNPCMP parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table on</td>
<td>30 rpm</td>
</tr>
<tr>
<td>Head1 on</td>
<td>30 rpm</td>
</tr>
<tr>
<td>Head2 on</td>
<td>30 rpm</td>
</tr>
<tr>
<td>Pressure</td>
<td>80 g/cm²</td>
</tr>
<tr>
<td>Polishing time</td>
<td>90 sec</td>
</tr>
</tbody>
</table>

(By lab convention Slurry1 line is for alumina based slurries and the Slurry2 line is for silica based slurries. For this recipe, slurry line 1 is connected to the Eminess Ultra-Sol 200A slurry and slurry line 2 is connected to DI-H₂O.)

Polish

**GNPCMP parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table on</td>
<td>10 rpm</td>
</tr>
<tr>
<td>Head1 on</td>
<td>10 rpm</td>
</tr>
<tr>
<td>Head2 off</td>
<td>10 rpm</td>
</tr>
<tr>
<td>Pressure</td>
<td>80 g/cm²</td>
</tr>
<tr>
<td>Polishing time</td>
<td>600 sec</td>
</tr>
</tbody>
</table>

(By lab convention Slurry1 line is for alumina based slurries and the Slurry2 line is for silica based slurries. For this recipe, slurry line 1 is connected to DI-H₂O and slurry line 2 is connected to Logitech SF1 silica-based slurry.)
Again, to clean the wafer of all alumina grit, wash it with DI-H₂O from the nearby deck hose, then wipe it with a PVA sponge soaked with dilute (10%) NH₄OH. Next, put the wafer in the same dilute NH₄OH for 10 minutes. Finally, ultra-sound in DI-H₂O for 1 minute.

Planarization of Cu

Pad: IC1010 - OR - IC1000
Slurry: NP1000MS (Nitta Haas, Inc) - Mixed with peroxide (NP1000MS:H₂O₂) (100:76.5) at time of use.
Table: 40rpm
Head: 30rpm
Pressure: 1.25 psi (setting 100 for 6")
Slurry dispense: 200 mL/min
Cu Removal rate: ~ 1um/min