HTS tape RF coil for low field MRI

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Abstract
A 5-inch RF receiving coil for 0.21T MRI system was developed using multifilament Bi-2223 High Temperature Superconducting (HTS) tape. The coil was designed to enclose the imaging sample so as to enhance the filling factor and field-of-view (FOV) over traditional HTS thin-film surface coil. A cryostat has also been developed to suit such application. In both human and saline phantom MR images, the Bi-based coil at 77K has demonstrated a 3 times signal-to-noise improvement over an equivalent room temperature copper coil.

Introduction
To compensate the lower SNR in low field MRI system [1], expensive High Temperature Superconducting (HTS) thin-film has been employed to fabricate RF coil and substantial SNR improvements have been observed [2]. However, as the HTS material has to be coated on rigid substrate, most of the coils are in planar geometry and this severely limits the FOV and imaging depth. Also, the improved SNR due to higher Q [3] is somehow offset by the reduced filling factor [4]. Despite the high material cost, the HTS wafer has to go through complicated simulation and photolithography process to obtain the desirable resonant frequency.

To overcome the various constraints of thin-film, we have used the Bi-2223 HTS tape to develop a 5” RF coil. The advantages include: (i) low cost (ii) enhanced filling factor and FOV (iii) flexible coil design.

Material and Methods
The RF coil was prepared by a partly modified Ag-sheathed Bi-2223 tape. For picking up high frequency MR signals (0.21T @ 8.919MHz), the silver shield was wet-etched to prevent screening out the applied RF signal from the super-conducting phase [5]. The etched tape was wounded inside a coil holder with high Q capacitors soldered directly to form a resonant ring.

A simple cryostat was developed using styrofoam (fig.1). The HTS coil was mounted on a circular tube inside the cryostat and cooled by LN2. The imaging sample was put inside the circular tunnel with sufficient thermal and electrical insulation.

The performance of the HTS coil was characterized by its quality factor both inside and outside the magnet. Imaging was performed on a home-built 0.21T MRI system. A 2” phantom and human wrist were imaged with conventional Spin Echo pulse sequence. (FOV: 18cm X 18cm, TR=400ms, TE=31ms, NEX=2, Slice thickness: 5mm)

Results
The phantom and human wrist images of the HTS coils and the copper coil are shown in fig. 2 and 3 below.

Discussion
We have demonstrated a high-quality RF receiving coil with Bi-2223 tape instead of traditional HTS thin-film. Significant improvement in image quality (300% SNR gain) and FOV was observed. As the Bi-based tape is not designed for high frequency application, it is expected that the present results can be further improved by the introduction of new tape configuration that can better match the high frequency requirements.

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Reference