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Growth and Physical Properties of InAs 2DEG Structure for the Application to SPIN-FET

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Since Datta and Das proposed the concept of a spin-polarized filed effect transistor (SPIN-FET) [1], InAs 2DEGs have attracted more and more attentions due to its applicability to SPIN-FET, because InAs has the promising properties of a larger mobility, a narrower bandgap and a larger spin-orbit interaction parameter - so called α compared to conventional GaAs and InGaAs 2DEGs [2-3]. However, to achieve high quality InAs 2DEGs, researchers should overcome large lattice mismatch between InAs (0.605nm) and conventional wafers such as GaAs (0.565nm) or InP (0.587nm). This mismatch invokes 3 D growth of InAs or various crystal defects, which are inadequate for 2DEG application. Therefore, they introduced highly strained InAs 2DEGs on InP [2], or meta-morphic growth of InAs on GaAs with the help of Sb based materials [3].

In this presentation, we will report growth of InAs 2DEGs and their physical properties with three methods. 1) InAs 2DEGs on InP wafers, 2) InAs 2DEGs on AlSb/GaAs structures, 3) InAs 2DEGs on GaAs with meta-morphic growth method. 1), 2) are well-reported. However, 3) is the first approach for this application. For the real application, cost and mass-production ability are critical. During 3 methods, 3) is promising because this method does not require expensive InP wafer and Sb sources. Furthermore, GaAs industry for mass-production is well established.

The samples shown here were grown by molecular beam epitaxy, and their optical, structural, electrical properties were measured by low-temperature photoluminescence, atomic force microscope, cross-sectional transmission electron microscope, and hall measurement etc.

Finally, we will compare the properties of 3 methods and discuss the applicability of these methods to SPIN-FET.

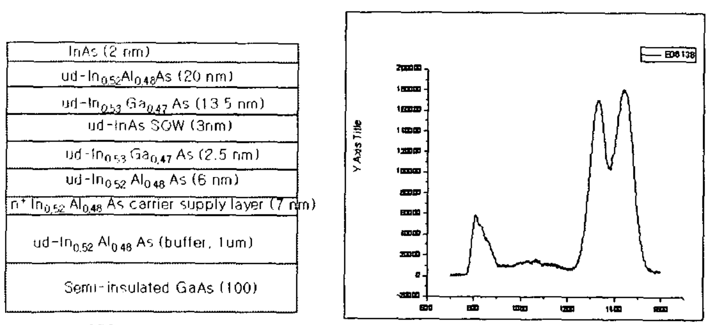

Fig. 1. (left) proposed InAs 2DEG on GaAs. (right) 10K-PL spectrum from InGaAs/InAlAs QWs on GaAs wafers with meta-morphic methods.

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UB01

Texture in die-upset Nd-Fe-B magnet consisting of near single domain particles

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Essential requirements for high performance in permanent magnet are high remanence and high coercivity. For high remanence a good alignment of magnetic grain is essential and for high coercivity a fine grain structure, ideally single domain grain structure, is desirable. For a Nd-Fe-B material a die-upsetting technique is a well-established process to achieve a texture (magnetic alignment) of $Nd_2Fe_{14}B$ grains in the nanocrystalline materials. Meanwhile, an HDDR (hydrogenation, disproportionation, desorption and recombination) process is a well-established technique to prepare a fine grain structured (comparable to single domain size of $Nd_2Fe_{14}B$ compound) Nd-Fe-B material. The authors have thought that it would be interesting to apply the die-upset and HDDR processes to a Nd-Fe-B ingot material. If the die-upsetting can develop a texture in the fine grain structured HDDR material, the ideal requirements of high remanence and high coercivity for high permanent magnetic performance will be fulfilled.

In the present study, the $Nd_{15}Fe_{77}B_8$ ingot was HDDR treated. The large $Nd_2Fe_{14}B$ grains were reformed into fine grains comparable to the single domain size (~0.3 μm) after the HDDR, and the finely recombined $Nd_2Fe_{14}B$ grains were separated by a subsequent roller-milling. These near single domain grain particles were consolidated. The consolidated body was subsequently die-upset with height reduction up to 70%. For a magnetic characterization, the die-upset magnet was briefly milled and the obtained powder was aligned under magnetic field of 10 kO. The demagnetization curve was measured along the direction parallel or perpendicular to the aligning direction using a VSM at room temperature after pre-magnetizing with pulsing field of 50 kOe. The obtained demagnetization curve was corrected to compensate the demagnetizing field of the specimen using a proper correction factor. Magnetic evaluation of the texture in the die-upset magnets was performed by comparing the demagnetization curves along the parallel and perpendicular directions. Microstructure of the material at various conditions was examined using SEM and TEM.

Fig. 1 shows the demagnetization curves measured along the parallel and perpendicular directions to the aligning direction for the powder prepared from the die-upset material. It can be seen that the demagnetization curve along the parallel direction showed much higher magnetization, compared with that along the perpendicular direction. This good anisotropy is firm evidence of good texture or magnetic grain alignment in the die-upset magnet. It can be concluded, therefore, that the die-upsetting leads to a good texture in the material consisting of near single domain grains, in which the magnetisation easy axis (c-axis) of the $Nd_2Fe_{14}B$ grains was aligned parallel to the pressing direction. In this article the texture and over-all magnetic properties of the die-upset Nd-Fe-B magnet with near single domain grain structure is to be discussed. This study may offer us some clues as to the formation mechanism of the texture taking place in the die-upset material, which could help in finding new ways to prepare a high performance Nd-Fe-B magnet.

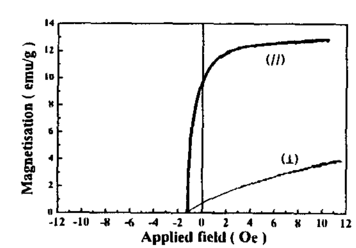

Fig. 1. Demagnetization curves of the die-upset $Nd_{15}Fe_{77}B_8$ magnet measured along different directions.