In-vivo mice imaging using HTS volume coil

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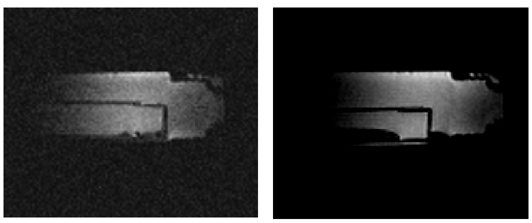
Introduction

Receiver coils using High-Temperature Superconducting (HTS) materials are able to achieve higher quality factor (Q-factor) over conventional copper coils, thus higher signal-to-noise ratio (SNR) or shorter imaging time [1]. Substantial SNR improvements were introduced by surface coils made of expensive HTS thin film [2]. A 5-inch HTS coil using silver-alloy sheathed Bi-2223 tape was first developed [3], where lower cost, easier fabrication and more flexible coil configuration can be achieved. In our work, an HTS volume coil for in-vivo mice imaging in low-field MRI system is first demonstrated.

Materials and Methods

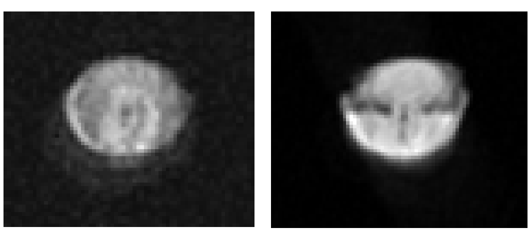
A 3-turn HTS solenoid coil of diameter 6 cm is fabricated using commercially available silver-alloy sheathed Bi-2223 HTS tape. The desired resonant frequency (8.92Hz at 0.21T) is achieved by attaching the two ends of the tape with high quality capacitors from American Technical Ceramics (ATC). In order to resist the relatively large recoil force experienced by small-size HTS coil, a new method is adopted in fabricating HTS tape coil [4]. Silver coatings on the inner side of the HTS tape is substantially removed to avoid screening of RF signals from superconducting phase while those on the outer side are retained to act as a protective layer to the HTS filaments. To further enhance the protection for the HTS coil, a coil holder made of polyethylene plastic and high-density sponge is designed, which facilities its storage, transportation and mechanical protection. A home-made cryogenic system is employed to accommodate our coil in liquid nitrogen. An insulated sample chamber, together with an opening of 3 cm, is used to admit sample through the solenoid coil. Inductive coupling is used for signal pick-up.

To evaluate the performance of our coil, its unloaded quality factor (Q-factor) is measured with a Hewlett Packard-8753ES Network Analyzer at the iso-center of 0.21T magnet. Phantom and mice images are acquired using conventional spin-echo (SE) pulse sequence and its performance is compared to that by an equivalent copper coil.



Copper (300K) HTS (77K)

Fig 1: Comparison between images using copper and HTS coils. The phantom consists of two bottles of deionized water. The width of phantom is 25 mm. Images are acquired using conventional spin-echo (SE) pulse sequence (TR = 400ms, TE = 30ms, NEX = 2, slice thickness = 5mm)



Copper (300K) HTS (77K)

Fig 2: Comparison of in-vivo mice brain images using copper and HTS coils. Images are acquired using conventional spin-echo (SE) pulse sequence (TR = 500ms, TE = 30ms, NEX = 2, slice thickness = 5mm)

Results

Results show that the Q-factor of our developed coil is about 450, which is 4 times better than that of a conventional copper coil. Phantom images are captured in a home-built 0.21T MRI system at 77K, and its performance is compared with that of an equivalent copper coil at room temperature, as shown in figure 1. Images are acquired using conventional spin-echo (SE) pulse sequence. SNR improvement of 2.7 times is introduced by the coil compared to an equivalent copper coil, which is better than any previous results for HTS volume coil. In-vivo mice imaging is also performed (figure 2). We can clearly see the boundary of hemisphere and anatomical structure of mouse brain using HTS coil but not the copper coil using the same sequence.

Conclusions

An HTS volume coil for in-vivo mice imaging is developed in our work. It is shown that our coil is useful to enhance the quality of the image in low-field MRI system. Further study should be carried out at 1.5T or 3T MRI systems to improve quality of images.

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