WB6-2-INV

Development of ultra small cryogen-free Superconducting Magnet for High-Resolution NMR

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In 2007, we reported observations of NMR signals of superconducting bulk magnets [1]. The first NMR signal was very broad and could not be used for analytical purposes. However, we achieved a magnetic field strength of 3T that could not be reached with a permanent magnet, found that the stability of the magnetic field was very high, and convinced that the bulk magnet could be used for NMR analysis if the inhomogeneity was solved. Using FEM, we determined the bulk magnet size to keep the magnet homogeneity from the commercial widebore (i.e. 89 mm inner diameter) NMR superconducting magnet to the superconducting bulk magnet. The concept of copying a homogeneous magnetic field from a superconducting magnet for NMR to a bulk magnet is based on a stack of several annular bulk superconductors and is placed on the NMR superconducting magnet using a magnetic field cooling method. By using this method and dealing with magnetic field inhomogeneities that occur during the magnetization process, the magnetic field homogeneity of bulk magnets has improved dramatically. In 2011, we reported the results of MRI [2], and in 2015 we reported a magnet that can observe chemical shifts by NMR [3]. We also found a way to compensate for the inhomogeneous that occurs when magnetizing by inserting HTS tape on the cylinder into bulk magnet[4]. Using these achievements, we integrated an RF probe, room temperature shim, and magnetic field lock system necessary for high-resolution NMR observation, and created a cryogen-free ultra-small superconducting NMR bulk magnet.

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Keywords: Bulk Superconductor, Superconducting Bulk Magnet, Bench-top NMR, Cryogen-free