

A Short Note on Different Approaches to fabricate Nanostructures

Kevin Jacobs*

Department of Pharmacy, UCL College of Pharmacy, London, United Kingdom

INTRODUCTION

A nanostructure, by definition, is an item with at least one dimension of 100 nanometres or less. Nanoparticles, Nano pores, Nano rods, nanowires, Nano ribbons, nanotubes, and Nano scaffolds are only a few of the many nanostructures available. Their size-dependent qualities are the most promising features of these structures. Metallic nanoparticles, for example, have tunable absorption and radiation wavelengths based on their aspect ratio and coating. The phenomenon of localized surface Plasmon resonance is responsible for these unique features (LSPR). Each particle has the ability to produce a million dye molecules worth of photoluminescence. They're also photo-stable, meaning they won't fade when exposed to light. They can produce more signal than regular dye molecules because of their enhanced optical characteristics. The optical characteristics of nanostructures allow the detection of certain target molecules once they have been coated with probe molecules. Some nanostructured surfaces have been shown to promote cell adhesion and proliferation. This is thought to be due to imitating the Nano-features of biological systems. Carbon nanotubes have a phenomenal current carrying capability. They can be used to connect devices with very small dimensions where regular metals have excessive contact resistance and electro migration [1]. At the Nano scale, electro migration prevents copper from being employed as a connecting metal. Nanowires have been found to be useful in a variety of sensing methods, including electrical, electrochemical, optical, and mass-based methods. Nanowires typically have a high resistance due to carrier surface dispersion; however this resistance is highly influenced by the species adhering to the surface. It can detect an ultralow concentration of target species if the immobilized species can preferentially bind to it. For some disorders, such as cancer, early discovery is essential for effective treatment. Early identification enhances the chances of curing diseases and lowers mortality rates [2]. Due to the lack of ultra-sensitive instruments capable of detecting a multivariate disease like cancer, early or precancerous stages have historically been difficult to identify. Using a huge number of nanostructures on a single assay system, however, such devices may now be possible. In order to fabricate nanostructures, there are two methods: top down and bottom up, depending on the field of application. A sequence of subtractive and additive procedures is used to shape a bulk material laterally in

a top-down method (i) lithography, (ii) oxidation; (iii) etching (iv) ion implantation, (v) diffusion, and (vi) deposition are the essential fabrication stages in a top-down approach [3].

1. **Lithography:** Lithography is the process of transferring a pattern from a mask to a substrate through the use of a mask. The semiconductor industry's mainstay has long been optical lithography, often known as photolithography [4]. Next-generation lithography (e.g., e-beam/ion-beam lithography, X-ray lithography, nanoimprint lithography, scanning probe lithography, interference lithography, nanotemplating, etc.) is a more experimental technology that is intended to eventually replace photolithography. Photolithography necessitates the use of a mask with template elements. When exposed optically to a specified wavelength of light through the mask, a photosensitive material (photoresist) is spun cast on the substrates and undergoes chemical composition changes [5]. The pattern is subsequently created by immersing the exposed wafer in a solution (MF-319 developer solution).
2. **The development of silicon dioxide (SiO₂) on a silicon substrate** is known as oxidation. Thermal oxidation, plasma anodization, and wet anodization are three of the most prevalent methods for generating SiO₂ on a silicon substrate [6]. Thermal oxidation is one of them, and it's used for large-scale electronic device integration. In a furnace, a silicon wafer is heated to a high temperature, either with or without the presence of water vapour. Thermal oxides are divided into two categories: dry oxidation oxides and wet oxidation oxides. The furnace (which is already at or above 1000°C) is pumped with a mixture of nitrogen and oxygen in dry oxidation. Silicon interacts with oxygen at high temperatures, forming the SiO₂ layer. Wet oxidation involves pumping water vapour and nitrogen into a chamber instead of oxygen [7]. Temperature, pressure, wafer orientation, dopant species in the wafer, moisture content inside the chamber, chlorine presence, and other factors all influence the rate of oxide development in both scenarios. Tunneling oxide, gate oxide in metal oxide field effect transistors (MOSFETs), dielectric material in capacitors, ion implantation and diffusion masking material, passivation layer on the substrate, device

*Correspondence to: Kevin Jacobs, Department of Pharmacy, UCL College of Pharmacy, London, United Kingdom, E-mail: kevinjacobsers@yandex.com

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isolating material, and so on are all examples of thermally produced oxides.

3. Etching is a subtractive technique for removing material from a substrate selectively. On the to-be-etched layer, a mask pattern is initially produced. After that, the etchant is added to the mix. Depending on the circumstances, this can be done in dry or rainy conditions. Although wet etching has a high etch rate, it is typically isotropic, which isn't always desirable. Dry etching, on the other hand, is more directive than wet etching, but it is less selective. In cases when a high aspect ratio is required, dry etching is favoured over wet etching. To make patterns, almost all lithography steps are followed by an etching step [8].
4. Ion Implantation is a method in which energetic, charged atoms (or molecules) are injected directly into the substrate. It's the regulated introduction of contaminants. The type of particle, its energy, and the orientation of the wafer in relation to the ion beam all influence the dispersion of impurity atoms [9].
5. Diffusion is a spontaneous migration of particles toward a lower concentration location due to a concentration gradient is known as diffusion. It's a technique for introducing dopants into crystals. It's a process that takes place at a very high temperature.

Deposition is a technique for laying down homogeneous layers of materials on substrates. Chemical vapour deposition (CVD) or physical vapour deposition (PVD) is two types of vapour deposition (PVD). The reactant species are injected into the chamber during CVD. These react with one another to form a layer of a single product material. The by-products that remain are usually gaseous and are pushed out of the chamber. CVD allows for homogeneous, durable, and high-throughput material deposition. It may deposit a variety of materials such as Si₃N₄, SiO₂, Al, and W. PVD is a physical method that involves vaporizing a target material with the help of heat or an electron beam. The vaporized atoms or

molecules settle on the substrate's surface. In this technique, there is no chemical reaction. PVD produces purer deposited films than CVD because there is no other material inside the chamber, although it has a lower throughput [10].

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