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COMPARISON OF THICK COPPER PLATING RESULTS WITH LABORATORY AND INDUSTRIAL ELECTROPLATING TOOLS.

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INTRODUCTION

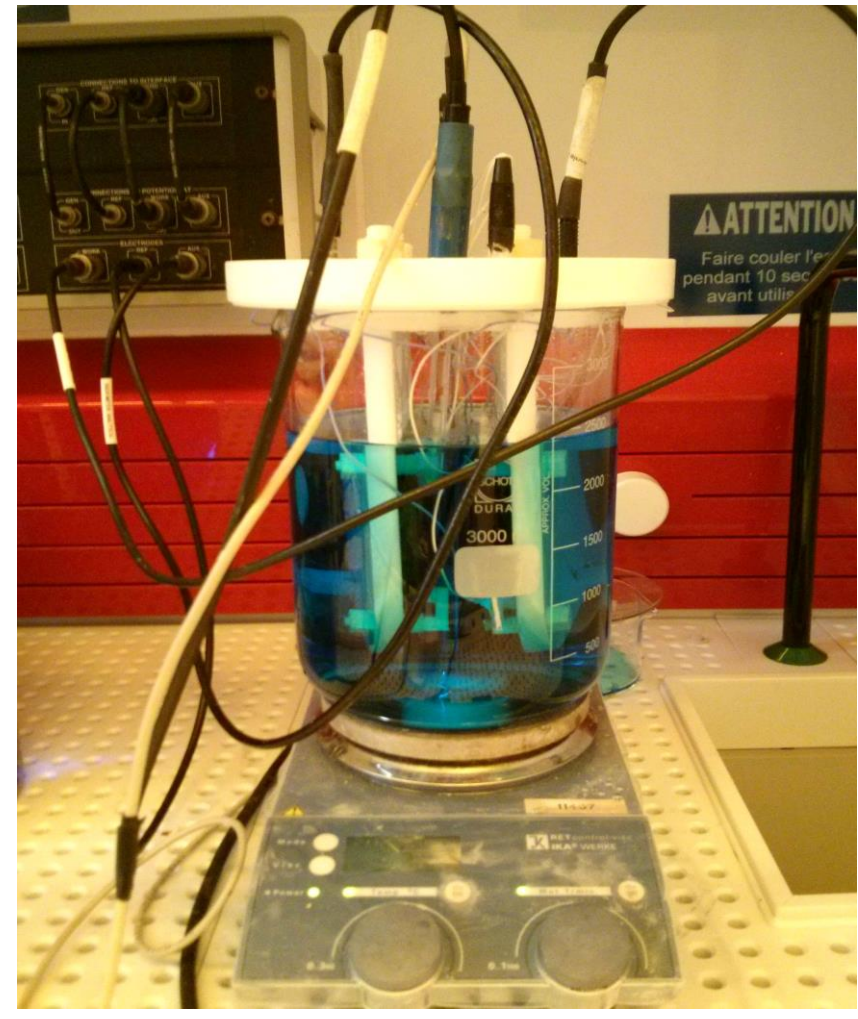
New power components, 3D inter-connexion, RDL, TSV... needs thicker and thicker metal layer. Electrochemistry is one of the most appropriate technology able to answer these needs by supplying metal plating from 1um to 500um thickness in accordance to any resist mold, design and shape, especially very high aspect ratio. However, the difficulty of electroplating processes resides in plating very thick metal layer while keeping a good inhomogeneity rate on the whole surface.

In order to reach this goal and complete our electroplating facilities, we purchased a new plating tool made by a Japanese company called YAMAMOTO. This paper will introduce the first experiments we made with this equipment on thick copper plating and compare the results between our actual facilities and this new reactor.

EQUIPMENT

BEAKER

- Basic hand-made reactor for 4"
- 2,5L Table-top equipment.
- Flow ensured by magnetic stirring
- Wafer stand motionless in front of the anode
- Use soluble copper anode.
- Four metallic electric contact.



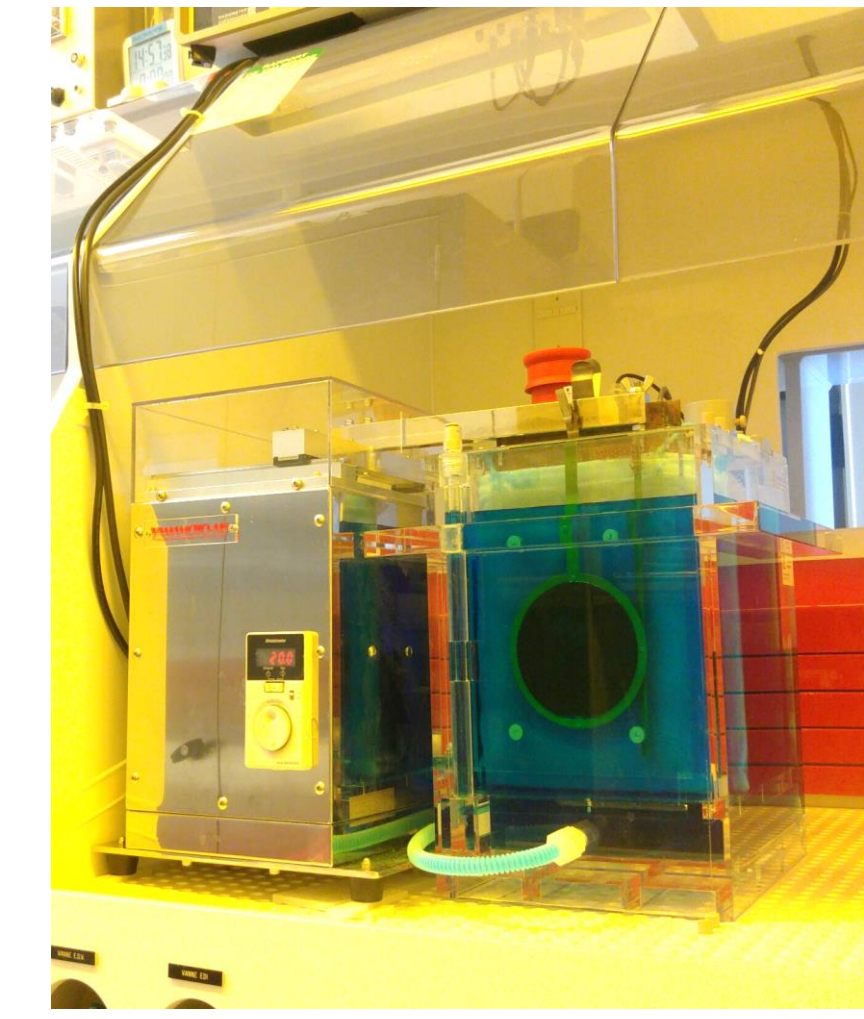
INDUSTRIAL RENA

- Industrial reactor for 4" and 6" wafers.
- 25L integrated equipment.
- Flow ensured by electrolyte pumping.
- Wafer motionless perpendicularly to the flow.
- Use insoluble platinum anode.
- Adaptable distance between the wafer and the anode.
- Electric contact crown.



YAMAMOTO PLATING SET

- 4" and 6" industrial equipment.
- 13L Table-top equipment,
- Flow ensured by electrolyte pumping.
- Stirring ensured by a rocking paddle.
- Wafer motionless in front of the anode.
- Use soluble copper anode.
- Adaptable distance between the wafer and the anode.
- Eight electric contacts



METHODOLOGY

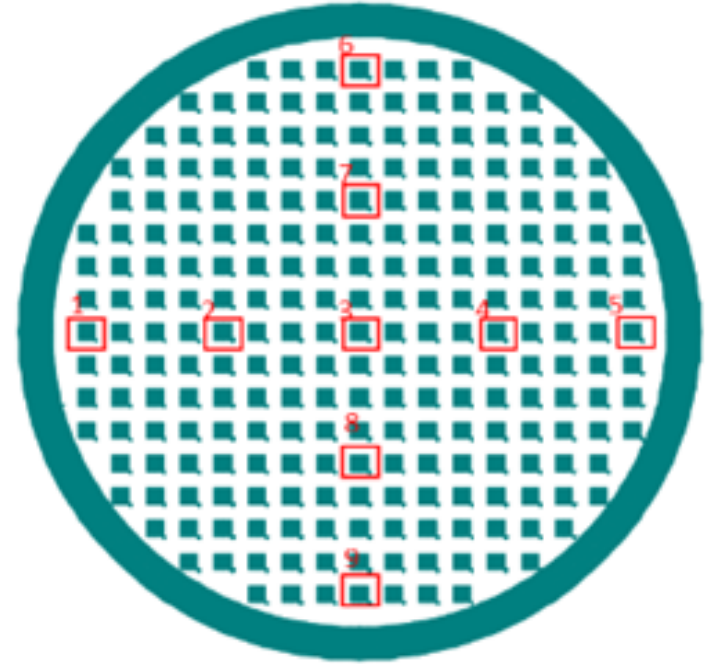
SETTINGS ADJUSTABLE ON EQUIPMENT

In order to conduct this study on each tool, we varied the following parameters using two different mask design:

Settings to adjust	Beaker	Vertical RENA	Yamamoto
Flow rate	no	21 - 26L/min	no
Distance wafer/anode	no	0,5 - 12mm	20 - 40mm
Stirring speed	100 - 1000 rpm	no	25 - 105 rpm

IDEALLY DISPERSED DESIGN

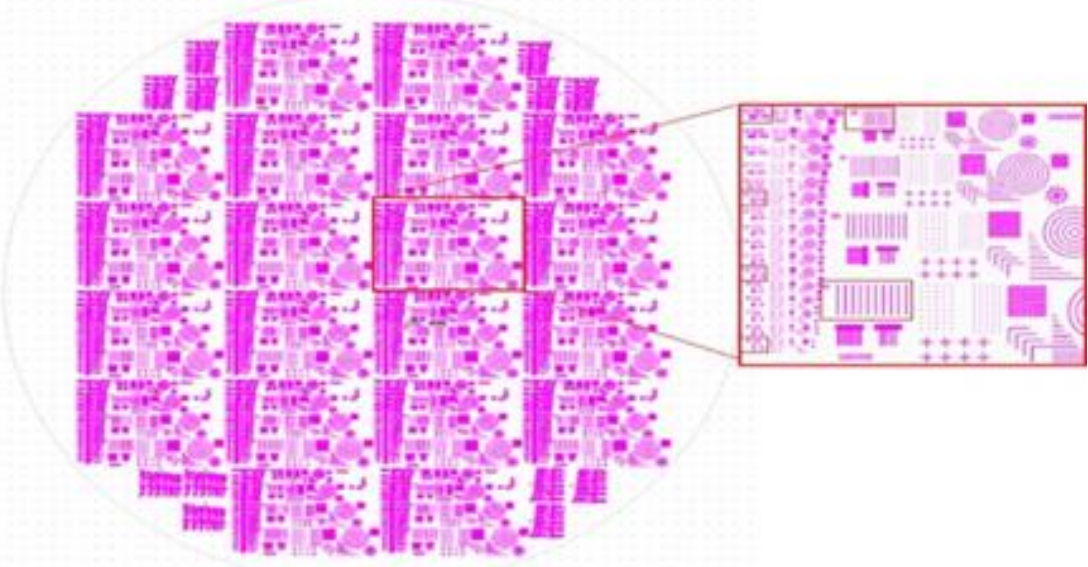
The first mask design has 2.5mm squares ideally dispersed on the wafer.



With this mask, we varied several parameters on each tool according to our bath restrictions before measuring thickness on 9 points ideally dispersed on the wafer, these measurements allowed us to determine the optimum parameters to reach the best metal distribution rate with ideally dispersed design:

Then we used these optimum parameters to do a 20um thickness plating on non-ideally dispersed design.

NON-IDEALLY DISPERSED DESIGN



The second mask has design with different shapes (lines, squares, circles...) and sizes (from 5um to 60um) non-ideally dispersed on the wafer, according to micro fabrication processes with different sized components.

On the second mask, we measured the thickness of all the 5,10,15,20,30 and 60um lines dispersed on the wafer which represent 120 measurements points.

CALCULATION METHOD

$$\text{Inhomogeneity}(\%) = \frac{\text{max value} - \text{min value}}{\text{average value}} \times 100$$

CONCLUSION AND PERSPECTIVES

Our experiment helped us to determine that all our plating tools are able to reach a good metal distribution rate, even if our results are unequal. In fact, Beaker and RENA tools are efficient, but still have an important inhomogeneity on non-ideally dispersed design. To fill this gap, we tried the YAMAMOTO Japanese plating set which has just come to the European market.

Even with our first experiment, we already obtained as good or better results than with our actual equipment. We succeeded not only to reach the best metal distribution thickness rate with any design shape or width, but we also found the most flexible equipment which allow us to easily transfer optimum parameters to a new design while keeping good results without doing a new optimization each time. Last but not least, the compact shape of the YAMAMOTO plating set allows us to easily change the plating bath and give us a full access if maintenance is needed.

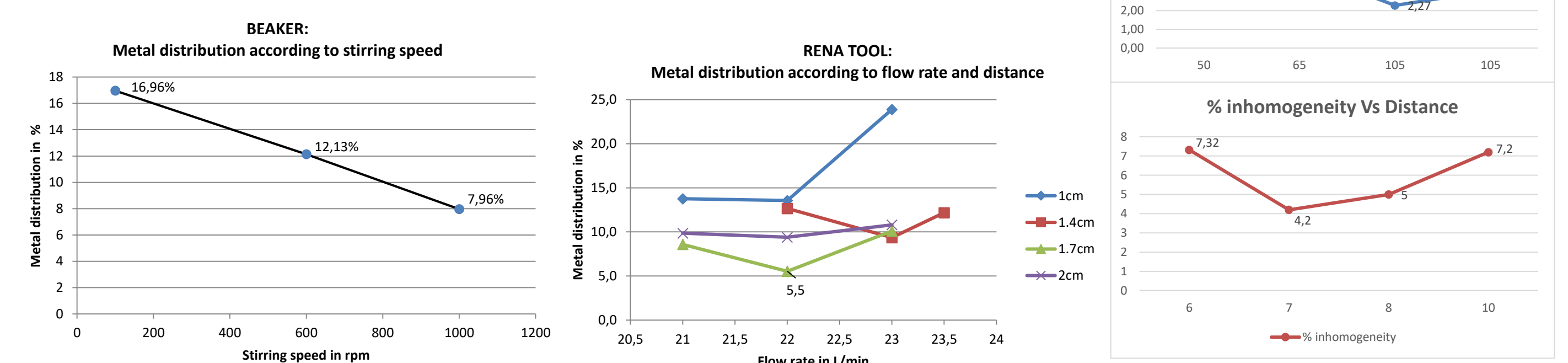
RESULTS

By varying each parameter, we were able to find the optimum plating parameters which allow us to reach the best metal distribution rate on 45 um thickness copper layer and 20um thickness (non-ideally dispersed design) :

Optimum parameters	Beaker	Vertical RENA	Yamamoto
Flow rate	no	22L/min	no
Distance wafer/anode	no	2,7mm	21,5mm
Stirring speed	1000 rpm	no	105 rpm

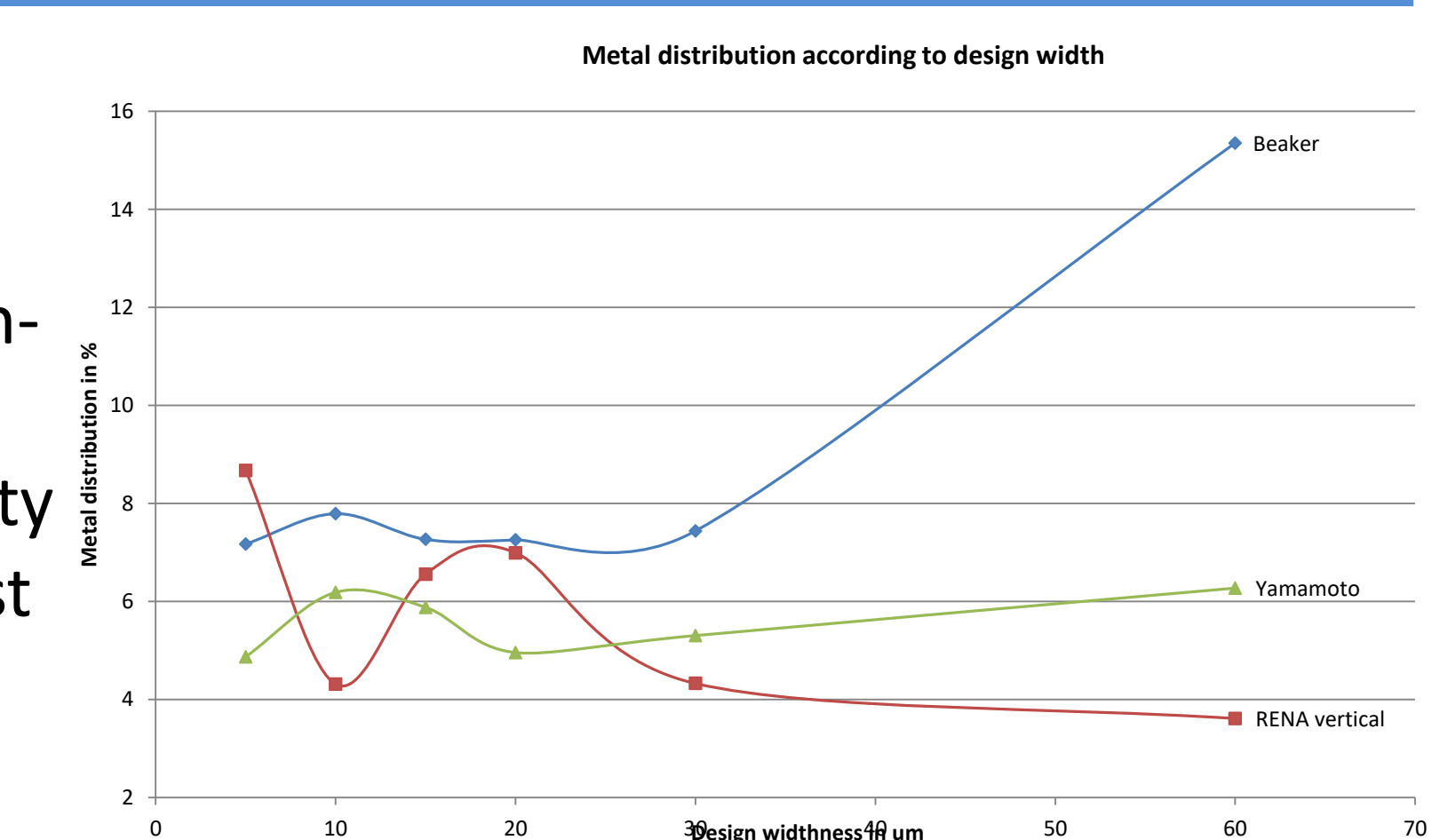
IDEALLY DISPERSED DESIGN

The following figure show the metal distribution according to several parameters on ideally dispersed design, these figure allowed us to find the optimum parameters:



NON-IDEALLY DISPERSED DESIGN

The following figure show the inhomogeneity evolution according to design width on non-ideally dispersed design. We can notice that inhomogeneity gap between biggest and smallest design is clearly more important on the beaker, than with other equipment.



Global Inhomogeneity	Beaker	Vertical RENA	Yamamoto
Ideally dispersed design	7,9%	5,5%	2,3%
non-ideally dispersed design	32,8%	23,5%	8%