

Flexible Circuits: Project Scope Presentation

“Flexible circuits are a high-growth technology in the area of electrical interconnectivity and look set to deliver improved performance against the demands of many 21st century products... flexible printed circuits have replaced hand-built wire harnesses in many applications.”

Peter Macleod, Flexible Circuit Technology
Prime Faraday Technology Watch

What is **diabetes**?

A metabolic disease in which the body's inability to produce any or enough insulin causes elevated levels of glucose in the blood.

If not controlled, diabetes can produce complications that can affect nearly every organ in the body:

- heart attack
- stroke
- atherosclerosis
- high blood pressure
- neuropathy
- nephropathy
- cataracts and glaucoma
- foot damage and possible limb amputation
- hearing impairment
- skin conditions
- Alzheimer's disease

Diabetes Care

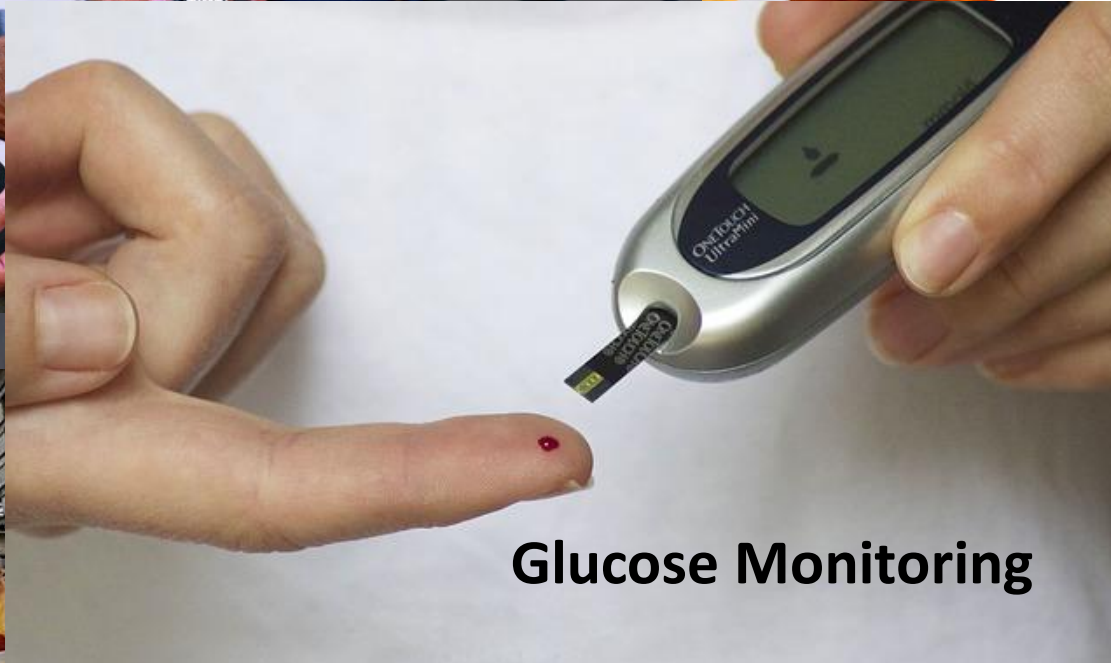
Medical Care



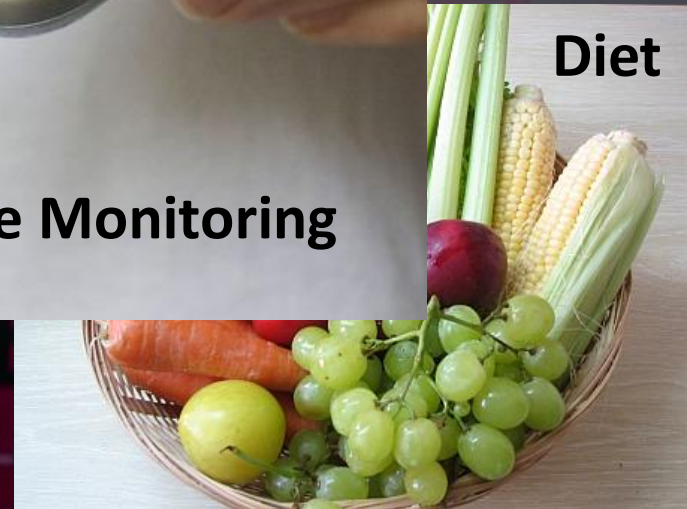
Medication



Glucose Monitoring



Diet



Exercise and Lifestyle



Glucose Monitoring

A hand is shown holding a finger over a glucose test strip. In the foreground, a glucose meter is visible, partially obscured by the hand and the test strip. The background is dark and out of focus.

For some people, it is necessary to monitor their blood glucose levels daily—and sometimes more than once a day!

Fact: Glucose levels can be also measured in other corporal (human body) fluids...

Knowing this... Could an alternative to the annoying pinching procedure be developed?

Example Idea: **Smart Lens**



- Developed by Google Labs and Novartis
- The lens can measure blood sugar levels directly from tear fluid on the eyeball surface
- It contains a low-power microchip and an almost invisible, hair-thin **electronic flexible circuit**
- The system sends data to a mobile device to keep the person informed.

Flexible Electronics

At the core of the Google smart lens is a thin and **flexible printed circuit**

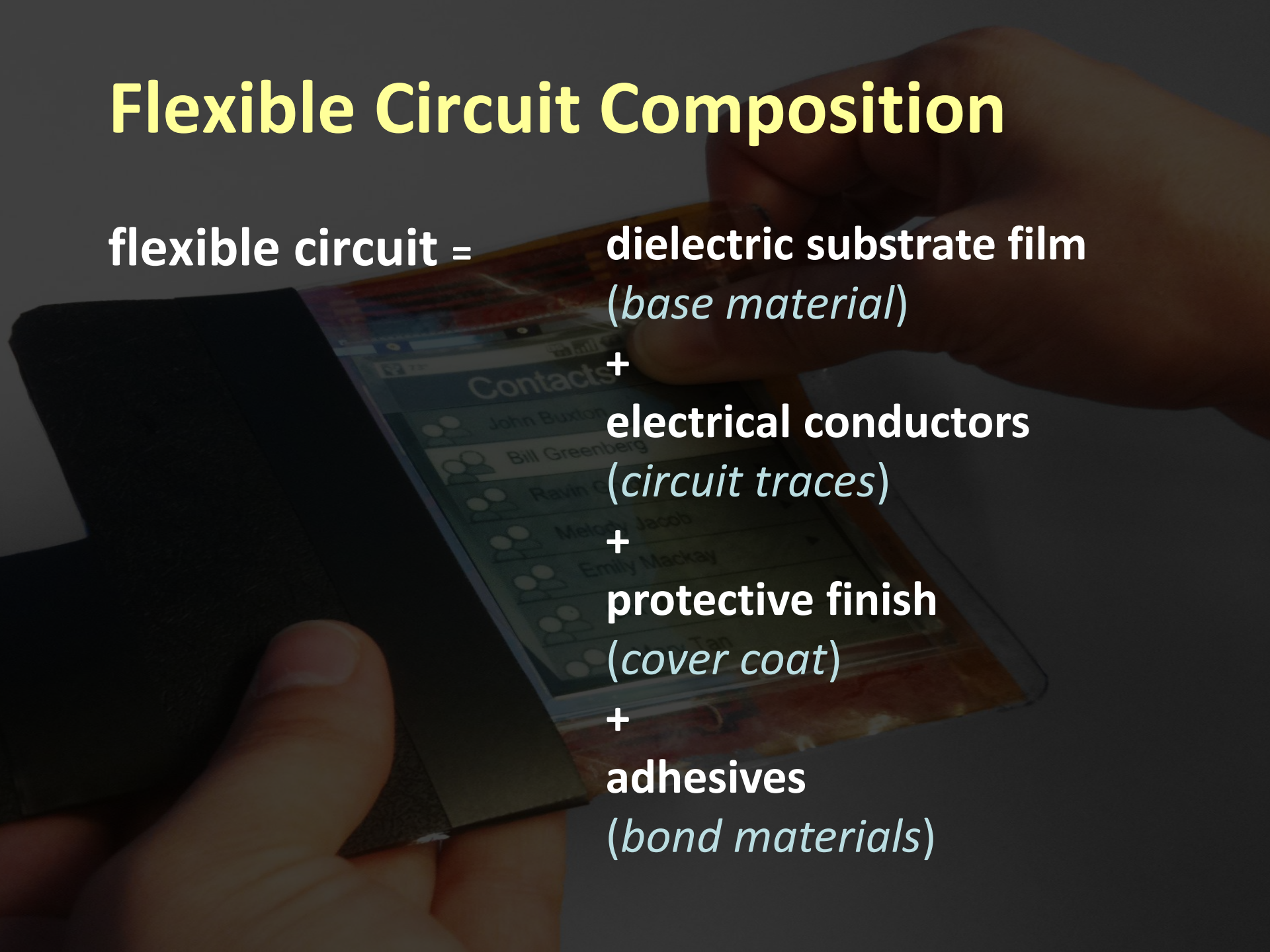
“A flexible printed circuit is a patterned arrangement of printed circuitry and components that uses a flexible base material with or without a flexible cover lay.”

—IPC, Association Connecting Electronics Industries

Flexible Circuit Composition

flexible circuit =

- dielectric substrate film**
(base material)
- +**
- electrical conductors**
(circuit traces)
- +**
- protective finish**
(cover coat)
- +**
- adhesives**
(bond materials)

A hand is holding a flexible circuit board. The board is partially covered by a black protective sleeve. The visible part of the board shows a contact list with names and phone numbers. The text is overlaid on the image in white and yellow.

Flexible Circuit Composition

A hand is holding a flexible circuit board. The board is yellow and has a contact pad on the left side. On the right side, there is a list of names: "Bill Greenberg", "Melody Jacob", "Emily Mackay", "Orli Miller", and "Mary Tan". The board is being held against a dark background.

Substrate materials:

- **Polyesters:** *Low cost and highly flexible*
- **Polymides:** *high-temperature characteristics (~700 °C) and low thermal expansion*

Electrical conductors:

- Gold, aluminum, nickel or silver, *but mainly copper*
- *Ink loaded with carbon or silver particles*

Flexible Circuit Composition

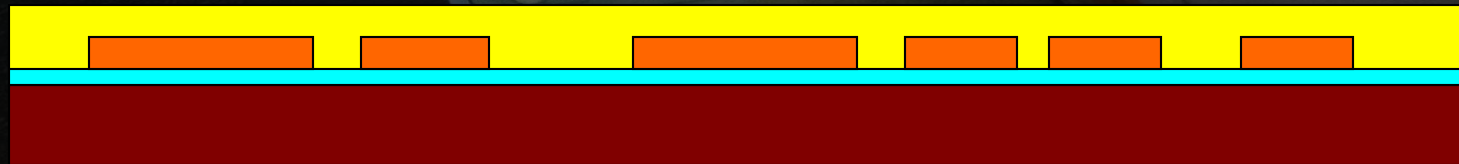
A hand is holding a flexible circuit board. The board is yellow and has a grid of contact pads. The word "Contacts" is printed on the board. The background is dark and out of focus.


Single-Sided Flexible Circuits


- Most common type
- Single conductor layer on a flexible dielectric film
- Access to circuit-termination from one side only
- With or without cover lays and protective coatings
- Simple design; highly cost effective
- Best suited to dynamic-flexing


Flexible Circuits Composition

Single-Sided Flexible Circuits



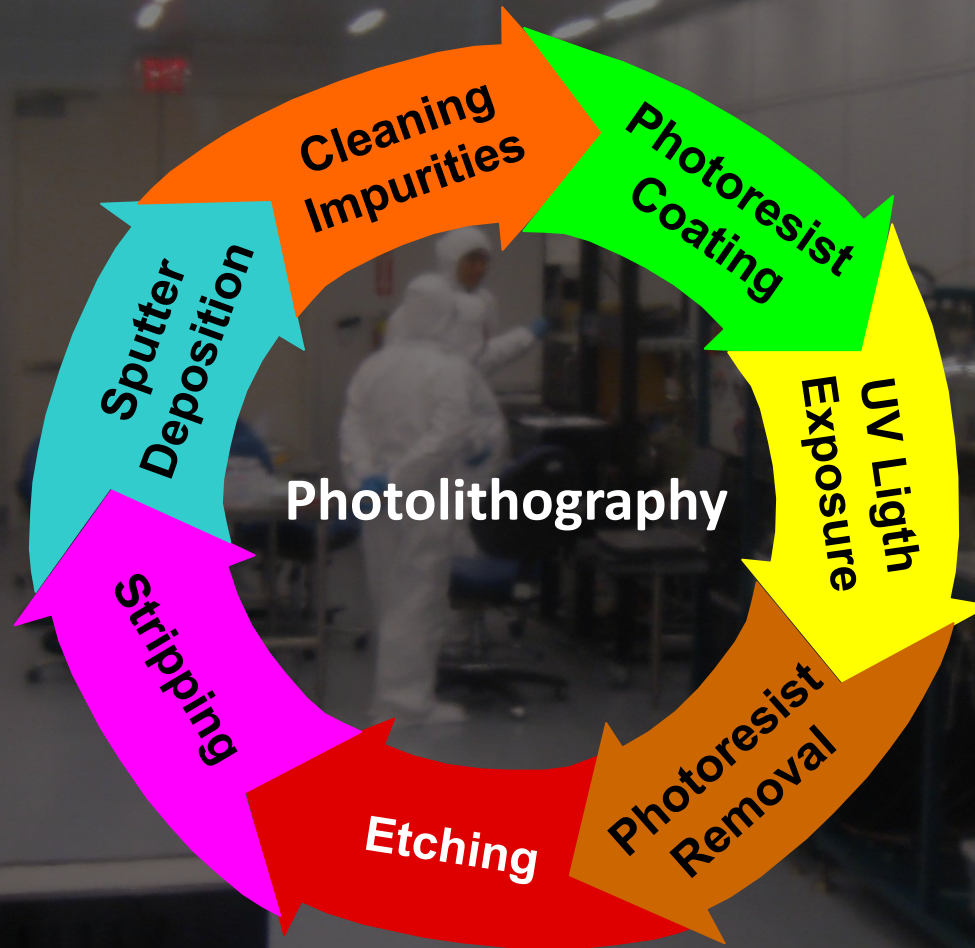
 Base Substrate

 Adhesive

 Conductor

 Coverlay

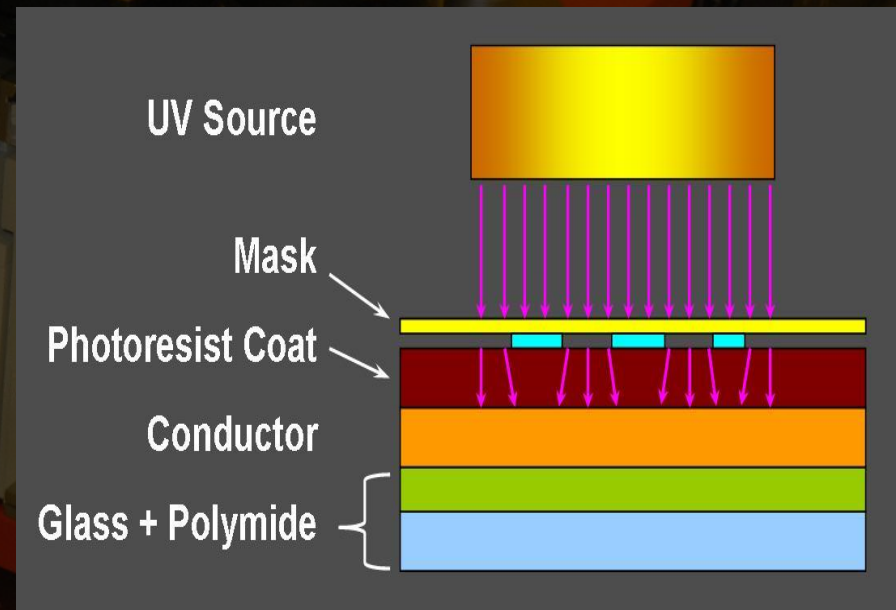
Flexible Circuit Fabrication



What is the research?

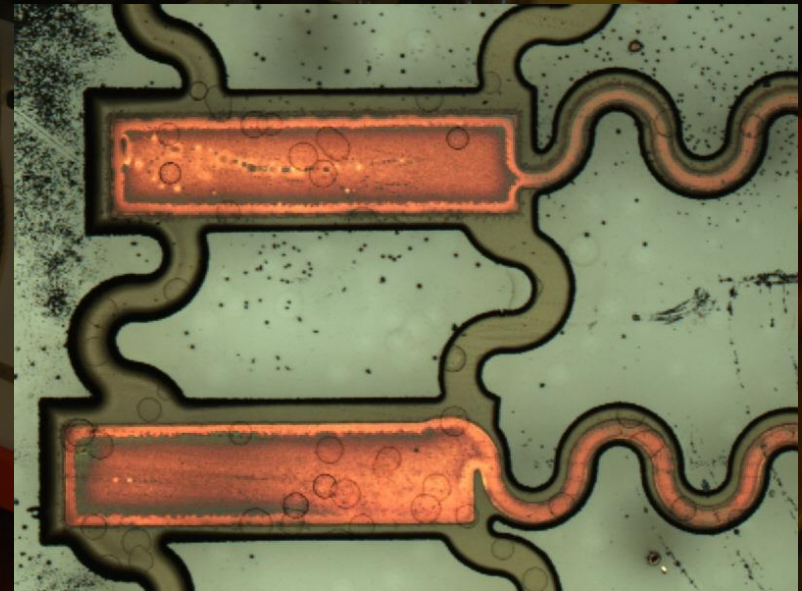
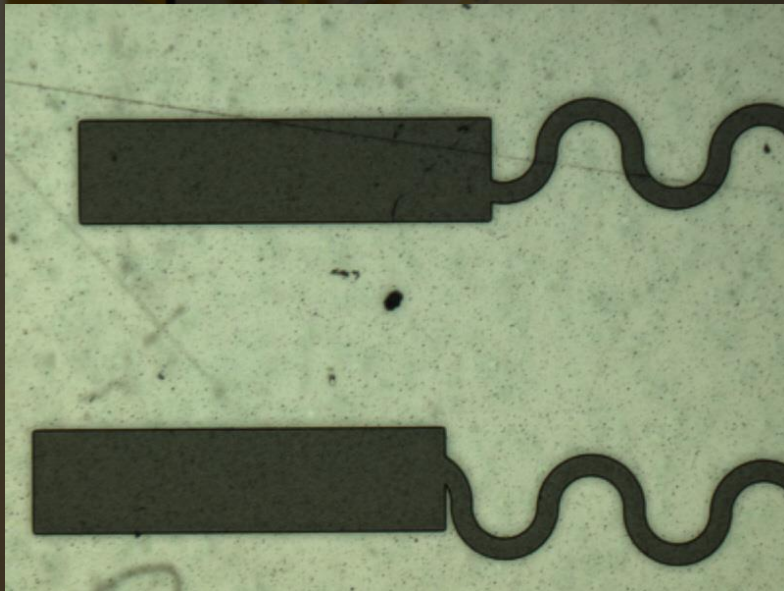
The UV light exposure step in the photolithography process is the core of the research performed for this lesson. Note that the circuit mask is placed over the wafer coated with the photoresist. **Challenge question:**

Is it expected that that the printed circuit is an exact copy of the mask, or is an alteration produced by the pass of the UV light through the photoresist coat? Or, is the diffraction of the light in this coating significant?



What is the research?

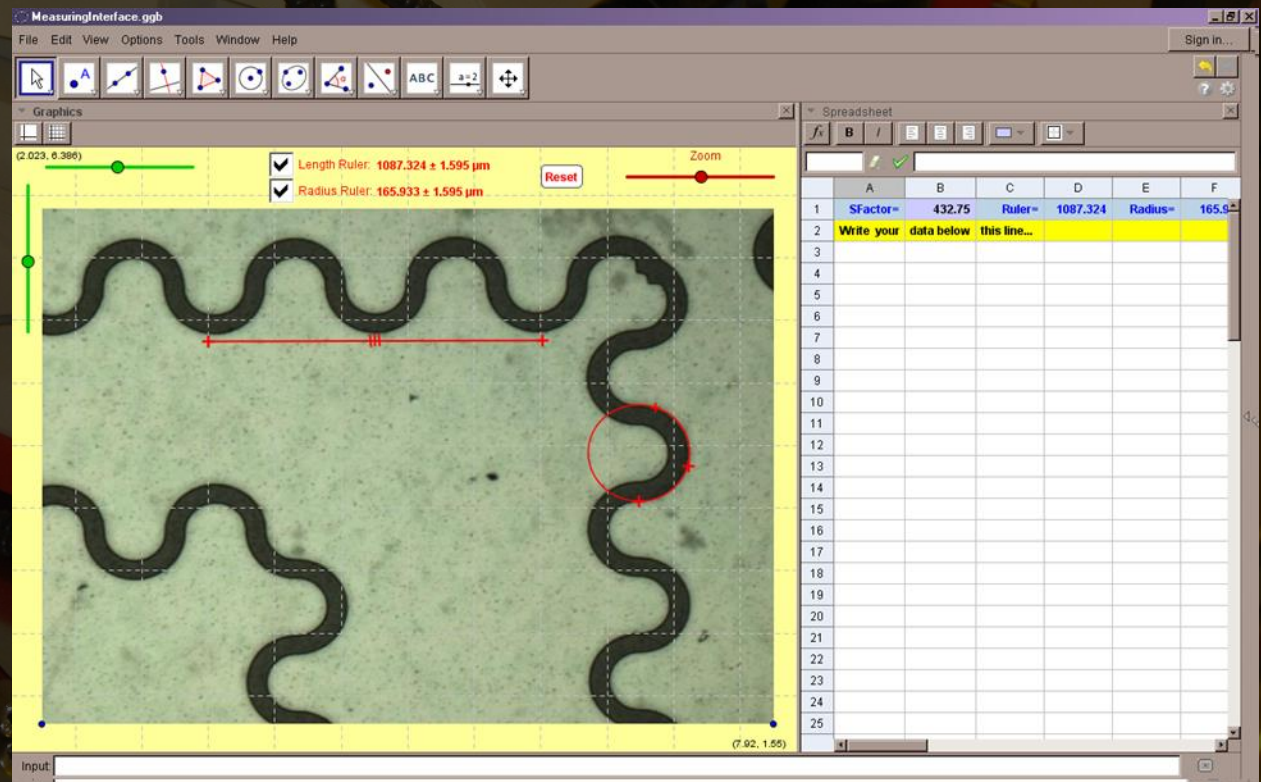
To answer this question, we must **compare the dimensions** of a circuit in the original mask, and the dimensions of the final circuit obtained through the photolithography process.



What is the research?

We will take **samples of measurements** from two sets of pictures: original circuits on masks and their corresponding printed circuits.

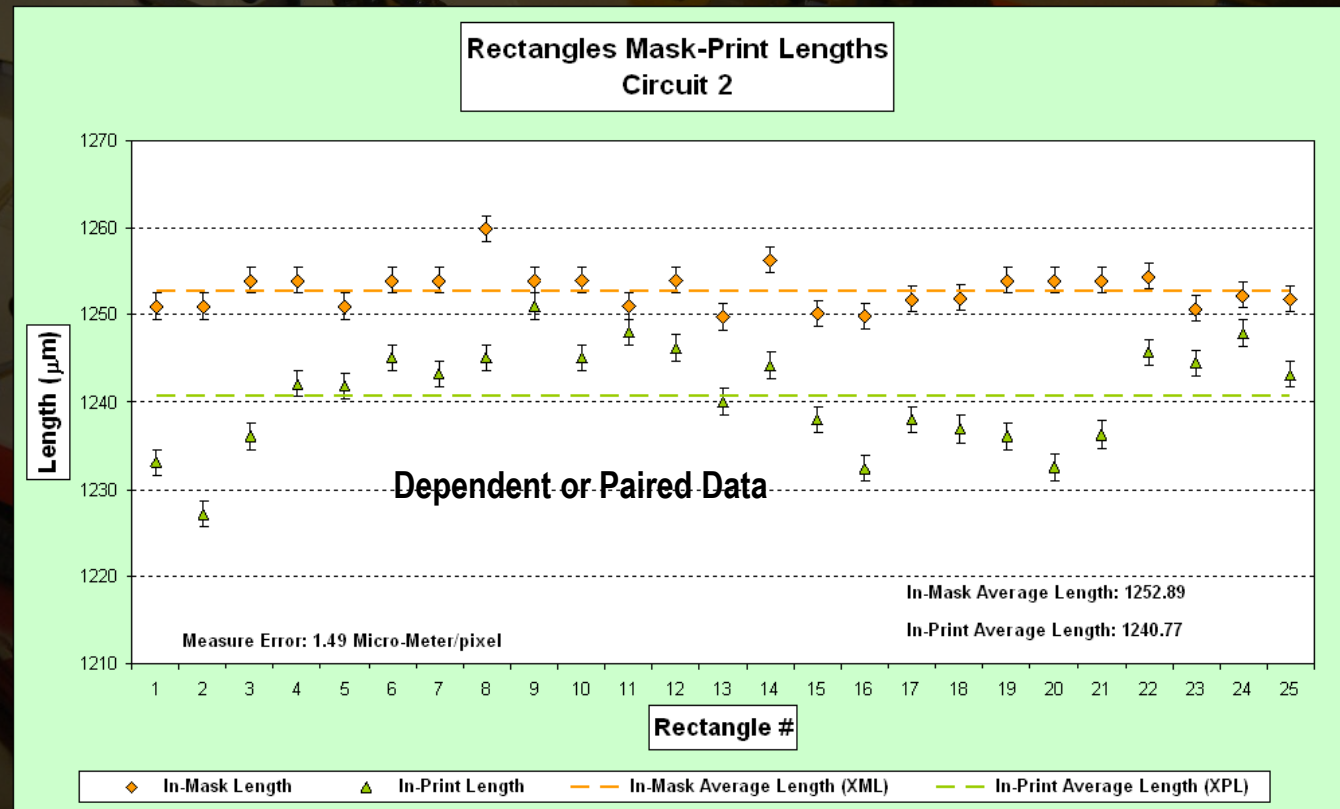
We will use a special graph interface created in **GeoGebra** to perform these measurements



What is the research?

We will use **statistical analysis, hypothesis testing for differences**, to conclude if the differences in dimensions mask-printed circuits are statistically significant or not.

A **T-test** is the correct approach for dependent or independent samples



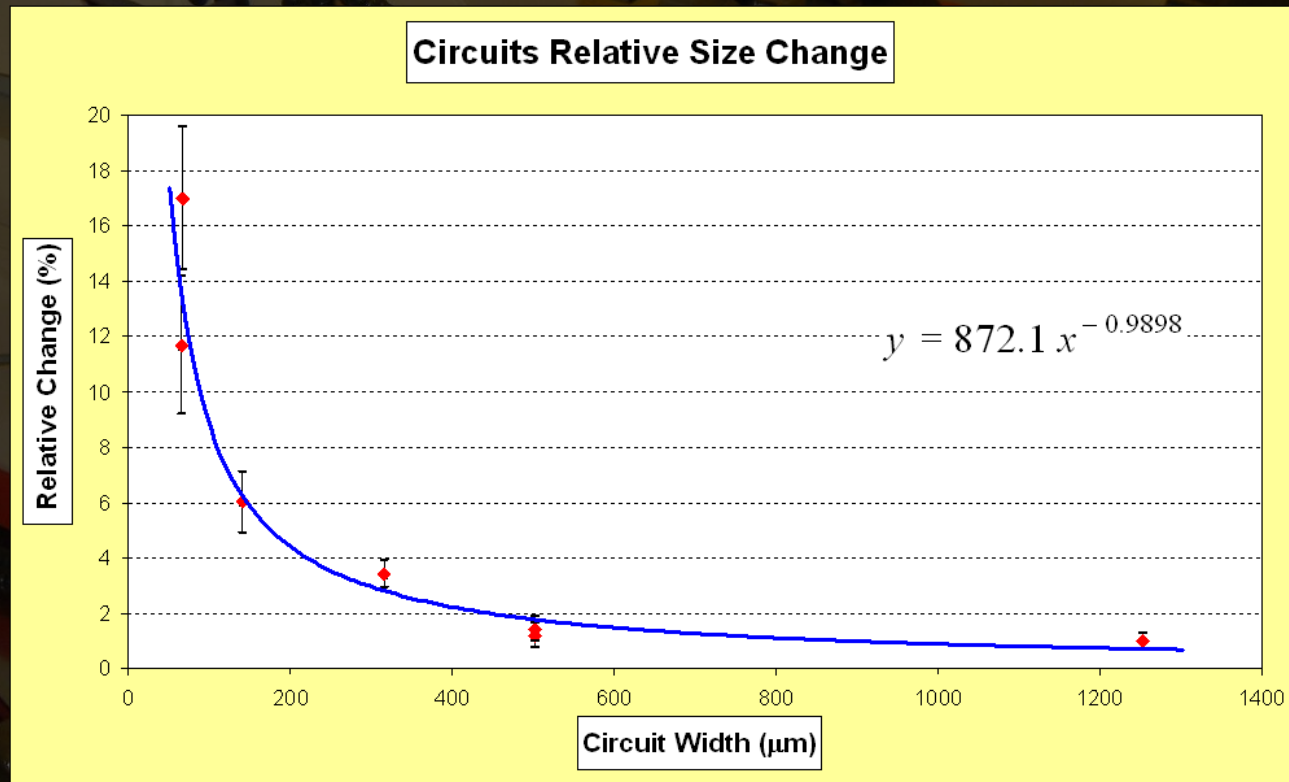
What is the research?

We'll put the measurements from the different circuits together in a **relative size change** graph

We'll use the equation:

$$\frac{\bar{x}_m - \bar{x}_p}{\bar{x}_m} \times 100$$

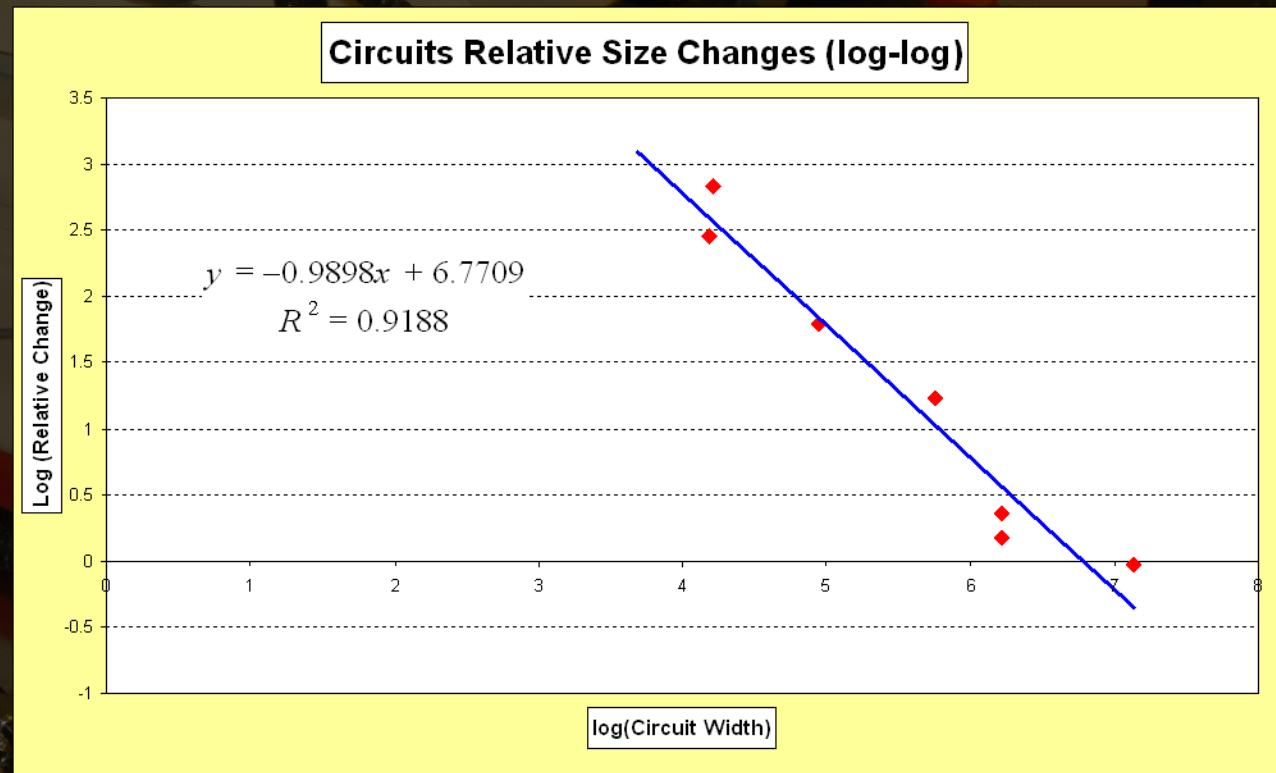
to compute the dependent variable y of the graph



What is the research?

Taking logarithm of the y variable, **a linear relationship** can be found. Solving for y , an empirical relationship for the relative change can be obtained.

With this equation, it is possible to **predict the change** in the printed circuit as a function of the original dimensions



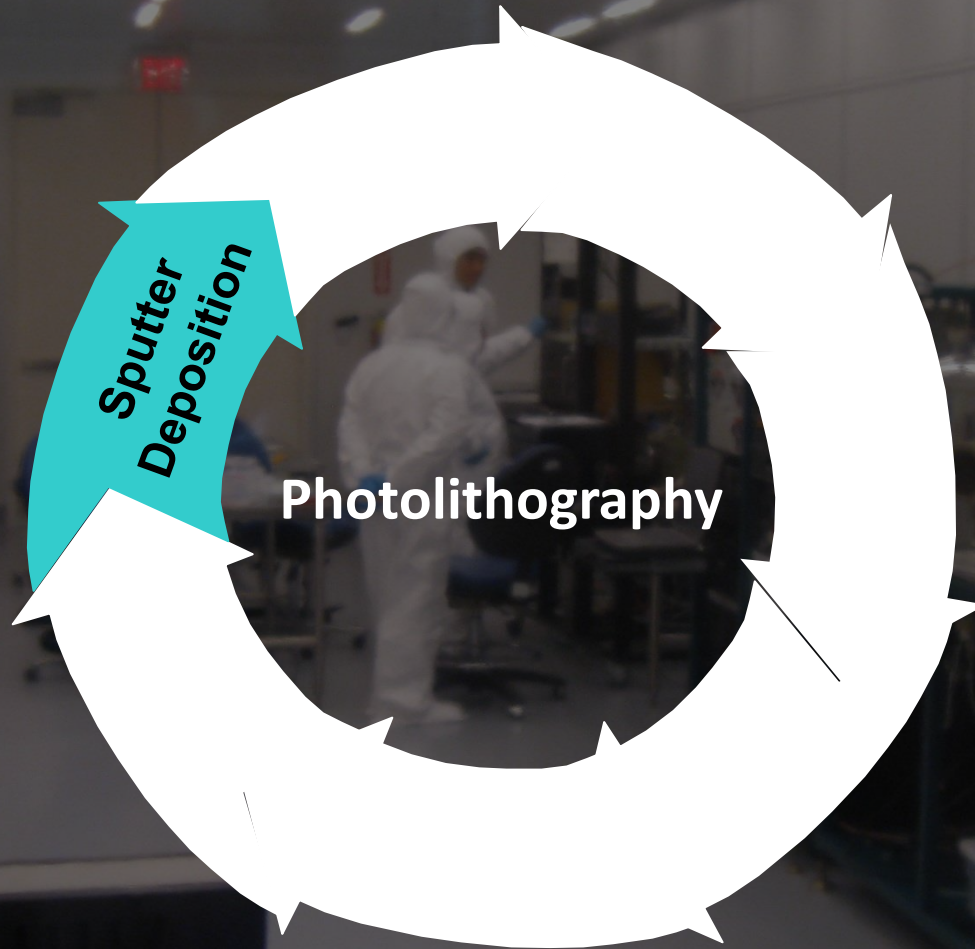
Suggested reading:

- Photolithography: <http://en.wikipedia.org/wiki/Photolithography>
- What is photolithography:
<http://whatis.techtarget.com/definition/photolithography>
- Carl Batt: Photolithography:
<http://www.youtube.com/watch?v=9x3Lh1ZfggM>
- Semiconductor Lithography. The Basic Process:
<http://www.lithoguru.com/scientist/lithobasics.html>
- What Else Could Smart Contact Lenses Do?:
<http://www.technologyreview.com/news/529196/what-else-could-smart-contact-lenses-do/>
- Google's Prototype "Smart Contact Lens": Measuring Blood Glucose Levels for People with Diabetes:
<http://www.visionaware.org/blog/visionaware-blog/googles-prototype-smart-contact-lens-measuring-blood-glucose-levels-for-people-with-diabetes-1418/12>



Custom Shows Shows

Flexible Circuit Fabrication



Sputter Deposition

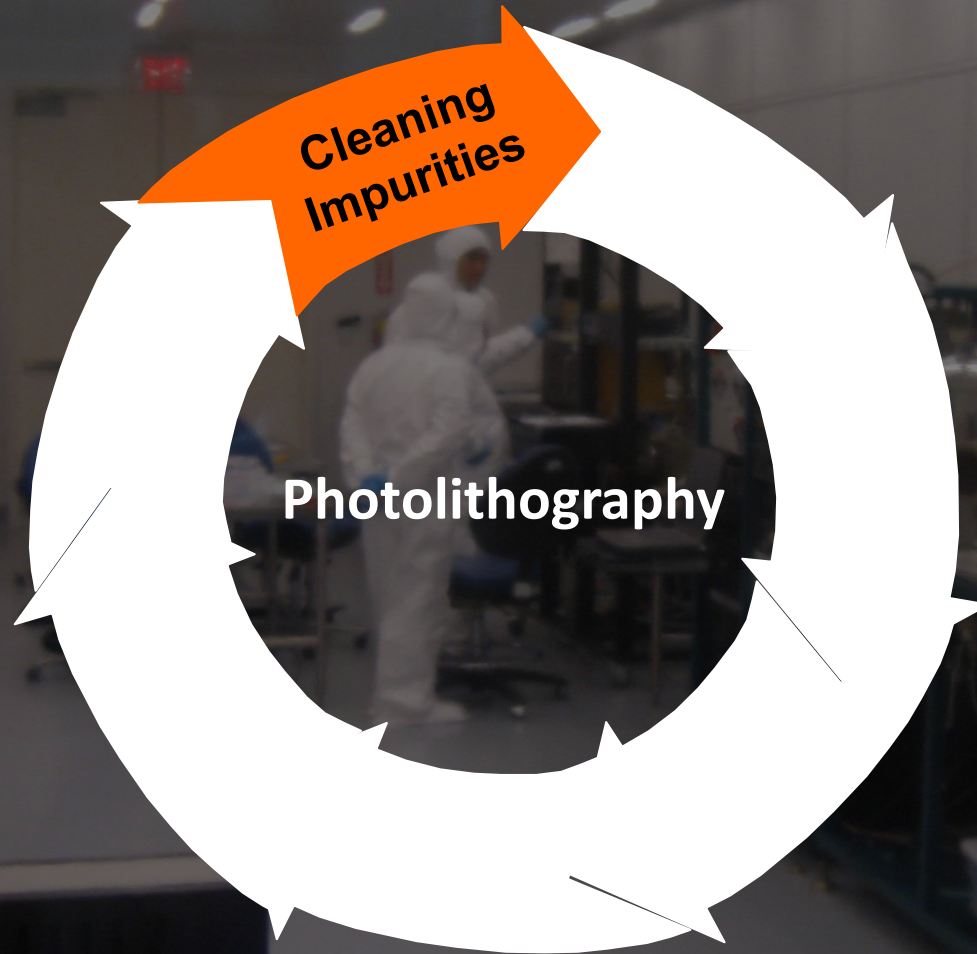
A method of depositing thin films by way of eroding material from a “target” source onto a “substrate.”

Typically accomplished by bombarding the “target” (that is, the source of deposition material) with atoms of inert gas.

The momentum of the bombarding atoms transfers to target atoms enabling them to separate from the target flying towards the deposition surface.



Flexible Circuit Fabrication



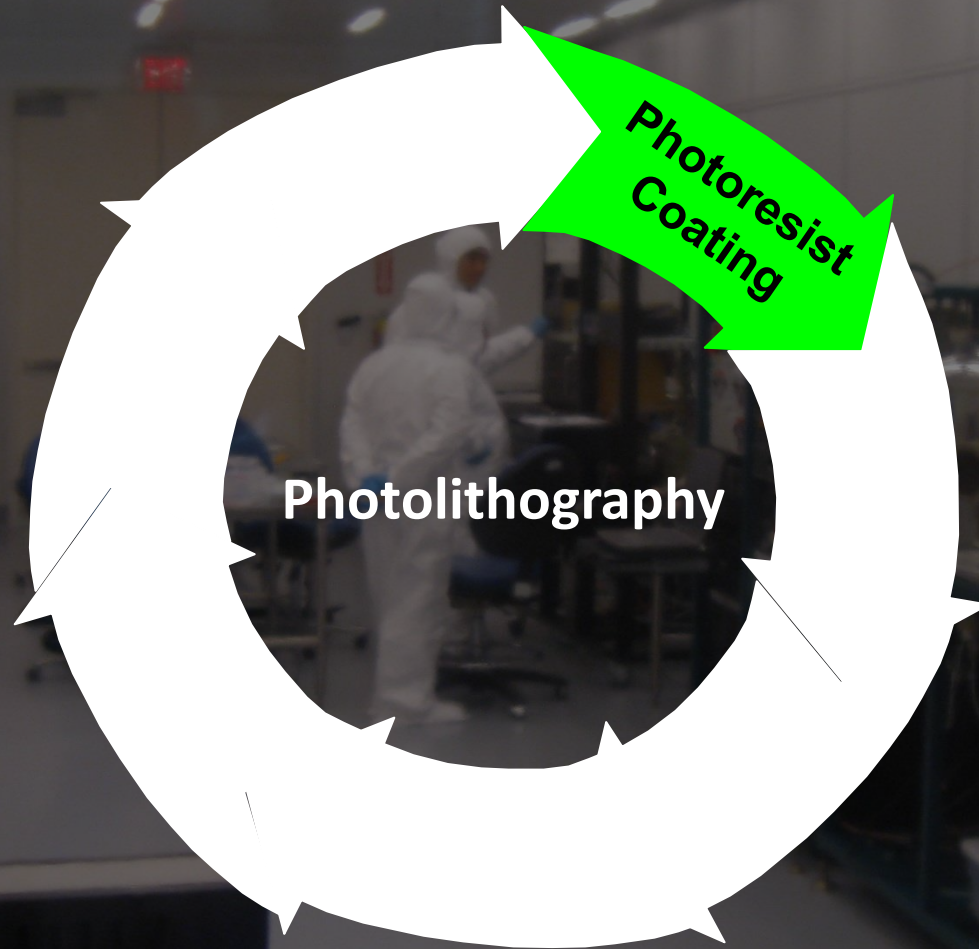
Cleaning Impurities

Organic / inorganic contaminations are usually removed by wet chemical treatment using solutions containing hydrogen peroxide.

Other solutions made with trichloro-ethylene, acetone or methanol may also be used to clean



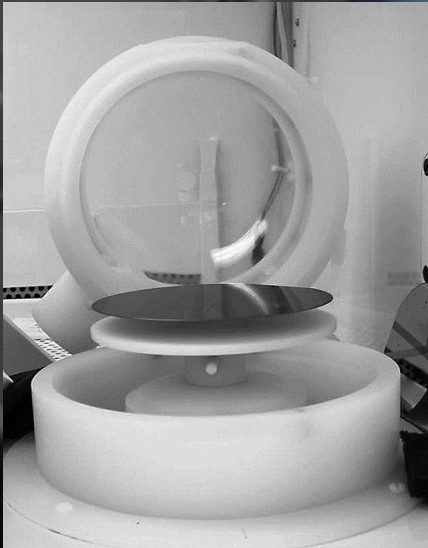
Flexible Circuit Fabrication



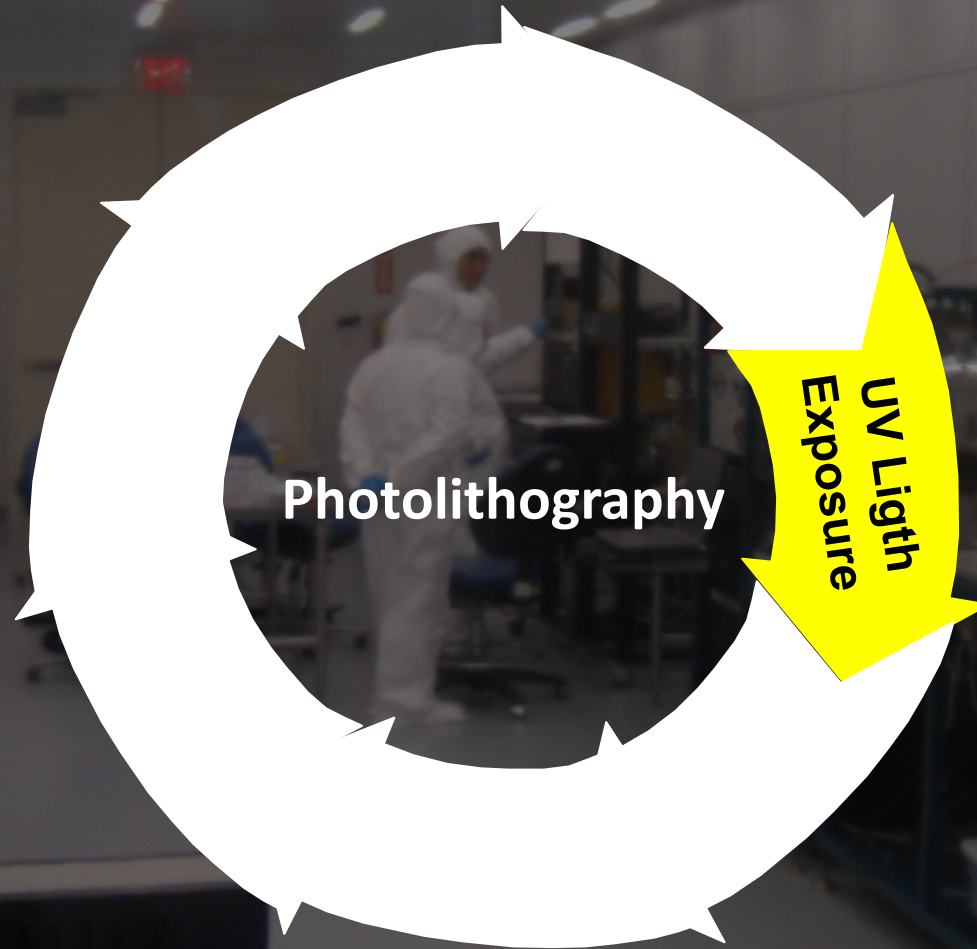
Photoresist Coating

A UV light-sensitive liquid that loses its resistance (its susceptibility to attack by an etchant or solvent) when exposed to UV light.

A wafer coated with a thin conductor, is covered with photoresist by spin coating; this viscous liquid solution is dispensed onto a rapidly spun wafer, to produce a uniformly thick layer.

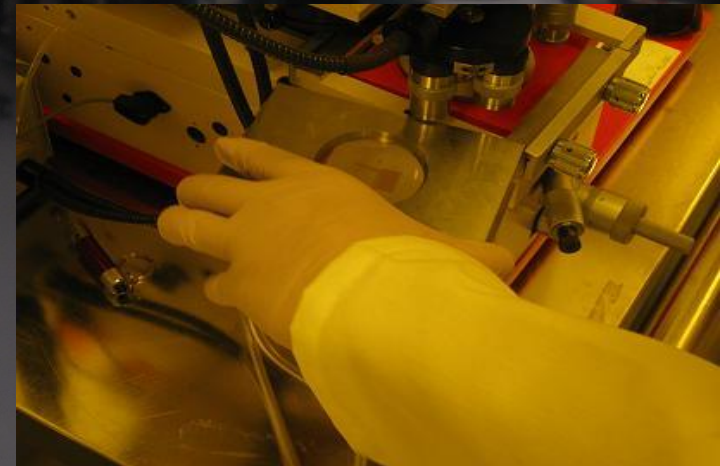
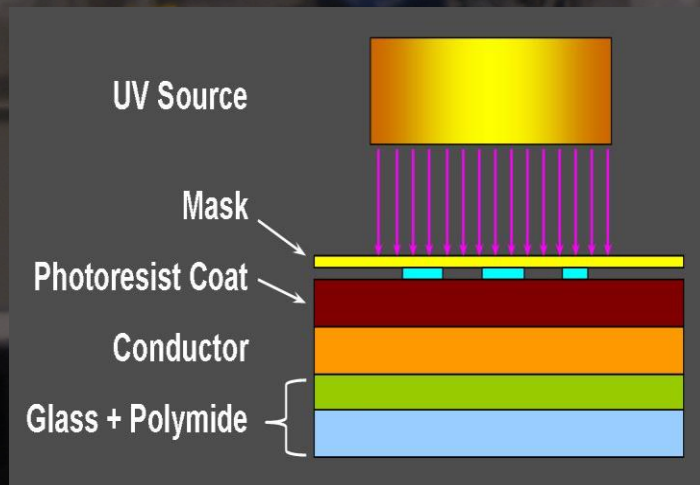


Flexible Circuit Fabrication

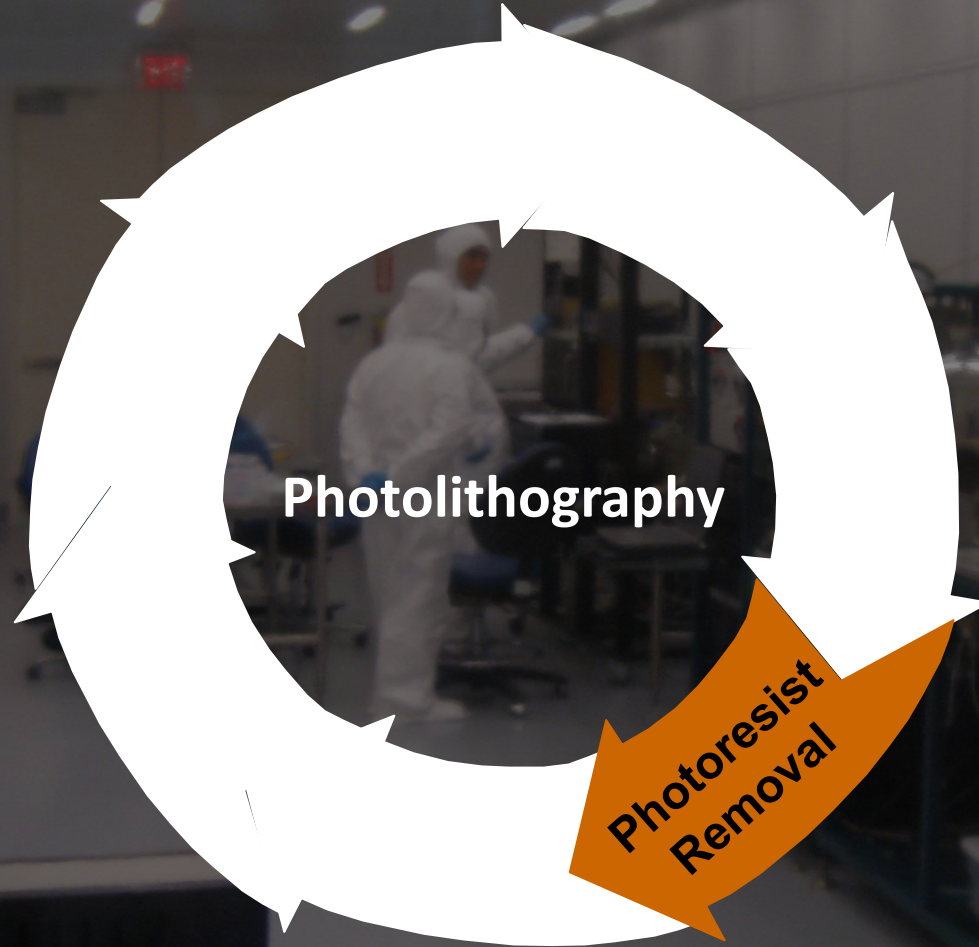


UV Light Exposure

UV light passes through a **mask** (a print of the circuit to be transferred to the wafer) placed on the conductor coated wafer. Light causes a chemical change on the photoresist. Positive photoresist becomes soluble in the developer when exposed; with negative photoresist, unexposed regions are soluble in the developer.



Flexible Circuit Fabrication



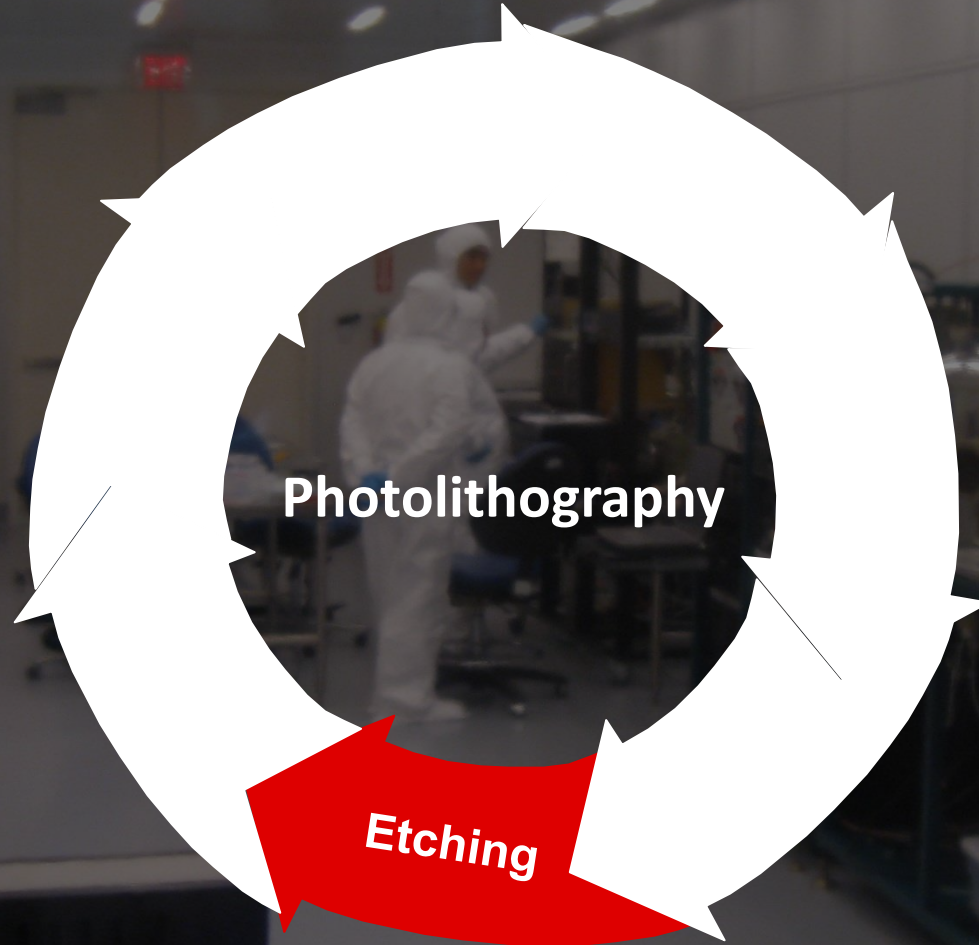
Photoresist Removal

After a photoresist is no longer needed, it must be removed from the substrate

This usually requires a liquid *resist stripper* or *developer* that chemically alters the resist so that it no longer adheres to the substrate

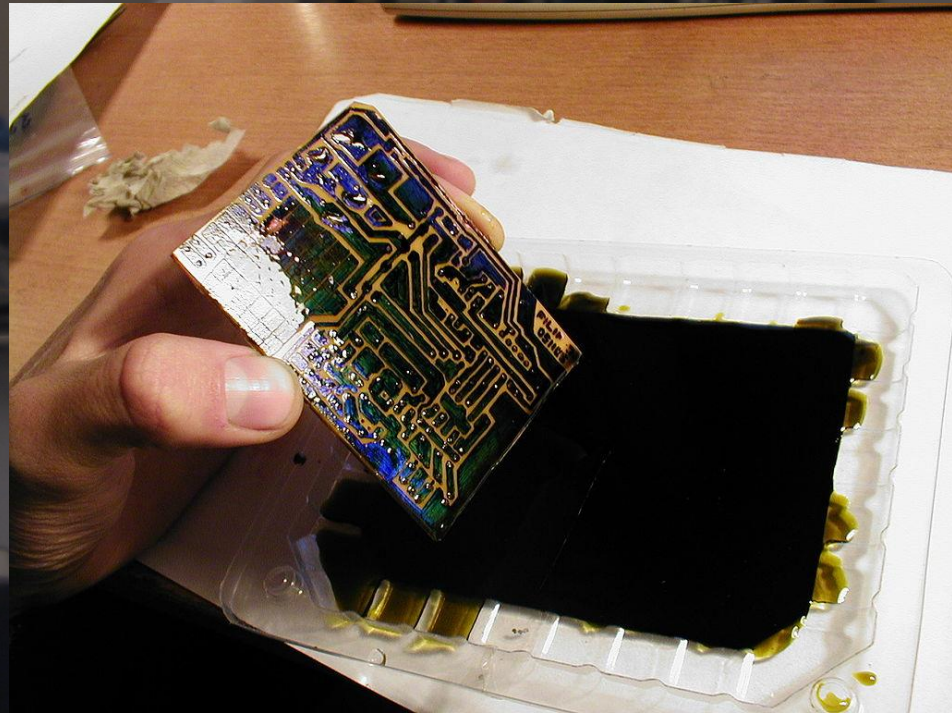


Flexible Circuit Fabrication

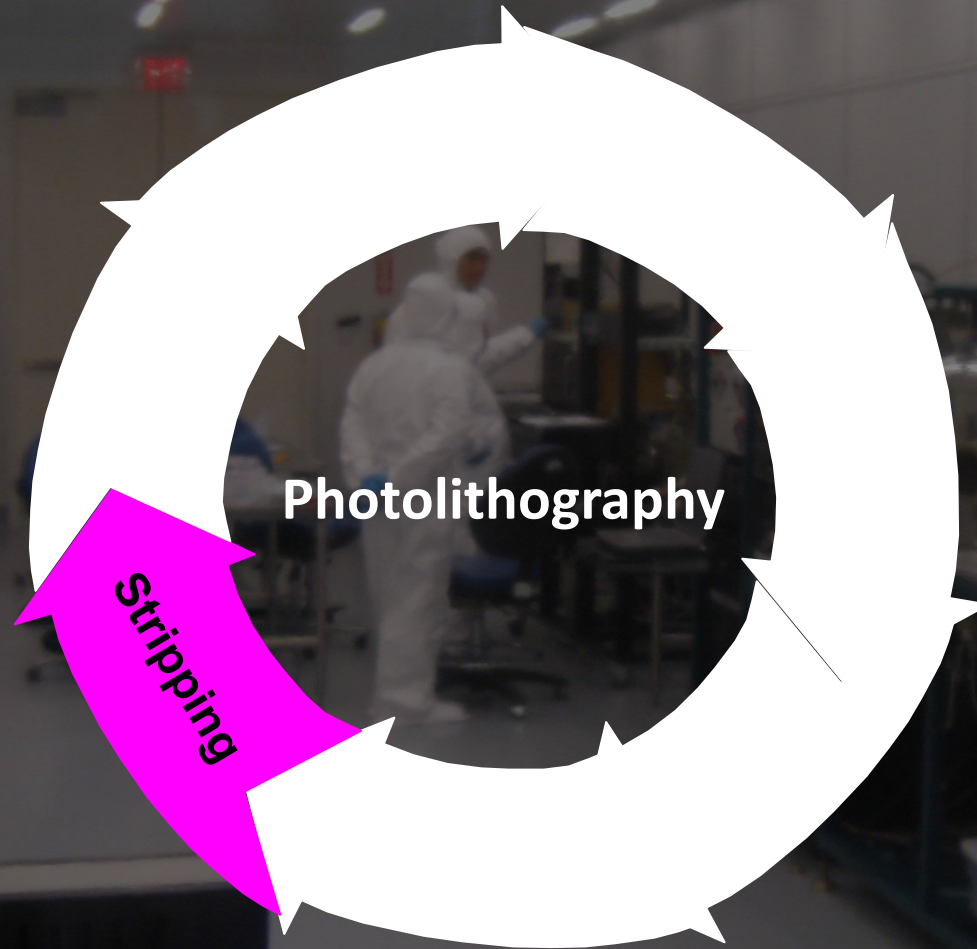


Etching

A liquid ("wet") or plasma ("dry") chemical agent is used to remove the uppermost layer of the substrate in the areas that are not protected by photoresist



Flexible Circuit Fabrication



Stripping

The use of a solvent called a *stripper* to remove the photoresist and any of its residues

