Electro Lithography: UPSC Notes for Science and Technology

Electron-beam lithography is the practice of scanning a focused beam of electrons on a surface coated with a film that is resistant to electrons called a resist, in order to draw custom shapes.

Overview of electron-beam lithography

Also known as e-beam lithography. The electron beam enables selective removal of either the exposed or the non-exposed areas of the resist by dipping it in a solvent, and changes the resist's solubility. Just like in photolithography, the purpose of electron beam lithography is to generate very small structures in the resist which can then be transferred to the substrate material, mostly through etching. The major benefit of this type of maskless lithography is that it can create custom shapes (direct-write) with sub-10 nm resolution. This type of lithography has a high resolution and low throughput. It is used in photomask fabrication, production of semiconductor devices in low volumes and in research & development.

How does electron-beam lithography work?

The new technology can drastically reduce the cost of the existing state-of-the-art e-beam lithography and optical lithography. This invention is a new way to etch thin lines on a substrate using electrodes, termed electro lithography.

Technically the main steps they have to take will be in putting the whole assemblage into a black box which can be easily operated using the proverbial "push-button."

1. The lithography process is straightforward. A transparent glass plate is taken and is coated with a layer of an appropriate polymer.
2. On top of this a chromium layer is added, then a trench of the wanted pattern on the chromium layer is dug exposing parts of the polymer layer.
3. Using acetone, the exposed polymer is dissolved and those parts of it are removed.
4. This causes a gap to be made in the polymer-chromium sandwich.

This whole assemblage acts like the negative of a developed photo film.

- When the chosen metal is to be "spluttered" on to this sandwich, it will occupy the gap that has been formed and directly fall onto the glass plate.

- In this way, the required pattern is formed using a metal of choice. This pattern will have a width equal to the trench's width and thickness of the polymer layer.

Difference between existing processes and the latest Electro Lithography?

- It is in the manner in which the trench is dug.
- The electrodes used are broadly separated from each other.
- When the really thin cathode treads like a nib over the chromium layer, it causes the metal to heat up, then dissolve and flow out. This creates a trench with width almost the same as that of the tip of the electrode.
- This set up could be brought about at a cost price of some Rs.20,00,000.

What are the advantages of Electro Lithography?

- This technique could in principle reduce the cost of the equipment used presently from about five crore rupees per piece to merely Rs.15-20 lakhs.
- This would come in useful not just in the industry but in academia, too, with more colleges being able to afford research in nanotechnology.
- Since it does not require high currents or vacuum atmosphere it is a relatively more environmentally-friendly method than existing ones.

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What are the disadvantages of Electro Lithography?

Despite the high resolution of electron-beam lithography, the generation of defects during electron-beam lithography is often not considered by users. Defects may be classified into two categories: data-related defects, and physical defects.

Data-related defects may be classified further into two sub-categories. Blanking or deflection errors occur when the electron beam is not deflected properly when it is supposed to, while shaping errors occur in variable-shaped beam systems when the wrong shape is projected onto the sample. These errors can originate either from the electron optical control hardware or the input data that was taped out. As might be expected, larger data files are more susceptible to data-related defects.

Physical defects are more varied, and can include sample charging (either negative or positive)

1. Backscattering calculation errors,
2. Outgassing,
3. Contamination,

Since the write time for electron beam lithography can easily exceed a day, "randomly occurring" defects are more likely to occur. Here again, larger data files can present more opportunities for defects.