Nanogaps Formation Using Scanning Electron Microscope (SEM) Based E-Beam Lithography (EBL) Technique

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The semiconductor industry and wafer fabrication developments are driven by customer's needs. Customers require faster, more reliable and lower cost chips. To achieve this, chip manufacturers and researchers have learned to reduce the size and dimension of component on the chip. The physical dimension of a feature on the chip is referred to as the feature size. Of special note is the minimum feature size on the wafer known as critical dimension. Device critical dimensions (CD) have continually shrunk since the beginning of semiconductor fabrication starting with critical dimension of about 125um in the early 1950s and currently at 0.13um and less [1]. This is about 1/1000 smaller than structure resolvable by the naked eyes but still 1000 times larger than an atom. Today's developments are addressing the size range below these dimensions. Because typical size is in the nanometer range, the methods and techniques are defined as nanotechnology [2]. Us National Science Foundation defined nanoscale lithography as using lithographic tools for fabrication of any structure having feature sizes less than 100nm [3]. As the beginning of nanotechnology, this work is focus on forming the nanogaps formation using SEM based EBL. EBL has played an important role in the development of nanostructure physics [4]. A key factor in the success of the EBL technique is the ability to fine nanostructure in an appropriate resist and development process. PMMA resist is used due to its high resolution positive resist for direct writing EBL applications [5]. In this paper, the latest nanogaps formation including the EBL system, process and resist have been reviewed and discussed. There are 10 basic steps involved in order to form nanogaps structure using SEM based EBL technique as shown in figure 1.

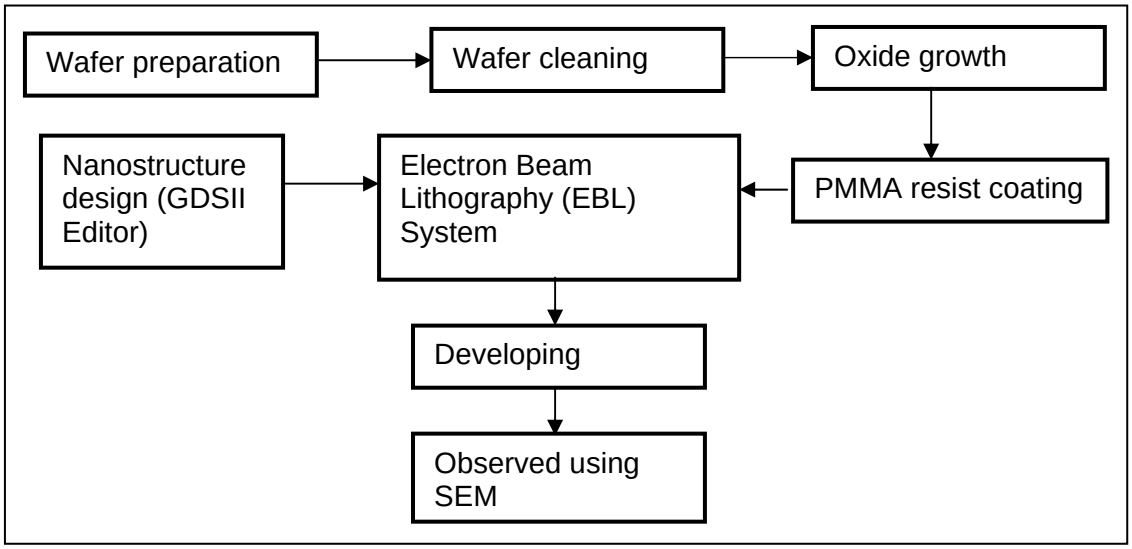

Figure 1: The nanofabrication process flow for nanogaps formation

References:

[1] Quirk M and Serda J, "Semiconductor Manufacturing Technology", Prentice Hall, US of America, 2000.

[2] Kohler M. and Fritzsche W., "Nanotechnology: An Introduction to Nanostructuring Techniques".Wiley- VHC, Germany, 2004.

[3] Ampere A. Tseng, Kuan Chen, Chii D. Chen, and Kung J. Ma, "Electron Beam Lithography in Nanoscale Fabrication: Recent Development", *IEEE Transaction on Electronics Packaging Manufacturing*, Vol. 26, No.2, pp. 141-149, 2003.

[4] I zailer, J.E.F. Frost, V Chabasseur-Molyneux, C.J.B. Ford and M.Pepper, " Crosslinked PMMA as a high resolution negative resist for electron beam lithography and applications for physics of low-dimensional structures", Semicond.Sci.Technol.,UK, 1996.

[5] S Niza Mohammad Bajuri, Nur Hamidah Abdul Halim, Mohammad Nuzaihan Md Nor and Uda Hashim, "495K & 950K PMMA Thickness Characterizations and Optimization", Proceeding of Annual Fundamental Science Seminar 2005, AFSS 2005, 140-144.

Figures:

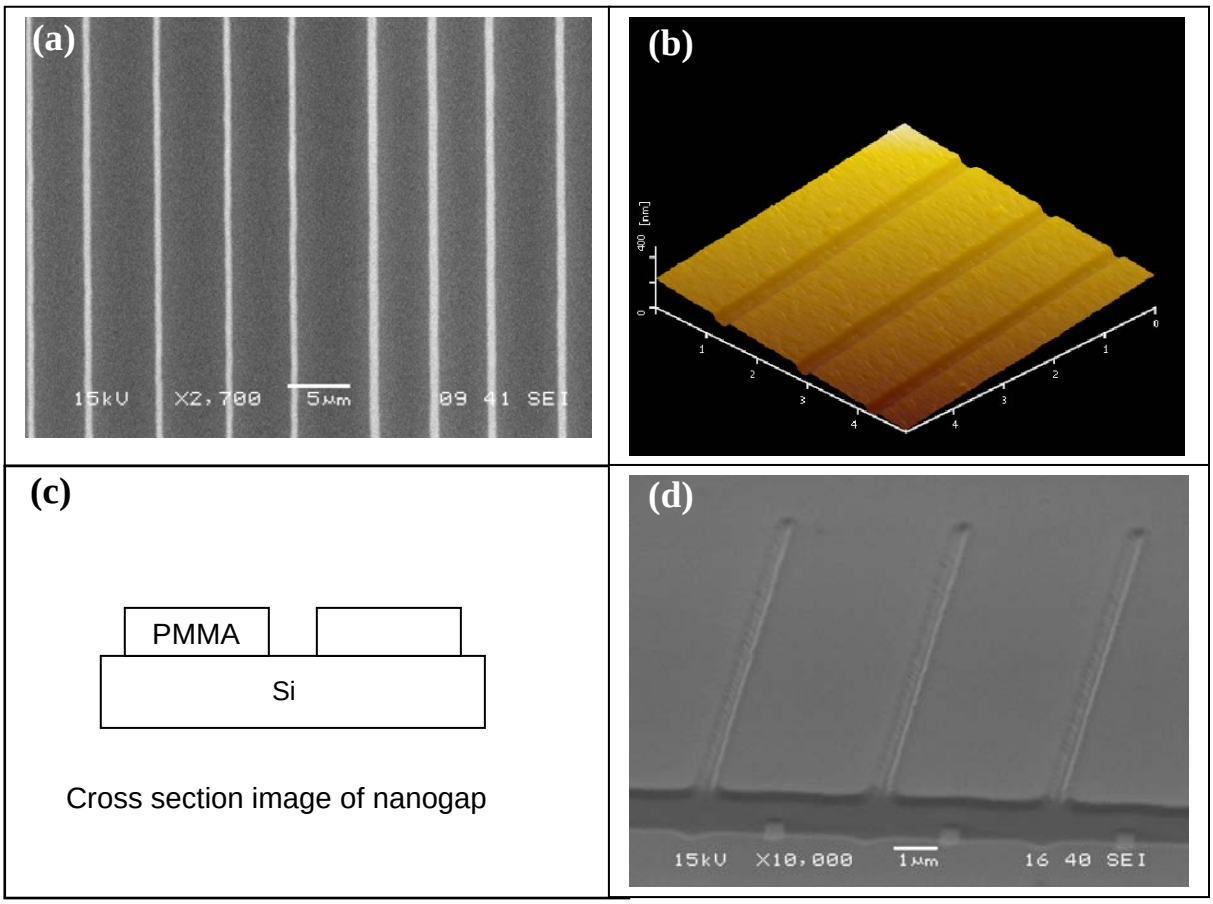

Figure 2: Nanogaps formation: (a) SEM images shows a series of nanogaps, (b) AFM surface topography shows the three- dimensional view of nanogaps, (c) Cross section image of nanogap, (d) SEM images shows the three- dimensional view of nanogaps