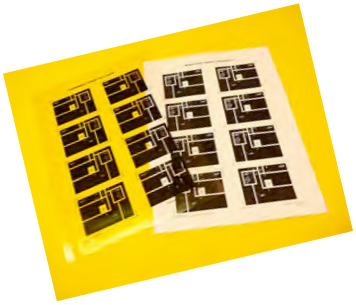
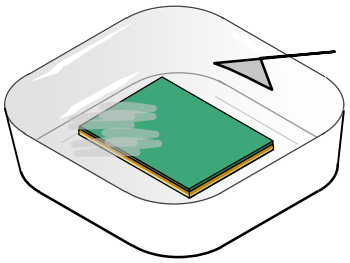
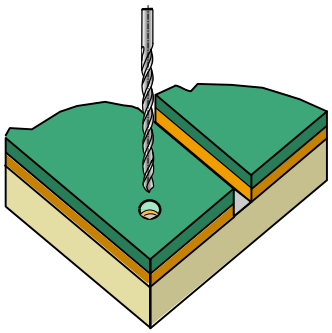
centre de développement pédagogique
pour la formation générale en science et technologie

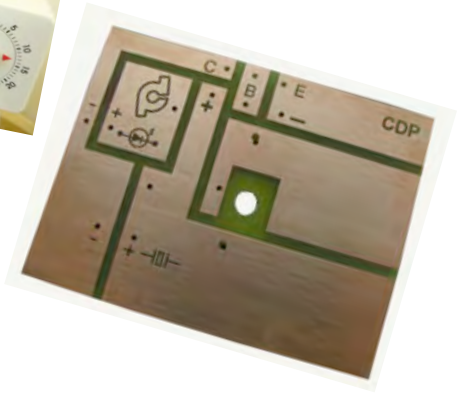
Working document

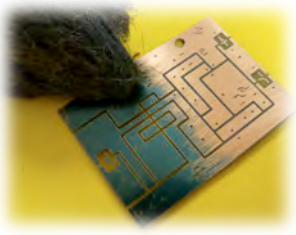
MAKING A PRINTED CIRCUIT PLATE

This technical file is intended for technical or teaching personnel







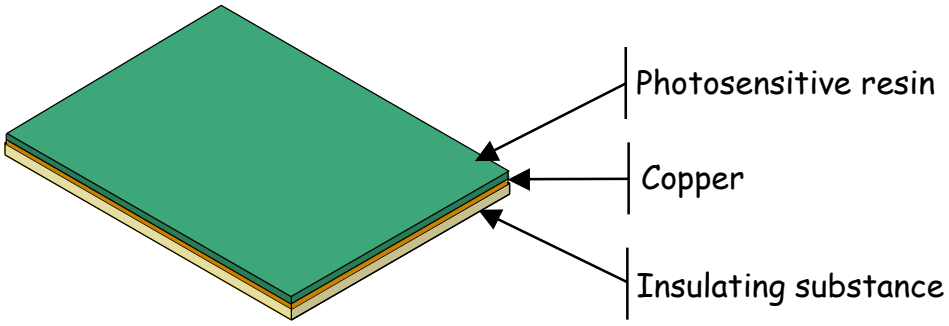
APRIL 2012

MAKING A PRINTED CIRCUIT PLATE

To make a printed circuit, we will use an insulated plate covered with a thin layer of copper, a ribbon of copper or copper wafers. There are two types of plates:

- The standard plate (bakelite or epoxy plate covered with a thin layer of copper).
- The pre-sensitized or photo-sensitive plate (the type of plate we will use for this project).

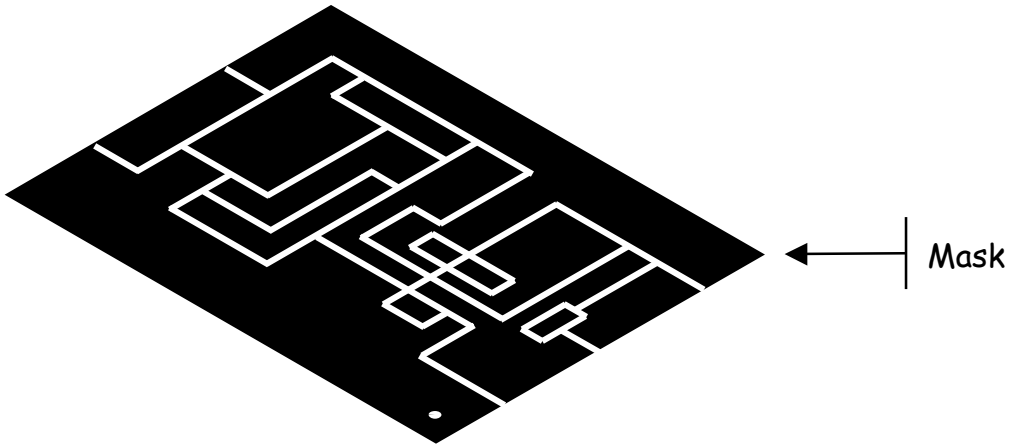
Photosensitive plates are made up of three distinct layers. The first layer, usually green, is a resin sensitive to ultraviolet rays (photosensitive resin). The second is a thin layer of copper, which is an excellent electrical conductor. The last layer is made from an insulating, heat-resistant substance (example: thermosetting plastics such as epoxy or fibreglass).



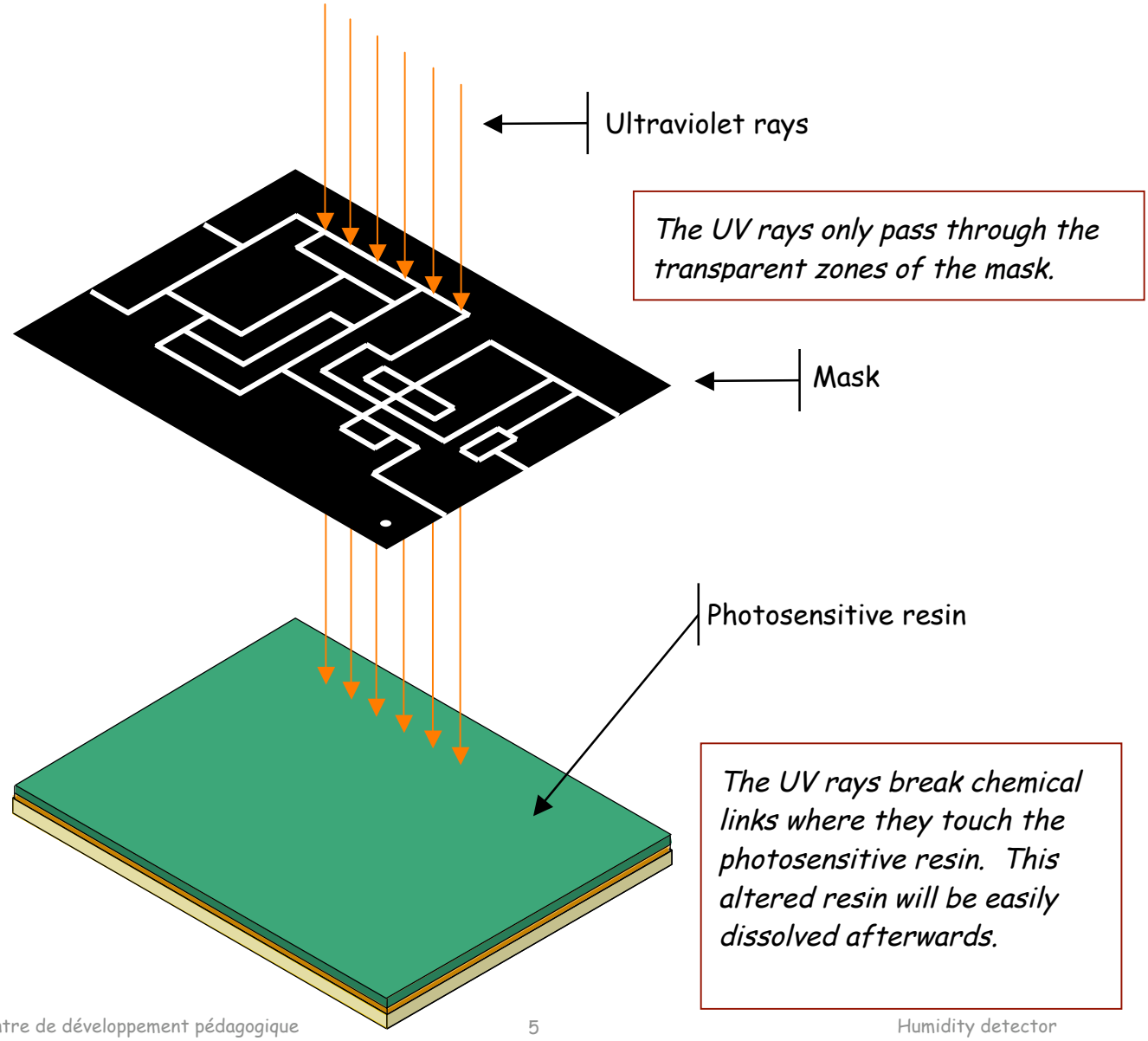
Here is a summary of the process you will use when you make the printed circuit plate for the humidity detector. This process has seven steps:

1. printing the mask on a transparent acetate (reticle);
2. exposing the photosensitive resin using ultraviolet rays (UV);
3. developing the plate (dissolving the photosensitive resin exposed to the UV rays);
4. engraving the circuit by withdrawing the copper not protected by the photosensitive resin;
5. drilling the holes (this step may be carried out at the end of the process);
6. baring the copper by withdrawing the rest of the non-exposed photosensitive resin;
7. tinning the copper to prevent oxidation and for ease of soldering.

1- **Printing the mask** on a transparency (acetate)

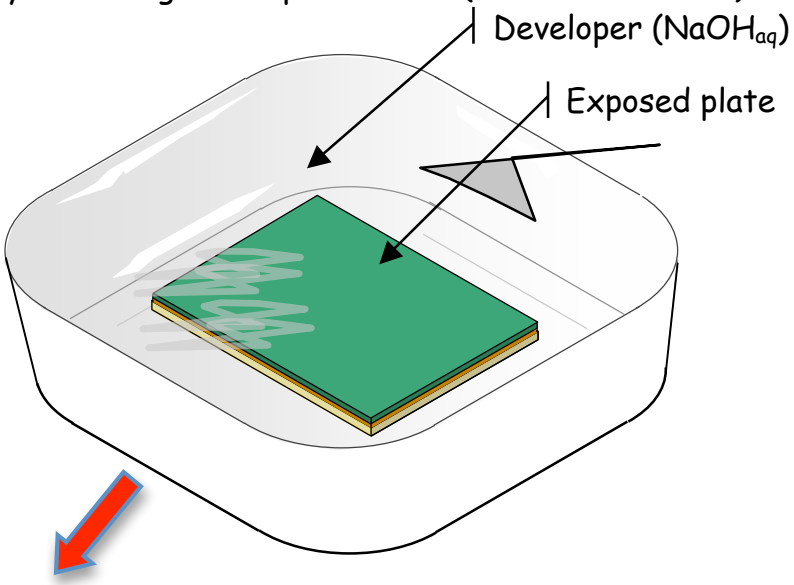


2- Exposing the photosensitive resin using ultraviolet rays

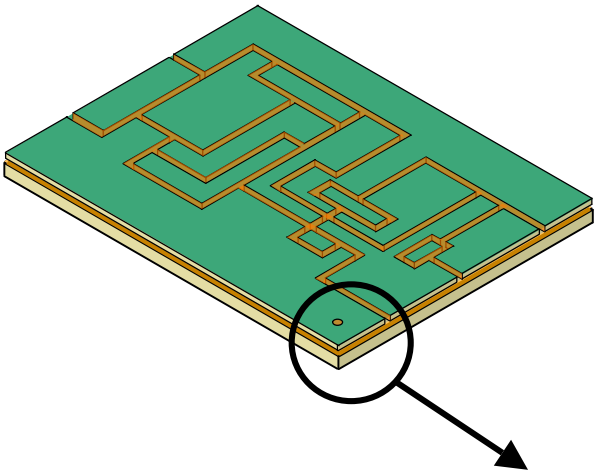


3- Developing the plate by dissolving the exposed resin (chemical reaction)

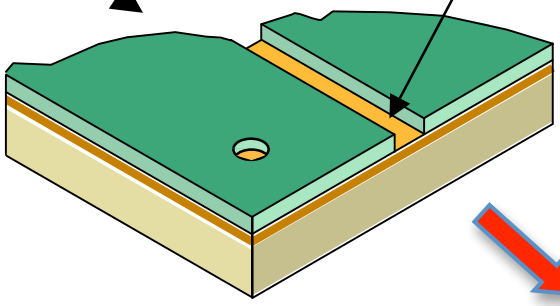
The exposed resin is dissolved by the developer.



The copper appears and forms a pattern in the



This copper is no longer protected by the resin.

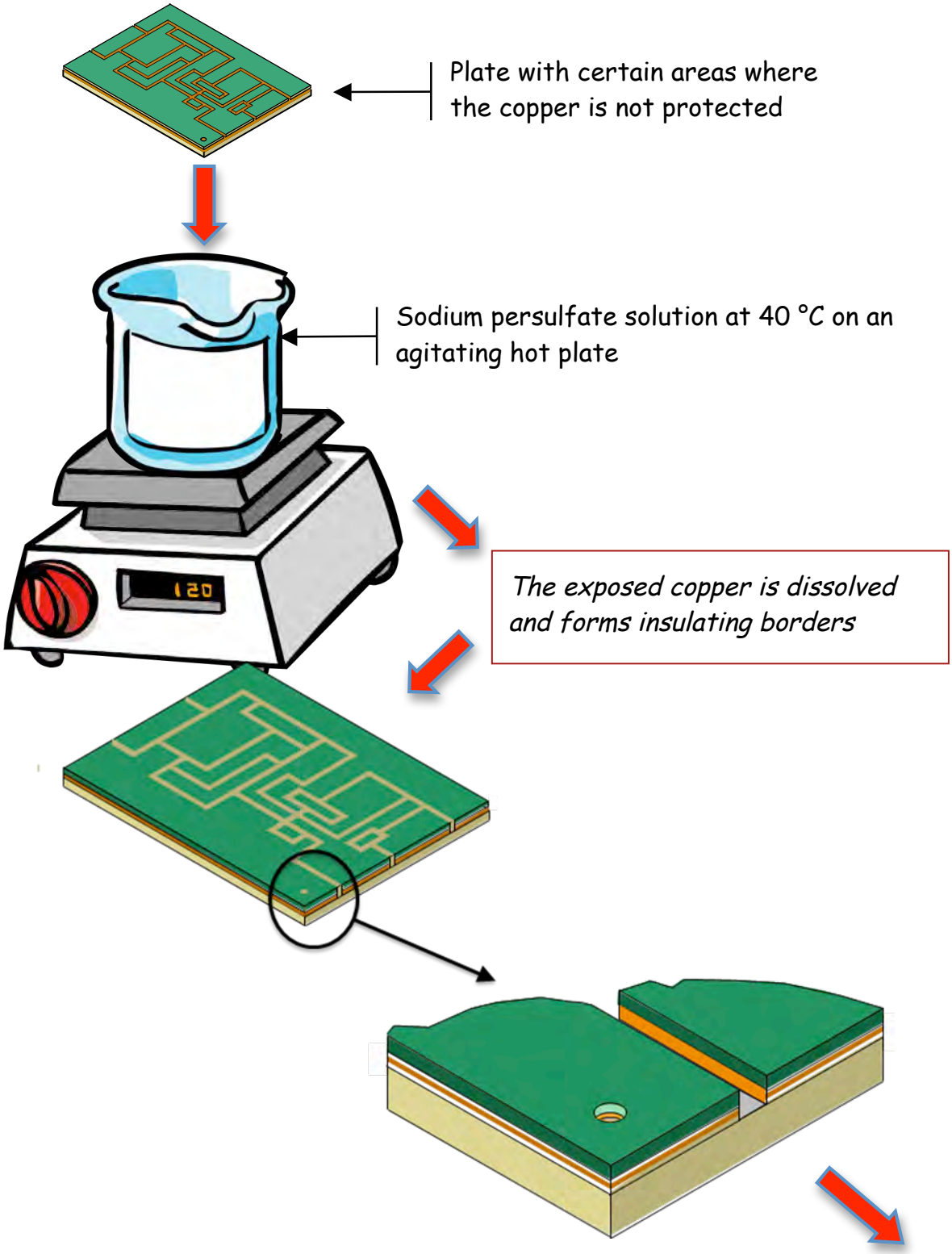


Rinsing with water

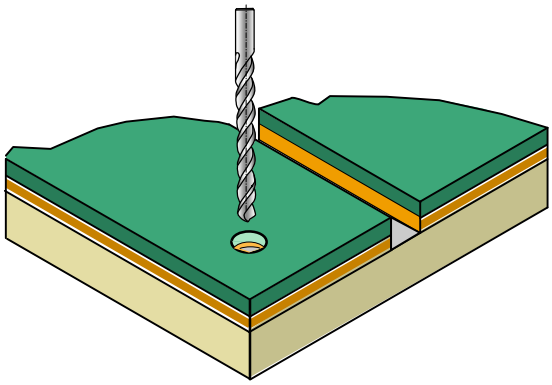
Careful! *At this stage, the resin is fragile - the plates must be handled with care. Any potential scratch could cause a defect in the circuit.*

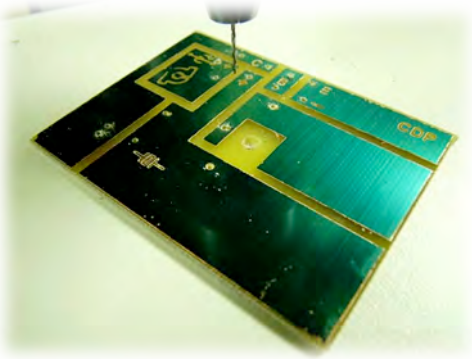
4- Engraving the plate by withdrawing the non protected copper (chemical reaction)

It is recommended that you perform this step under a hood.



5- Drilling the holes





Note: *This is the ideal time to drill the holes needed to affix the components onto the plate (the holes are very visible and the bit can be guided by them). It is possible, however, to perform this step at the end of the process.*

6- **Baring the copper** by withdrawing the remaining resin

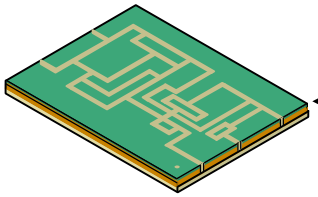
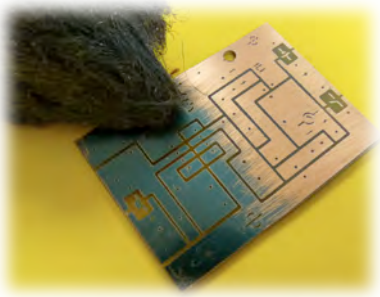


Plate made up of well delimited conductive areas, covered with resin.

The resin is completely withdrawn by rubbing with steel wool.



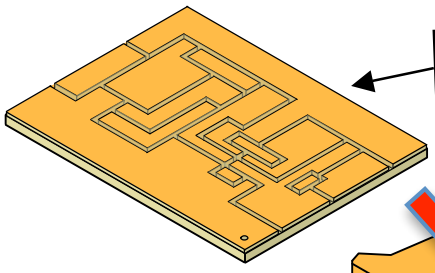
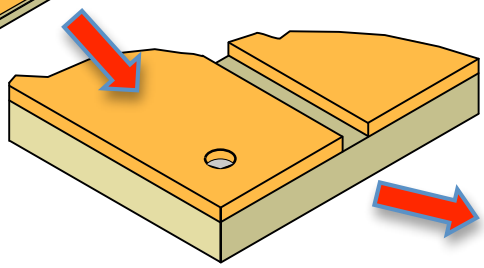


Plate made of well-defined conductive copper areas and of insulating borders.



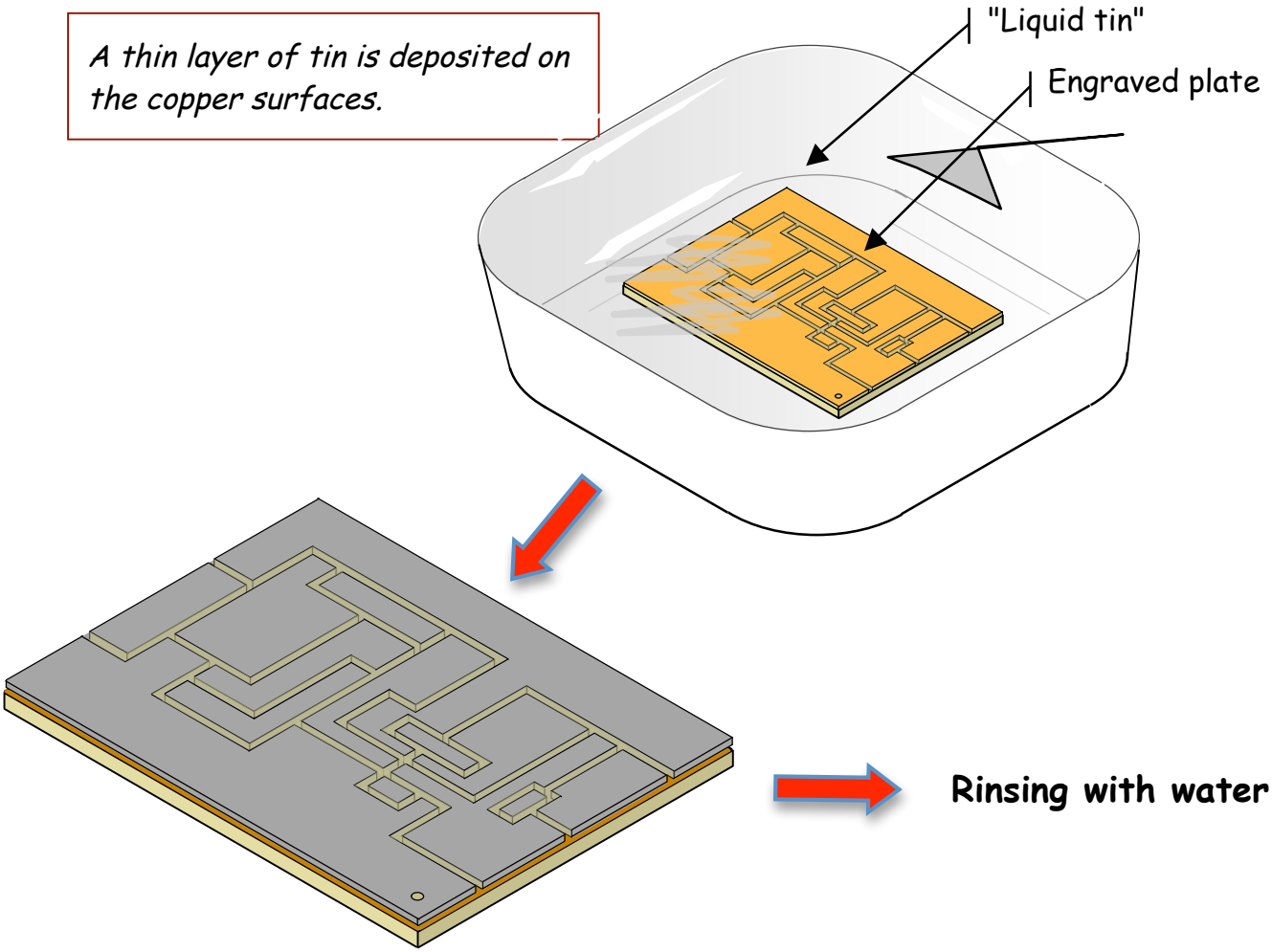
Rinsing with water

Careful! *At this stage, the copper surface must remain perfectly clean. Avoid touching the copper with your fingers, since the oil on them may contaminate the surface and prevent the tin from adhering at the next step.*

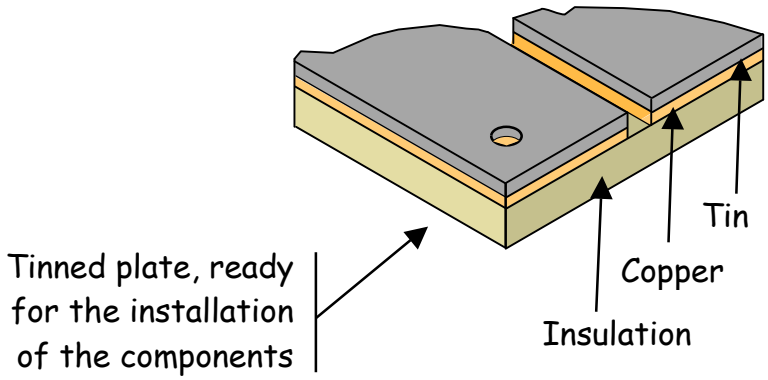
7- Tinning the plate using a "liquid tin" solution

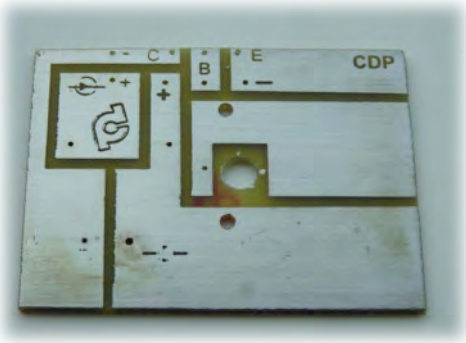
It is recommended that you perform this step under a hood.

A thin layer of tin is deposited on the copper surfaces.



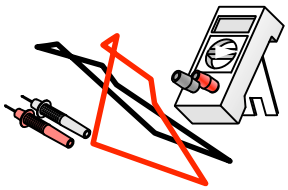
Note: *This tin layer prevents the copper from oxidation and prepares the plate for tin soldering the components.*



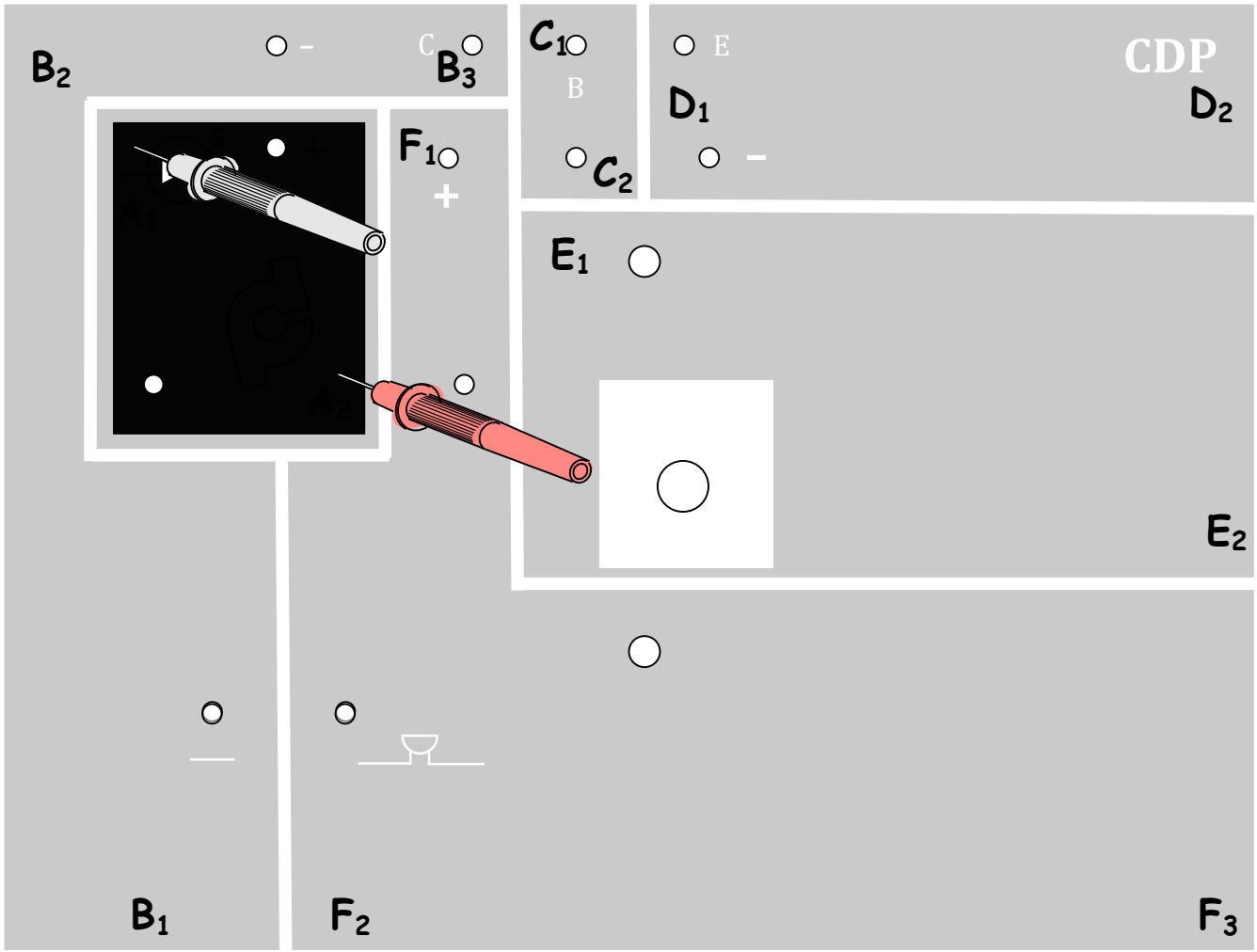


CONTROLLING THE STATE OF CONDUCTIVITY OF THE PRINTED CIRCUIT PLATE FOR THE HUMIDITY DETECTOR

Here is the printed circuit for the humidity detector. The grey areas are conductive and tinned. The white lines are insulating borders stripped of conductor.



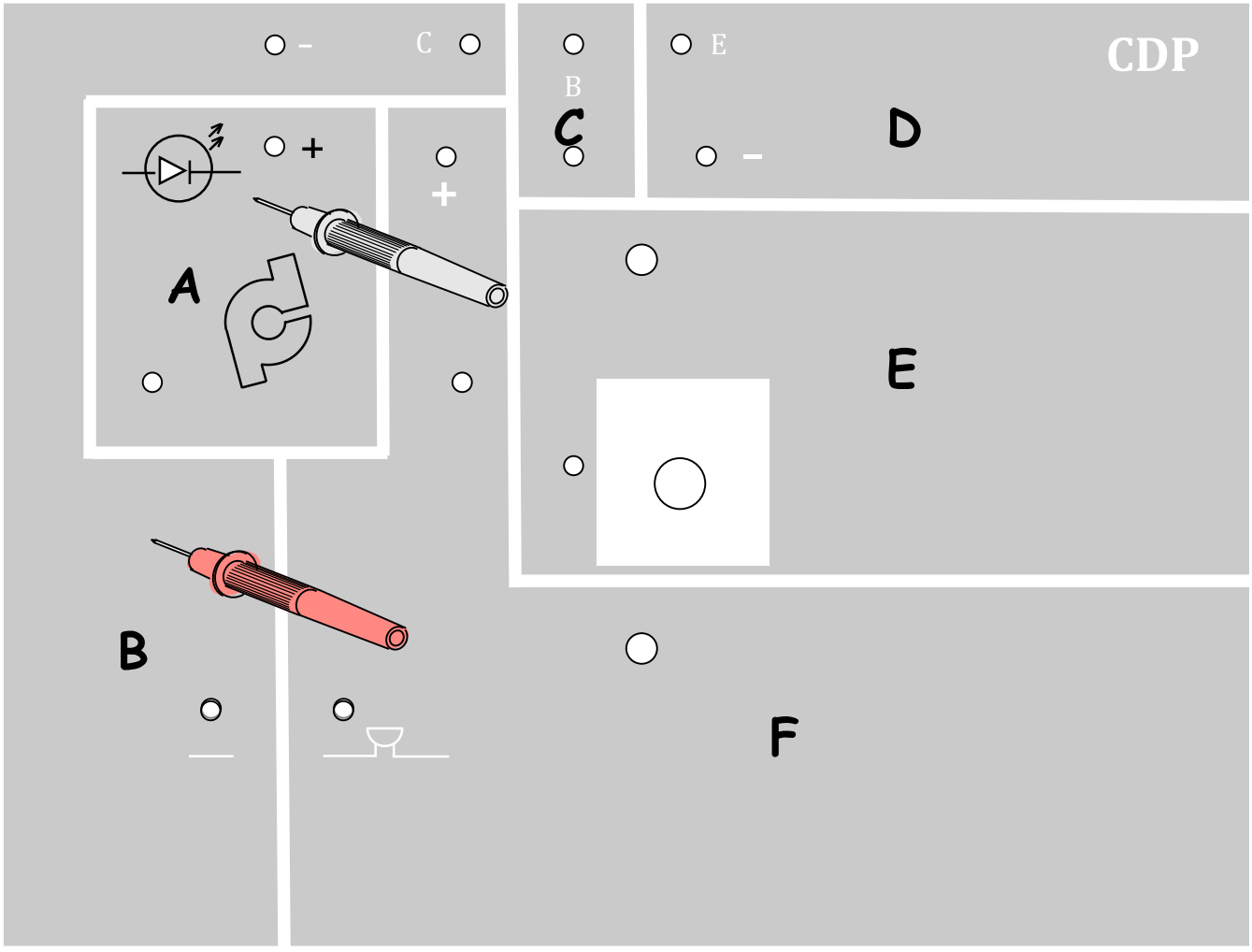
First, we must verify the electrical conductivity of each area. A fabrication defect may arise if the photosensitive resin is scratched before the engraving stage. Let's take textured area "A" below as an example: we need to test the conductivity between two distant points using a multi-meter in conduction mode. If the conductivity is good, we tick the control points in the table below. When the area has a more complex shape, additional measurements are necessary. If there were a defect, a dab of solder may re-establish conduction.



Verification table for good conductivity in each area							
Control points	✔	Control points	✔	Control points	✔	Control points	✔
A_1 to A_2		B_1 to B_2		B_1 to B_3		C_1 to C_2	
D_1 to D_2		E_1 to E_2		F_1 to F_2		F_2 to F_3	

VALIDATING THE INSULATING BORDERS BETWEEN THE CONDUCTIVE AREAS OF THE PLATE FOR THE HUMIDITY DETECTOR

Secondly, we need to **test if the borders insulate correctly**. A fabrication defect may arise when we superimpose the masks or when we print them.
This time, we need to check that electrical current does not travel between adjacent areas (see example below between areas **A** and **B**). If the insulation is adequate, we will tick the control points in the table below. If there were a defect, it would be possible to separate the two areas by scratching the borders using the point of a plastics knife.



Verification table for border insulation							
Control points	✔	Control points	✔	Control points	✔	Control points	✔
A and B		A and F		B and C		B and F	
C and F		C and D		C and E		C and F	
D and E		E and F					

TROUBLE SHOOTING COMMON PROBLEMS

(while making the plate)

Problem	Cause of the problem	Solving the problem
The plate develops poorly or not at all	1. Exposure time too short.	▪ Increase exposure time.
	2. Development time too short.	▪ Increase developer time.
	3. "Developer" solution past expiry date or saturated.	▪ Change the solution.
	4. Plate past expiry date.	▪ Change the plate lot.
Unfocused development	1. Dirty mask.	▪ Check the print quality from the printer.
		▪ Check the superimposition of the transparencies (acetates).
	2. Poor contact (space) between the mask and the plate.	▪ Improve the pressing.
		▪ Check that the mask is well affixed in the frame.
	3. Poor position of the UV lamp.	▪ Position the lamp in such a way that the UV rays hit the surface perpendicularly.
Circuit cut after engraving	1. Cut on the mask.	▪ Poor photocopy, so copy a new mask.
		▪ Mask deterioration - make a new mask.
		▪ Check the position of the UV lamp.
		▪ Solder a bridge (piece of wire) on the plate to re-establish the conductivity of the circuit.
	2. Scraped photosensitive resin before the engraving stage.	▪ Solder a bridge (piece of wire) on the plate to re-establish the conductivity of the circuit.

TROUBLE SHOOTING COMMON PROBLEMS

(while making the plate) (continued)

Problem	Cause of the problem	Solving the problem
Insulated borders too wide or conductive zone (coppered parts) perforated with a large number of small holes after engraving	1. Mask insufficiently opaque.	▪ Control the opacity when printing.
		▪ Superimpose two masks to increase opacity.
	2. Exposure time too long.	▪ Diminish exposure time.
	3. Engraving time too long.	▪ Diminish engraving time.
Development adequate, but engraving insufficient	1. Engraving time too short.	▪ Increase engraving time.
	2. Saturated sodium persulfate.	▪ Change the solution.
No engraving	1. There is resin left on the plate.	▪ Increase the exposure or development time.
	2. Saturated sodium persulfate.	▪ Change the solution.
Insulating borders reduced when engraved	1. Poor contact with the mask.	▪ Improve pressing.
		▪ Increase the width of the borders using the point of a plastics knife.

(Source : *jacques.boudier.pagesperso-orange.fr/.../cours/cours_01.pdf)*

In order to avoid contamination caused by the products from the various stages (development, engraving, etc.) it is preferable to have different rinsing containers for each step. In addition, it would be better to identify the containers with the step where they will be used.

PREPARING THE MATERIALS AND SOLUTIONS

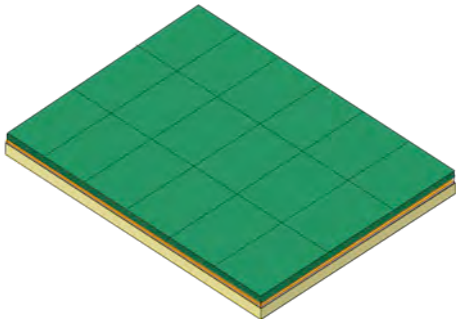
Cutting the circuit plates

Materials required:

- Band saw with a blade for cutting metal (18 teeth per inch)
- Permanent marker
- Ruler
- 8 X 12 circuit plate
- Safety glasses
- Mask

How to proceed:

1. Install the metal cutting blade onto the band saw.
2. Measure and divide the plate in order to get 18 sections.
3. Cut the plate with the band saw.
4. File the edges of the plates (if necessary).



Recommendations when cutting or filing:

1. Close the trap connecting the saw to the dust collector. The purpose is to avoid potential sparks from enflaming the wood sawdust contained in the dust collector.
2. If there is not a trap, do not use the dust collector while cutting and ensure that the area is well ventilated.
3. Wear a mask and safety glasses while cutting.
4. Use the same precautions if the use of the sander is required.

Note: Closing the trap on the saw and leaving the dust collector on ensures the area is well ventilated through the other machine tools.

PREPARING THE MATERIALS AND SOLUTIONS

(continued)

Preparing the solutions

Materials required:

- Safety glasses
- Scale
- Weighing tray
- Spatula
- 1L graduated balloon
- 100 mL graduated cylinder
- Eye-dropper (or transfer pipette)
- 1000 mL beaker
- Agitating hot plate and magnet (magnetic bar)
- Distilled water

1. **"Developer" developing solution:**

   NaOH aqueous solution with a concentration of: 0.3 mol/L

   Recipe: 12 g of NaOH for 1L of solution

   or

   Commercial "developer" solution (electronics supplier)

   Recipe: 1 part concentrated solution in 10 parts distilled water

2. **Solution for engraving: sodium persulfate**

   Recipe: 250 g in 1000 mL of distilled water

3. **Tinning: Liquid tin**

   Bought at an electronics supplier

IMPORTANT: Recycling these products must respect the regulations and procedures in the school, school board, etc.