Enhancing Etch Characteristics of MTJ using RF-Biased RIBE

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STT-MRAM is actively researched as a next-generation memory due to its non-volatility, fast operation, high stability, and ease of scaling, all of which are essential for high-performance computing and AI advancements.[1] Materials such as CoFeB, Ru, MgO, etc. are used in the Magnetic Tunnel Junction (MTJ) layer for data storage in addition to CoPt and CoIr to enhance magnetization stability. A common etching method for these MTJ stack layers is Ar^+ Ion Beam Etching (IBE). [2] However, the Ar^+ IBE process leads to MTJ etch by-products redepositing on the pattern sidewalls. Tilting the substrate during Ar^+ IBE is generally used to address this issue but does not fully resolve issues like shadow effects especially for recent high aspect ratio and small CD patterns. Previously, to address these issues, Reactive Ion Beam Etching (RIBE) has been investigated with reactive gases such as CO/NH_3 and Cl_2 to improve volatility of etch by-products.[3] However, this can degrade the MTJ magnetization properties. RIBE process using H_2/NH_3 mixed gases has been also investigated to mitigate some of these issues.[4]

This study aims to improve etching characteristics by using mainly physical etching with slight chemical assistance by RF-biasing. Ar gas is injected for physical etching while H_2/NH_3 mixed gas is injected on to the substrate for chemical effect. When RF power is applied to the substrate, the plasma of H_2/NH_3 mixed gas is discharged on the substrate and induces RF-Biased RIBE. SEM images were taken to analyze etch characteristics. TEM measurements were conducted to analyze the sidewall residues.

References:

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