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Review on Nanolithography

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ABSTRACT

Nanolithography deals with writing, etching, or printing at the microscopic level, where the dimensions of characters are in nanometers. This involves a variety of methods of modifying semiconductor chips at the atomic level for fabricating integrated circuits (ICs). Instruments used in nanolithography include the Atomic Force Microscope (ATM) and the Scanning Probe Microscope (SPM). The SPM allows surface viewing of the samples in fine detail without necessarily modifying it. Either the SPM or the ATM can be used to etch, write, or print on a surface in single-atom dimensions. This paper has a bird's eye view of various lithographic techniques such as Optical lithography, X-ray lithography, Extreme ultraviolet lithography (EUV), Magneto lithography, E-beam Nanolithography, Dip Pen Nanolithography. A detailed account on E-beam Nanolithography is also provided in order to have an insight into Nanolithography.

KEYWORDS: Nanolithography, Optical lithography, ultraviolet lithography.

1. INTRODUCTION

Optical lithography: Optical lithography, a predominant patterning is able to produce sub-100-nm patterns with the use of very short wavelengths (currently 193 nm). Optical lithography needs the use of liquid immersion and a host of high resolution technologies (phase-shift masks (PSM), optical proximity correction (OPC) at the 32 nm node.

X-ray lithography: It is extended to an optical resolution of 15 nm by using the short wavelengths of 1 nm for the illumination. This is implemented by the proximity printing approach. The technique is developed to the extent of batch processing. The extension of the method relies on Near Field X-rays in Fresnel diffraction: a clear mask feature is "demagnified" by proximity to a wafer that is set near to a "Critical Condition". It calculates the mask-to-wafer Gap and depends on both the size of the clear mask feature and on the wavelength.

Extreme ultraviolet lithography (EUV): The method is simple because it requires no lenses. Extreme ultraviolet lithography (EUV) Extreme ultraviolet lithography (EUV) is a form of optical lithography using ultrashort wavelengths (13.5 nm). It is the most popularly considered NGL technique.

Magneto lithography (ML): This apply a magnetic field on the substrate using paramagnetic metal masks call "magnetic mask". Magnetic mask which is analog to photomask define the spatial distribution and shape of the applied magnetic field. The ferromagnetic nanoparticles (analog to the photoresist) that are assembled onto the substrate according to the field induced by the magnetic mask. E-beam Nanolithography E-beam lithography provides better resolution and greater accuracy than optical lithography.

E-beam Nanolithography: E-beam lithography provides better resolution and greater accuracy than optical lithography. Many light-based nanotechnology are limited by the wavelength of light. However, the smaller the wavelength of light, the higher the energy of the light, which can subsequently cause unwanted side effects. These effects are minimized by the use of electrons instead of light. Fine resolution is provided by the tiny size of the focused electron beam, while accurate site-by-site pattern registration and the capacity to electronically adjust field size provide unequalled overlay accuracy. E-beam lithography consists of shooting a narrow, concentrated beam of electrons onto a resist coated substrate. Electrons can induce the deposition of substances onto a surface (additive), or etch away the surface (subtractive). It is necessary to perform E-beam lithography inside a vacuum, further complicating the required equipment and process.

E-beam Components: The process of E-beam lithography is simple, however, the schematics and the parts required are quite complex. The following are the components of E-beam lithography.

a. Electron Gun: The centerpiece behind E-beam lithography is the electron gun. It is an apparatus that is able to "shoot" a beam of electrons in a specific direction. The more commonly used sources in modern E-beam lithography are lanthanum hexa boride crystal (LaB6) and a zirconium oxide coated tungsten needle (thermal field emitter). Of these two the thermal field emitter provides highest brightness and smallest source size.

b. Electron Optical Column: The electron optical column has a set of lenses that, by a combination of electromagnetism and optics, has the ability to focus the electrons into a concentrated beam in a desired direction. Inside the column, two parallel plates are electro statically charged to a precise degree; the resulting electric field is able to bend the beam in a desired direction.

c. Surface: After the beam is directed by the optical column, it is all set to be focused on the surface. A substance called a photo resist covers the surface. When the beam hits the surface, either an additive or subtractive reaction takes place. An additive writing method uses the electrons to induce a deposition of a compound on the surface. Subtractive writing methods use the e-beam to remove the sections of the resist and surface.

Scanning Methods:

Raster Scan: The E-beam is swept across the entire surface, pixel by pixel, with the beam being turned on and off according to the desired pattern. This method is easy to design and calibrate. However, because the beam is scanned across the entire plane, light patterns take the same amount of time to write as strong patterns, making this method inefficient for certain types of patterns.

Vector Scan: The E-beam "jumps" from one patterned area to the next, skipping unwanted areas. This makes the vector scan much faster than the raster scan for sparse pattern writing. Adjustments to the beam can also be made relatively easily. However, it takes more time for the beam to settle, making it very difficult to maintain accurate placing for the beam.

Dip Pen Nanolithography: Dip Pen Nanolithography (DPN) is a scanning probe lithography technique where an atomic force microscope tip is used to transfer molecules to a surface via a solvent meniscus. This technique allows surface patterning on scales of fewer than 100 nanometers. meaning dip pen (also called the quill pen), where the tip of an atomic force microscope cantilever acts as a "pen," which is coated with a chemical compound or mixture acting as an "ink," and put in contact with a substrate, the "paper". The advantage of this technique is that anything can be used as nano ink to process any material.

DPN facilitates the direct deposition of nano materials on a substrate in a stretchy manner. The deposition can include pyramidal scanning probe microscope tips, hollow tips, and even tips on thermally actuated cantilevers. Fresh advances have demonstrated massively parallel patterning using arrays of 55,000 tips of two dimensional nature.

2. CONCLUSION

E-beam lithography is particularly significant in micro electronics, which require extremely precise placement of micro sized circuit elements. It allows scientists to design and place elements at the negligible possible scale. Also, electrons can be used to etch a "mask" whose patterns can be later got onto a substance using other techniques. Electron beam exposure tools satisfy all of the requirements, i.e., flexibility, resolution, line width control, pattern overlay, etc., for patterning submicron structures. With scanned electron beams no mask is required and the capacity to write a variety of pattern geometries is a significant advantage over other lithographic techniques.

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