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Processing of MnBi particles by high energy surfactant assisted ball milling

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Nowadays, the field of magnetic applications is dominated by high performance permanent magnets containing rare-earth metals. However, the high cost along with limited supply of rare-earth elements resulted in search of potential substitutions. The intermetallic compound MnBi is a rare-earth-free permanent magnetic material and its low temperature phase (LTP) has large magnetocrystalline anisotropy ($K \approx 10^7$ erg cm^{-3}) [1] due to its hexagonal NiAs crystal structure and a positive temperature coefficient of coercivity [2], which makes it an excellent candidate for high temperature applications [3].

Due to the peritectic reaction of Mn with Bi it is rather challenging to prepare single-phase MnBi particles. We followed a mechanochemical approach, with surfactant assisted high energy ball milling. MnBi ingots were arc-melted and subsequently annealed, then grinned and mechanically milled along with oleic acid and oleylamine as surfactants. Crystal structure of the samples were examined by X-ray powder diffraction (XRD) and chemical composition was measured with EDS. Scanning electron microscopy (SEM) and magnetic hysteresis loops by using a vibrating sample magnetometer (VSM) were also performed.

We began with MnBi particles (Fig. 1) smaller than 50 μm. Samples were extracted from the mill in t= 1, 2, 3, 5, 10, 20, 40, 80 h. From the first hour of milling the coercivity plummeted and did not increase with further processing. In a similar tone, MnBi has magnetic remanence (M_r) of 18.05 Am^2/kg at the beginning; however it drops to almost 0.1 Am^2/kg in all the samples. A new non-magnetic phase $Bi(Mn)_2O_3$ was detected. It seems that the surfactant is not adequate protection for the brittle MnBi LTP phase at least when high energy ball milling is used.

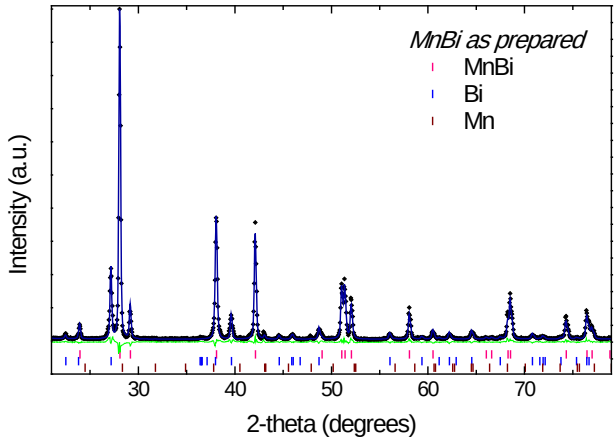

Fig. 1 – XRD analysis of initial MnBi powder.

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