عنوان البحث

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Abstract

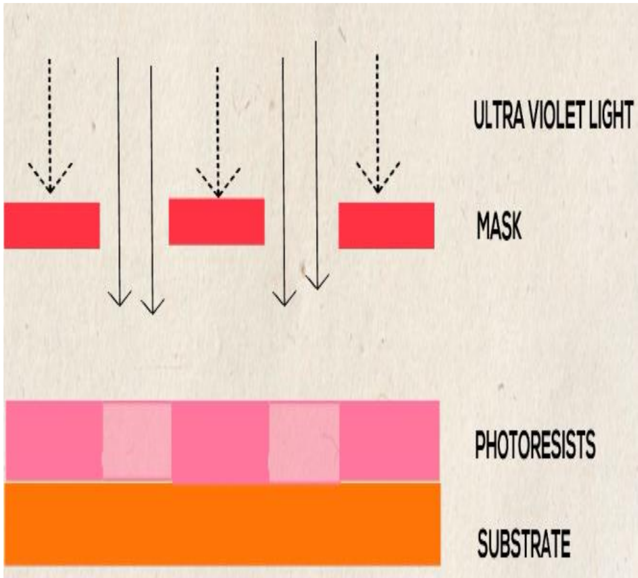
Photolithography or printing with light, is a process used in microfabrication to pattern parts on a thin film or the bulk of a substrate (also called a wafer). It uses light to transfer a geometric pattern from a photomask (also called an optical mask) to a photosensitive (that is, light-sensitive) chemical photoresist on the substrate. A series of chemical treatments then either etches the exposure pattern into the material or enables deposition of a new material in the desired pattern upon the material underneath the photoresist.

Introduction

Lithography is a word that comes from ancient Greek meaning printing with stones with this technique a stamp is made by carving a pattern into a stone the stone is then coated in ink and pressed onto a substrate such as paper similar methods are used when making small micro scale devices or a pattern needs to be made repeatedly on waivers. There are two methods, the most common method uses ultraviolet light and is called **photolithography** and the other one is **Electron beam lithography**. Both methods use an organic material called a resist which is sensitive either to electrons or light depending on the material used. A thin coat of this resist is applied to the substrate. In photo lithography the resist is exposed to light through a patterned mask. wherever the mask allows light to reach the resist, a chemical reaction occurs in which large resist molecules are broken down into smaller molecules. After **exposure** the next step is called **developing.** The area of the resist that has been exposed to light is removed by immersing the wafer in an organic solvent. The solvent dissolves only the molecules that were produced during the exposure. Finally, the pattern is transferred onto the substrate using several methods one of them is etching in which substrate is chemically removed from the pattern area that is not coated in resist. After etching the remaining resist is removed.

Research Project Contents

A **photoresist** is a light-sensitive polymer. when exposed to ultraviolet light, it turns to a soluble material. those exposed areas can then be dissolved by using a solvent, leaving behind a pattern.



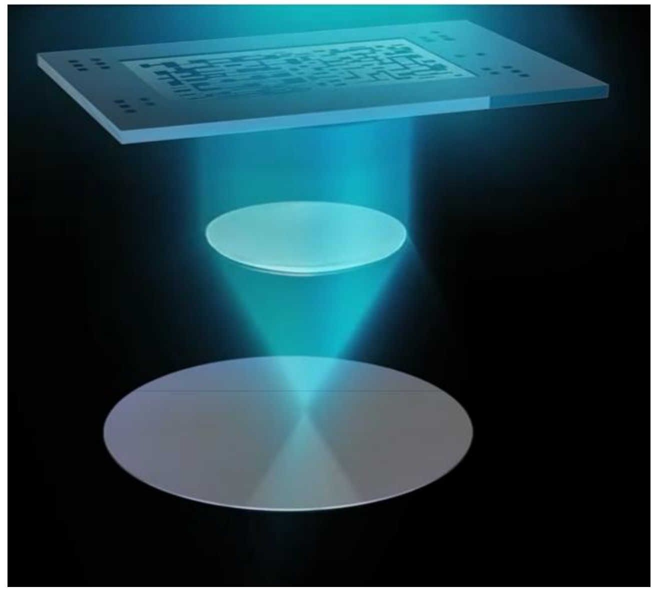


Fig. 1 photolithography technology

Types of photoresists:

1. Positive photoresist
2. Negative photoresist

Positive versus negative resists

Positive photoresist exposure to light increases the solubility of the polymer (opening in mask results in opening in resist)

negative photoresist exposure to light decreases the solubility of the polymer (opening in mask results in closed in resist)

fig. 2 a) positive resist

fig. 2 b) negative resist

FILM THICKNESS:

One of the important functions of the photoresist film is to protect underlying films of varying types (e.g. SiO_2, aluminum, polysilicon, silicon nitride). Thus, it has to be of enough thickness to provide an effective barrier to the various etches to be used. Also, in the case of selective ion implantation it has to prevent ions from reaching the underlying silicon. The way in which thin, uniform films are obtained is illustrated in Fig. 3. Drops of liquid photoresist are introduced onto the slice held by a vacuum chuck which can be set to rotate accurately at some predetermined speed. The slice is then spun, centrifugal forces spreading the liquid outwards, any excess being Thrown clear of the periphery. After a certain time, the thickness Stabilizes at a value dependent upon the rotational speed. The slice is then removed and baked in order to drive of the solvent and form a solid film which is thin and uniform over most of the slice. Some increase in thickness inevitably occurs at the edge of the slice due to surface tension in the liquid This it may be necessary to discard later some circuits very close to the edge. Fig. 5 also illustrates a commercial one-head spinner with accurate speed control, with very high acceleration and deceleration at the start of the spin cycle.

Fig. 3 commercial photoresist spinner

MASKS AND MASK MAKING:

Once the layout of the circuit has been created, the next step to manufacturing the integrated circuit (IC) is to transfer the layout onto a semiconductor substrate. Photolithography is a well-known process for transfer ring geometric shapes present on a mask onto the sur face of a silicon wafer. In the field of IC lithographic processing a photosensitive polymer film called photo resist is normally applied to a silicon substrate wafer and then allowed to dry. An exposure tool is utilized to expose the wafer with the proper geometrical patterns through a mask by means of a source of light or radiation. After exposure, the wafer is treated to develop the mask images transferred to the photosensitive material. These masking patterns are then used to create the device features of the circuit.

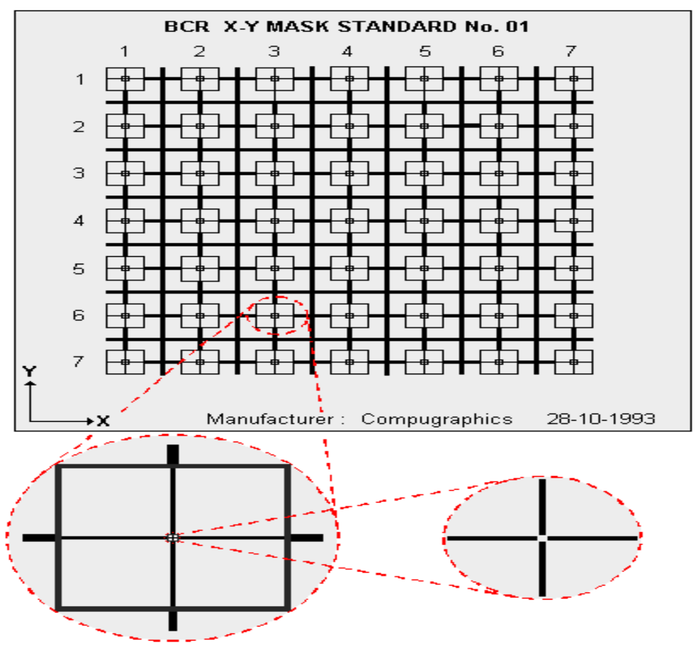


Fig. 4 standard mask

The way in which masks are produced is illustrated in Fig. 5. The integrated circuit designer has decided upon the number of masks needed for the complete process and has produced carefully dimensioned sketches of each mask. When the complexity of the integrated circuit is not very high the pattern is cut, say at a few hundred times actual size in double-skinned Mylar sheet. Mylar is a special plastic film which is dimensionally very stable. One skin is clear and the other is usually red and therefore photographically opaque. The pattern is cut in the red film and peeled away where clear are desired. The cutting is usually carried out on a precision table where the x and y positions of the cutter can be very accurately controlled. Only one pattern of the array is cut and the resulting sheet at this stage is called the initial artwork. The pattern is reduced by a factor of 10 or more using a reduction camera and the result is an intermediate photographic plate containing one pattern 10 times larger than finally required.

The final reduction is combined with precise stepping of the pattern in a piece of apparatus known as a step and repeat camera. This is illustrated schematically in Fig. 5.

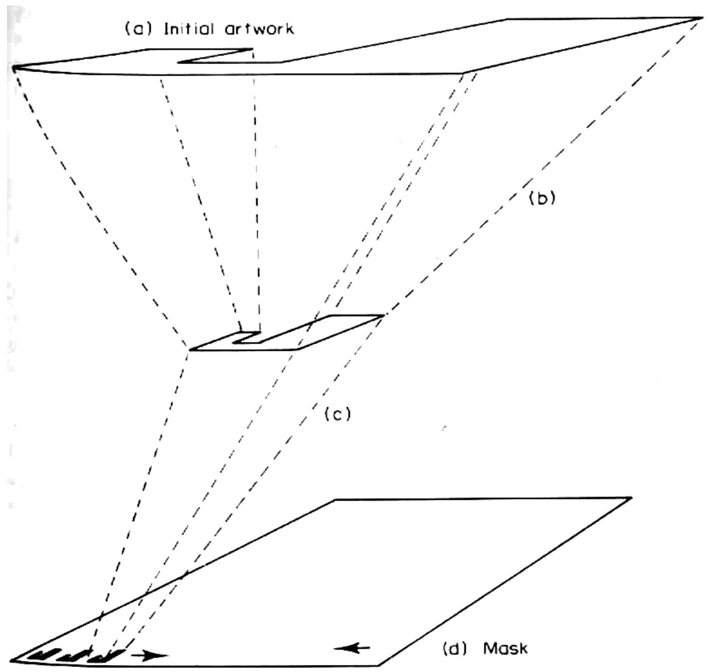


Fig. 5 Two-stage mask making procedure: a) initial artwork, b) first reduction (~ x10-40), c) step and repeat (~x10), d) mask

An alternative mask-making technique which is increasingly used, particularly for high-density circuits, for the designer to "**digitize**" the required patterns on the screen of a special purpose computer. The patterns are then stored on tapes which are used to drive a mask-making machine directly. An obvious advantage of this approach is that standard designs may be stored and, if necessary, modified at will without having to write off any earlier effort and start afresh each time.

Also, it enables the designer to check his design with great accuracy since the facility to zoom in on any portion of the overall circuit and to view several levels simultaneously is readily available on such machines. Because of the emergence of powerful low-cost workstations in recent years, the use of special purpose machines is progressively taking over, both for fully customized VLSI design, and for such semi-custom approaches as gate arrays and standard cell libraries.

MASK ALIGNMENT:

As mentioned, when more than one layer is to be used, each mask has to be precisely aligned with the previous layers. This is usually done by means of registration marks included on each mask. These masks are etched or pattered onto the silicon wafer along with the required pattern, for each mask used. The corresponding registration marks on the next mask to be used are then aligned under a microscope by means of a moveable stage. When alignment is correct the mask and wafer are brought into contact and the wafer exposed to UV light.

An alternative system, the project mask aligner, does not bring the mask and wafer into contact but projects one pattern at a time onto the wafer. This reduces damage to the mask and photoresist film but places stringent demands on lens quality and vibration control.

Electron beam lithography:

Although electron beam lithography uses the same process scheme as the photolithography, there are some differences between photolithography and electron beam lithography. One is that EBL uses electrons to print while photolithography uses light. A focused electron beam is used for exposure. the beam is accurately directed to positions on the wafer to form the pattern the electron beam exposes the pattern dot by dot and line by line which can be more time-consuming than photolithography however, it is a more flexible system and does not require expensive masks. The focused electron beam also allows feature sizes below 10 nanometers to be generated. Common applications for EBL are rapid prototyping small batch production where electron beam lithography and photo lithography are used in conjunction as well as the fabrication of masks and imprint templates. Figure 6 shows how electron beam technology looks like.

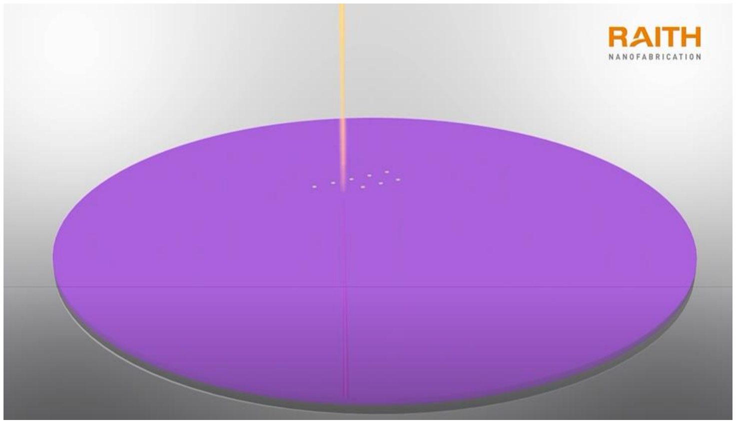


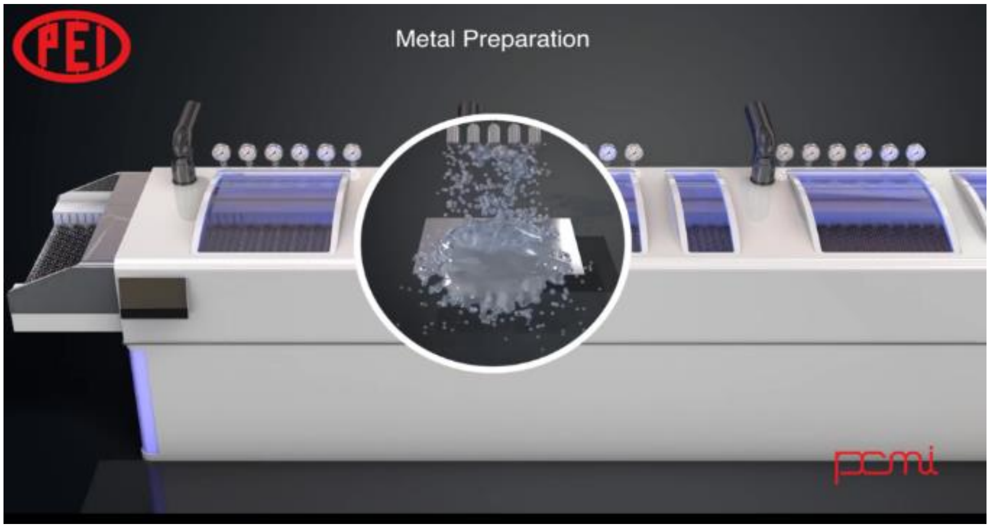
Fig. 6 Electron beam lithography technology

CHEMICAL ETCHING:

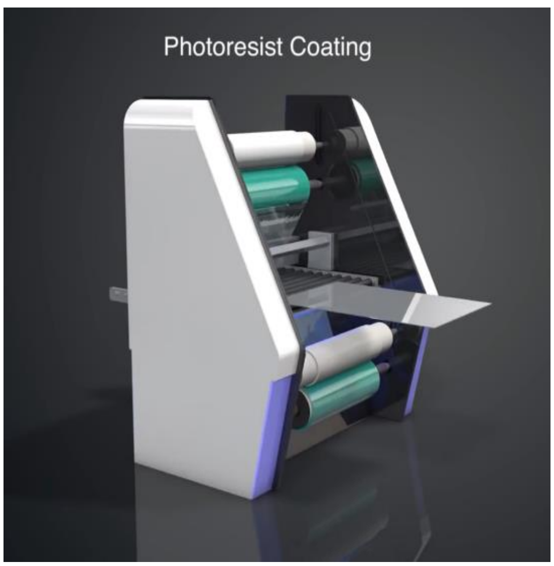
The first thing that needs to happen for a part to be chemically etched is for there to be artwork generated. Drawings are taken from computer data and photo plotted onto film creating areas on the film that are either black or clear. Depending on the type of photoresist being used either the clear areas or the black areas will be the image of the desired part. Generally, there are two pieces of film created that are aligned precisely front to back. Metal is then selected then sheets are cuts to match the size of the film created. The metal is then cleaned to remove any residual oils and oxide. It is very important to have clean surfaces on the metal to make sure the resist that will be applied will adhere successfully. The sheets are then coated with the photosensitive resist. The resist is sensitive to UV light and resistant to acid. After the resist is applied the material is then placed between the two pieces of artwork that have been created. The resist covered sheets is then exposed to UV light to create the desired image on the coated metal. Generally, where the light shines through the clear areas of the film, the resist is exposed and becomes hung, Where the resist is shielded from the lights by the black areas of the film, the resist remains soft. After exposure to the UV light, the sheets are put through a developer where the soft resist is dissolved away, and the hardened resist remains. The sheet of material will then have resists remaining in the areas where the material needs to remain while the rest of the sheet has exposed metal when the material is to be removed. The next step is to have the sheet put through an etching machine where **etchant** (etchant an acid or corrosive chemical used in etching) is sprayed on both sides of the sheet, where the etchant comes in contact with exposed material the metal is dissolved, where the resist has been applied the material will be protected from the etchant. when the sheet is finished edging the remaining resist must be removed. This is done by applying resist stripper which dissolves the resist. The results is the finished edge spot.
The whole process can be summed in the collection of figures bellow:

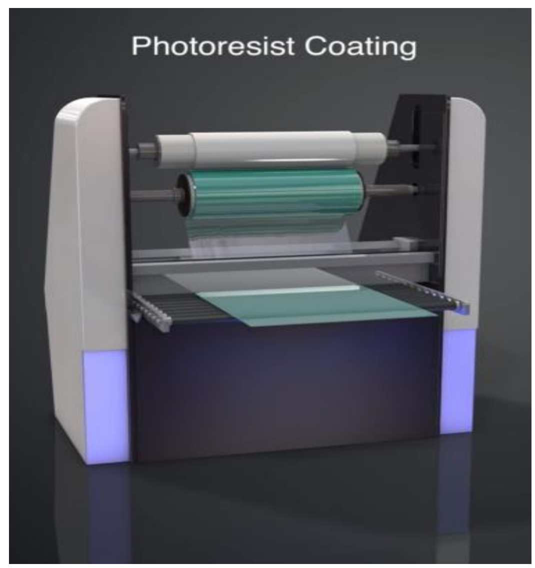
1. Cleaning the metal
2. Coating with photoresist
3. Transfer the msk into the wafer
4. Chemical etching

1)

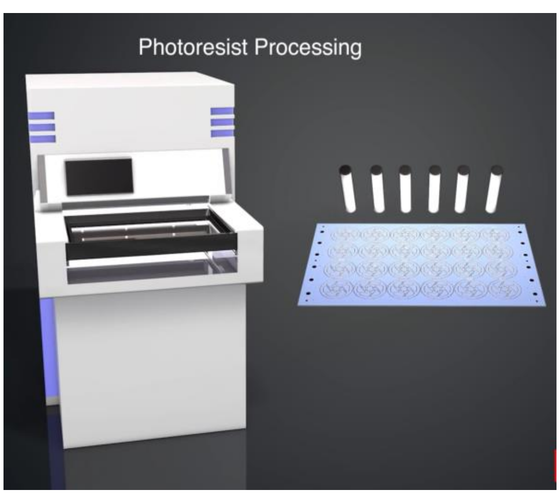

Metal Preparation

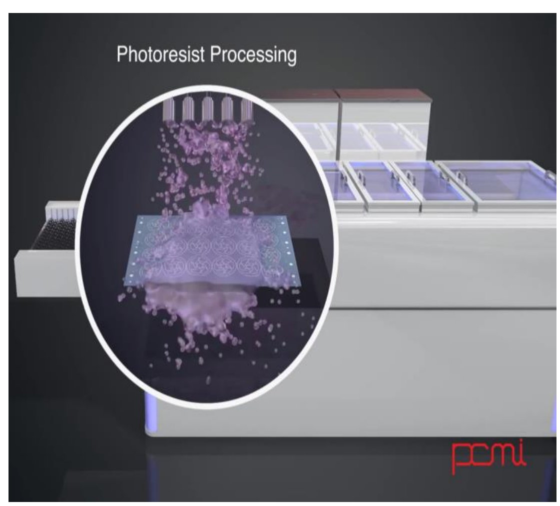
2)


Photoresist Coating

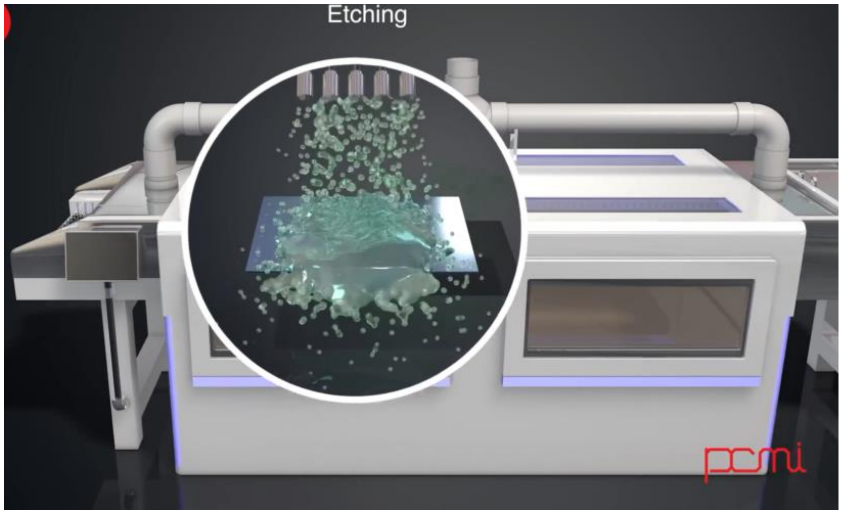

Photoresist Coating

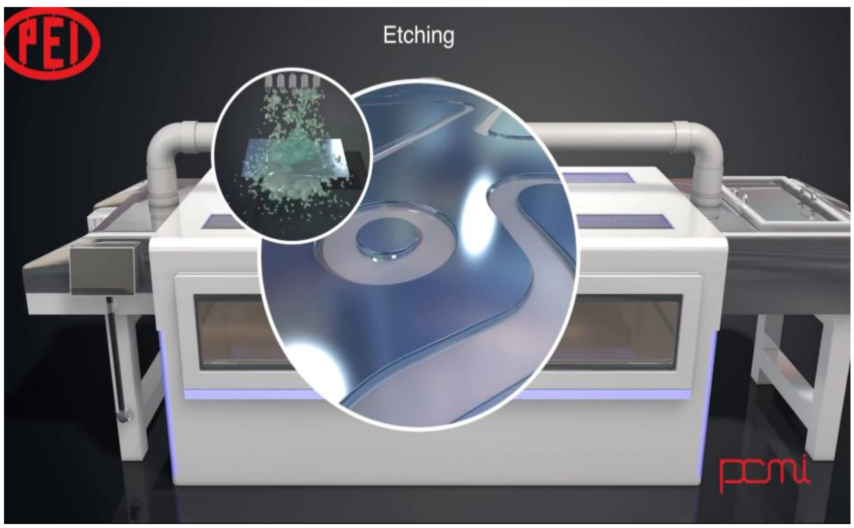
3)

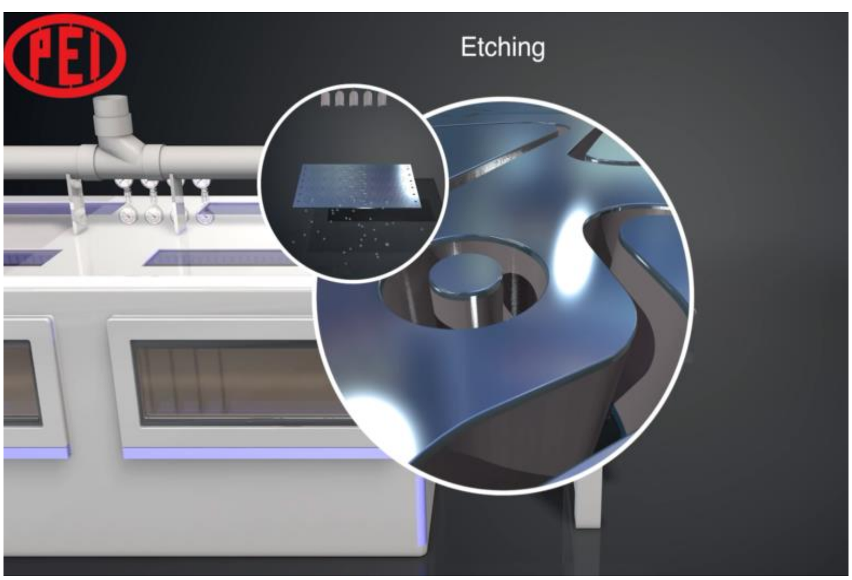

Photoresist Processing


Photoresist Processing

4)







References

Write the references of the research project in this part.

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