

## High Performance Nanomaterial Coil for Carotid Imaging

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### Introduction

A novel RF coil technology based on a nanostructured material was described recently [1], and an application in high resolution prostate imaging at 1.5T was discussed in [2]. Here we introduce an application of this technology in carotid imaging at high (3T) field strength. As described earlier in [1] and [2], the nanomaterial consists of a dense array of carbon nanotubes held together by van der Waals forces. It is macroscopically configured and demonstrates negligible skin effect over the entire frequency range of interest for MRI applications from low to high field strengths, so that with a sufficiently large packing density the resistance of a given length of nanomaterial can be made smaller than that expected for a metallic conductor of similar geometry. At the same time the material has a larger than expected electrical inductance due to kinetic/inertial effects in charge transport, so that the combination of increased inductance and reduced resistance can be used to build receive coils with enhanced SNR. This is demonstrated here for the case of a single channel nanomaterial coil that was built for carotid imaging and compared to a two-channel copper coil.

### Materials and Methods

Carbon nanotubes were grown in a furnace process and drawn into a continuous, macroscopic nanomaterial yarn or wire form by a spinning process. Four strips of nanomaterial were attached to metal electrodes and formed (on a plastic substrate) into a cylindrically curved rectangular coil with an approximate dimensional form factor of 7 cm x 4.5 cm. The nanomaterial coil was attached to a circuit board with suitable tuning and matching circuitry that included an active PIN diode-based block for detuning during transmit. The signal was routed to a scanner interface box via a half-wavelength cable; the interface box included a preamplifier and connected to a Siemens Trio 3T scanner (Siemens, Erlangen, Germany). While this arrangement was suboptimal due to possible introduction of unwanted noise in the length of cable before the preamplifier, it nevertheless met the need for data acquisition. The coil was tested on a standard carotid phantom in the form of a bottle about 12 cm in diameter (Siemens model no. 8624186 K2285, 1900 ml bottle) containing hydrated Nickel Sulphate (3.75 g/l) and Hydrochloric acid (5g/l). A Gradient Recovery Echo scan sequence was used for image acquisition (GRE, TE = 4.6 ms, TR = 50 ms, FOV = 24 cm x 24 cm, slice thickness 3 mm, 260 Hz pixel bandwidth). The same scan sequence was used to image with a 2-channel copper coil; each copper coil channel was cylindrically curved with approximate dimensions 7 cm x 5.3 cm and the channels were overlap-decoupled. This copper coil was very similar in form factor to a commercial high performance carotid coil (Machnet).

### Results

SNR contour maps were constructed for the nanomaterial-based imaging coil (nanocoil) and for the 2-channel copper coil (coronal slices). The phantom was placed horizontally on the patient table similar to a patient. A central coronal slice midway in the phantom, with the coil on the left, is shown in each of the figures below. Figure 1 shows a coronal image slice from the nanocoil. Figure 2 shows the SNR contour plot for the 2-channel copper coil, and Figure 3 shows the SNR contour plot for the single channel nanocoil. It can be seen that the single channel nanocoil yields higher SNR figures to an approximate depth of 3 cm into the phantom.



Fig. 1: Coronal Image from Nanocoil

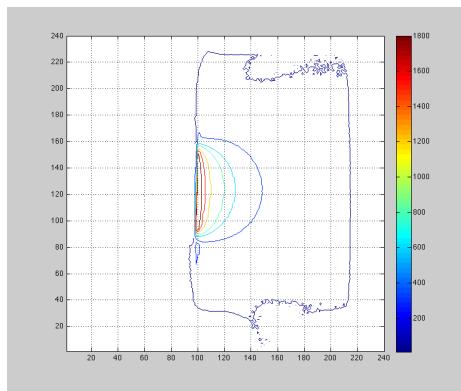


Fig. 2: SNR contours of 2-Ch copper coil

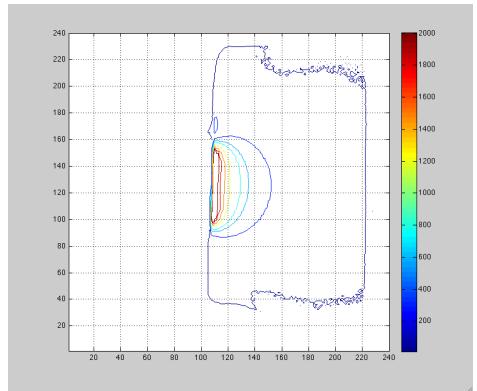


Fig. 3: SNR contours for the 1-Ch nanocoil

### Conclusions

We have directly shown, at a 3T field strength, the significantly higher performance that can be obtained with a nanomaterial coil for carotid imaging. While only a single channel nanomaterial coil was discussed here, we anticipate imaging performance to scale suitably for multi-channel versions. Such coils are in construction and results, both phantom and clinical, will be reported in the future.

### Reference

- [1] R. Viswanathan, B. Goldstein, K. Anderson, M.J. Bronskill, R. Baughman, M. Zhang, S. Fang, A. Zakhidov, A. Aliev, *Beyond Copper: MR Imaging with Carbon Nanotube Receiver Coils*, Proceedings, ISMRM 2009, page 504.
- [2] R. Viswanathan, B. Goldstein, K. Anderson, A. Krieger, *A Novel Nanomaterial Coil for High Resolution Prostate Imaging*, Proceedings, ISMRM 2010.