Effect of material selection on bonding interface for integrating epitaxial spintronic devices by Three-dimensional (3D) integration technology

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Introduction

Three-dimensional (3D) integration technology based on wafer bonding and backside silicon removal processes,[1] which can stack epitaxial multilayer device on polycrystalline electrode vertically, is a promising technology not only for utilizing epitaxial current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) device for ultrahigh-density hard disk drives (HDDs) read head sensor,[2] but also for 3D stacking of epitaxial magnetic tunneling junction (MTJ) in ultrahigh-density MRAM. [3] In this study, we investigated bonding interface condition dependence on different capping materials for direct wafer bonding processing.

Experiment detail

Epitaxial multilayers was fabricated on 2inch Si(001) single crystalline substrate with three different capping layers (Ta, Au and Ta/Au) to represent epitaxial device. On an 8 inch counter wafer, a polycrystalline electrode multilayer was stacked. The 2 inch Epi-multilayer and 8 inch Poly-electrode were bonded by a room-temperature bonding apparatus as shown in Fig. 1.

Experiment result

Fig. 2 shows the HAADF STEM images of three bonded samples with different combination of bonding materials. Those are Au-Ta bonding, Ta-Au bonding and Au-Au bonding, respectively. Among three bonded samples, Au-Au bonding shows the best bonding interface condition. The bonding interface looks perfect, free of damage and grain-boundary like. All layer structure remains uniform after bonding. In the case of Ta-Au bonding, layer structure seriously deteriorates in 2inch side because of mixing between Ag and Au layer. Note that damage can be always seen at the bonding interface of Ta side in Au-Ta bonding and Ta-Au bonding.

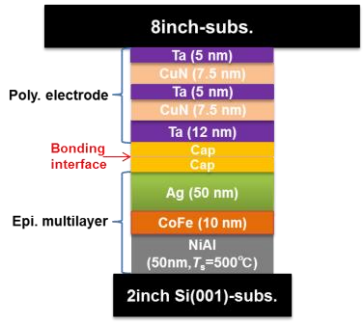

Fig.1 Schematic illustration of a bonded sample.

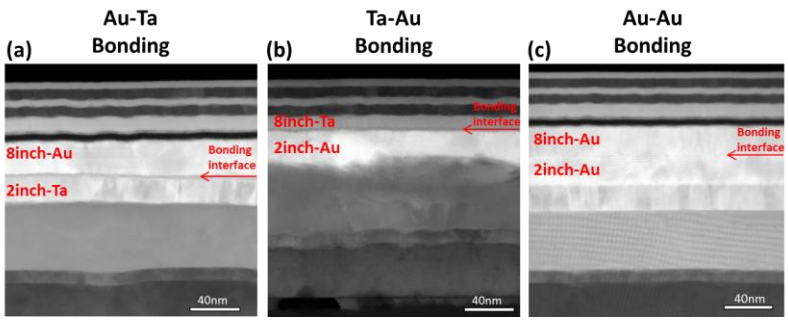

Fig.2 HAADF STEM images for (a) 8 inch Au cap- 2 inch Ta cap bonding, (b) 8 inch Ta cap- 2 inch Au cap bonding and (c)

References

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