High Performance Sm-Co Permanent Magnets for Traveling Wave Tube Applications

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Semicon Associates is one of the major $SmCo_5$ and Sm_2Co_{17} permanent magnets producers in the United States. Its magnet products are mainly applied in equipment where high precision and high temperature stability of magnetic properties are required including some military devises especially traveling wave tubes (TWT). At Semicon, extensive research is being conducted to optimize magnet processing, with a view to further improving the performance, quality and consistency of Semicon's magnet products. The focus of the study is on the control of particle size and its distribution of precursor powders, enhancement of particle alignment and optimization of sintering conditions.

Particle size and its distribution of a precursor powder are important parameters that affect significantly the magnetic performance of a permanent magnet produced by the powder metallurgy method. However, accurate characterization of particle size distribution has long been a challenge in the research field of powder metallurgy permanent magnets, because of the difficulty in particle separation due to the nature of agglomeration of magnetic materials. In this project, we invented a technique that allowed separation of the magnetic particles. Therefore, the particle size and its distribution could be quantified, which enabled quantitative control of the particle size and its distribution in production of the Sm-Co magnets. Fig. 1 shows scanning electron micrographs of the separated Sm_2Co_{17} particles and the distribution of the particle size.

A comparative study was also done of the effect of different compaction and magnetization techniques on particle alignment during compaction of the magnet powders. The compaction methods studied in this project were uniaxial pressing, by which a magnetic field was applied parallel to the pressing direction, and cold isostatic pressing. Fig. 2 shows the demagnetization curves of the $SmCo_5$ magnets produced using the powder with an optimized particle size and, by isostatic and uniaxial pressing respectively. It can be seen that the remnant magnetization of the isostatically pressed magnet is 11% higher than that of the uniaxially pressed one. Moreover, the maximum energy product of the former is 22% higher than that of the latter. The coercivity of the isostatically pressed magnets is also significantly higher.

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Sintering and post-heat treatment are other critical processing steps in the Sm-Co magnet production, which determine the final microstructure, density, mechanical properties and eventually the magnetic performance. In this project, the effect of sintering condition especially the post-annealing condition was also studied on the microstructure and magnetic performance. Some sintering procedures employed in this project were different from the conventionally used methods. Fig. 3 shows the demagnetization curves of the magnets annealed with different conditions. It reveals that annealing at higher temperature for a short period of time leads to high remnant magnetization and higher maximum energy products, while a long period of annealing at lower temperature results in higher coercivities but relatively lower remnent magnetizations.

Acknowledgement

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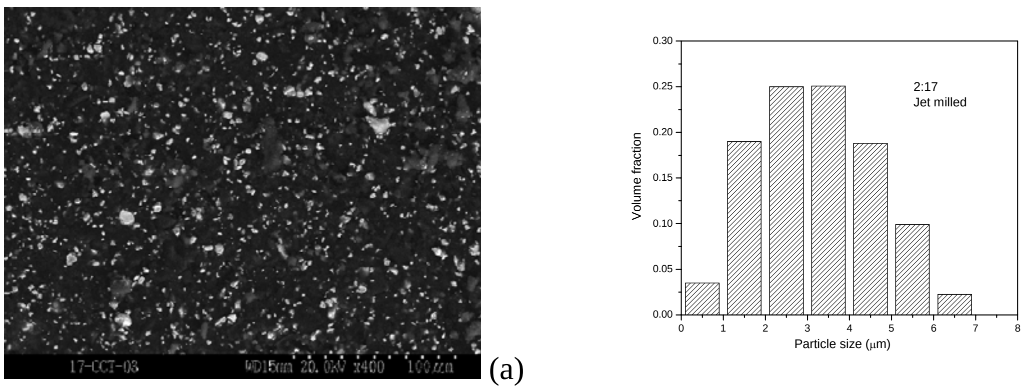

(a) (b)

Fig. 1. (a) SEM micrograph of the dispersed Sm_2Co_{17} magnetic powder and (b) the corresponding particle size distribution.

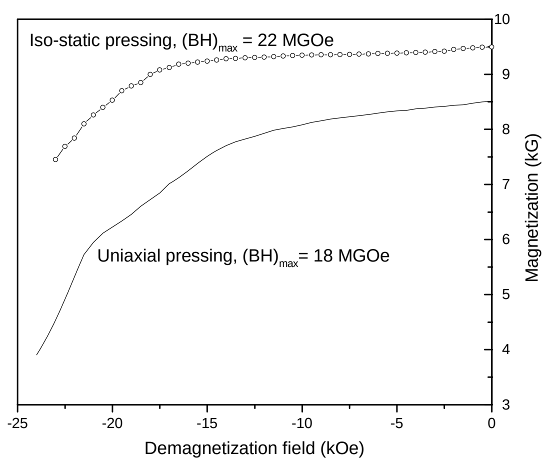

Fig. 2. Demagnetization curves of $SmCo_5$ magnets prepared by isostatic and uniaxial pressing.

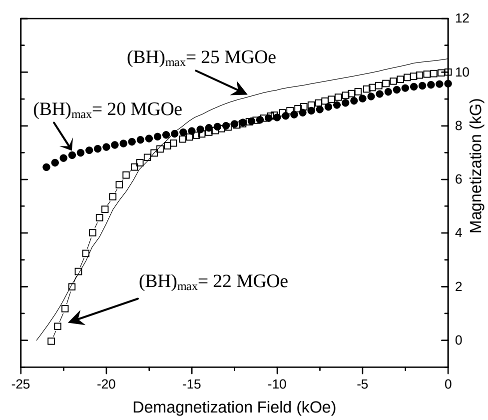

Fig. 3. The demagnetization curves of Sm_2Co_{17} magnets, iso-statically pressed and post-annealed at higher temperature for short time (solid line), the same post-annealing conditions but uniaxially pressed (□□□□ line) and uniaxially pressed but post-annealed at low temperature plus a long term cooling (••••• line).