Fabrication of Nano-Sized MTJ Array for MRAM Devices

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Spin-torque controlled, MgO-based magnetic tunnel junctions (MTJs) with a large TMR are promising candidates for a non-volatile random access memory. Such spin-torque controlled MTJs can provide high MR ratio, high-speed operation scalability and many read/write cycle endurance. In order to integrate high density spin transfer torque magnetic random access memory (STT-MRAM), a stable process for patterning metallic multilayer MTJs below sub-20 nm dimensions is highly desired. However, dry etching such as ion milling utilized to remove magnetic metals, such as by using Cl_2, may cause the thin films to corrode and induce an undesirable re-deposition of the ion-etched and removed metallic particles on the side of the MTJs. Such re-deposition can cause unwanted electrical shorts across the tunnel barrier reducing the TMR ratios. Therefore, a new approach of nano array patterning techniques can be utilized for sub-20 nm MTJ fabrication, without using ion milling.

Isolated Si nanopillar arrays are first fabricated by lithography or self-assembly such as by electron beam lithography or nano imprinting lithography. The diameter regime of the nano-patterned islands can be in the range of 20 – 100 nm. In order to ensure a good signal to noise ratio and reduced inter-island device interference, the magnetic material deposition is restricted only onto the top surface of the patterned islands, using a convenient, and reliable trench-filling planarization and magnetic material isolation process, which is applied between each successive layer deposition steps. On this planarized and cured surface, a uniform and undistorted magnetic layers, barrier layers or texture-inducing surface layers are deposited. By subsequent lift-off processing, the magnetic material outside the protruding island top surface area is removed together with the resist in the valley region, thus leaving isolated devices array. Using such planarization processes, perpendicular patterned, vertically protruding magnetic devices such as MTJ and MRAM can be fabricated without using dry etching especially avoiding ion milling process that tends to deteriorate the MTJ performance in high density device array structures.