High-Density, Low-Noise TMR Sensing Arrays Enabled by Three-Dimensional Heterogeneous Bonding

Jiamin Chen,[1,2,3] Zhenhu Jin,[1,2] Chenglong Zhang,[1] and Zi'ang Han[1,2]

[1]*State Key Laboratory of Transducer Technology,*
Aerospace Information Research Institute,
Chinese Academy of Sciences, Beijing 100190, China
[2]*School of Electronic, Electrical and Communication Engineering,*
University of Chinese Academy of Sciences, Beijing 100049, China
[3]*College of Materials Sciences and Opto-Electronic Technology,*
University of Chinese Academy of Sciences, Beijing 100049, China

With the rapid advancement of data-intensive applications, tunneling magnetoresistance (TMR) devices have emerged as key components for high-density and low-powermagnetic sensing. However, conventional lateral scaling faces fundamental limitations due to increased process complexity and parasitic resistance. In this work, we presenta three-dimensional heterogeneous bonding strategy for TMR sensors, enabling vertical integration of dual TMR film stacks. This architecture effectively doubles thenumber of serially connected magnetic tunnel junctions (MTJs) without enlargingthe chip footprint, thereby suppressing low-frequency 1/f noise and enhancing overallsensitivity. To ensure high-quality bonding, the sputtering parameters of the Cr/Aubonding layer, argon ion activation duration, and bonding pressure were systematically optimized. The resulting bonding interface exhibited a surface roughness of 0.509nm and a void ratio of only 0.73Experimental results revealed that at a 45° etchingangle, sidewall redeposition was effectively mitigated, leading to a magnetoresistance(MR) ratio enhancement from 149These results demonstrate that the proposed 3Dheterogeneous bonding approach enables high integration density, reduced noise, andimproved magnetic resolution without altering device dimensions, offering a promisingpathway toward next-generation high-performance TMR sensing arrays.