Double-Resonance HTS Coils toward Dual-Optimized High-Sensitivity NMR Probes

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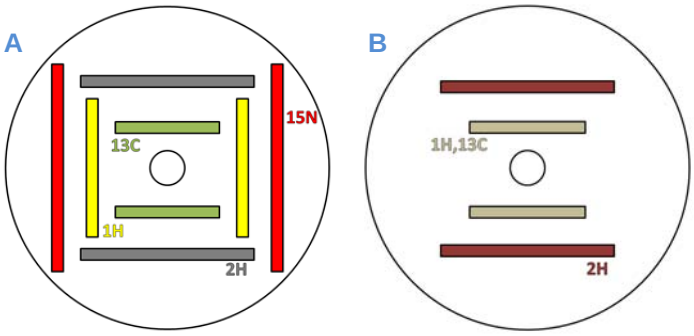
Introduction

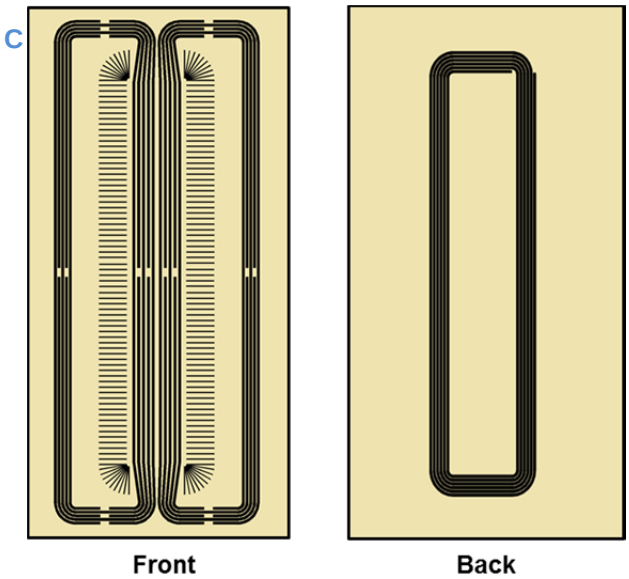
NMR probes based on high-temperature superconductors (HTS) provide significant gains in sensitivity. HTS coils are patterned out of thin-film YBCO on planar sapphire substrates. In order to build multi-channel probes, the pairs of HTS coils are nested orthogonally, as in the case of a 1.5-mm ^{13}C-optimized triple-resonance probe built by our group recently [1]. As shown in figure A, ^{13}C coils were placed closest for highest sensitivity, while sensitivity of other channels is compromised as the distance from sample increases. Novel double-resonance coils are required in order to optimize the sensitivity of two channels in the same probe configuration.

Experimental

In the current work, we have developed double-resonance coils which resonate at two different frequencies with strong and homogenous magnetic fields at both frequencies [2]. The magnetic fields at the resonance frequencies are made mutually orthogonal in order to minimize interaction. Shown in figure C is a two-sided design for a ^{1}H-^{13}C resonator. A figure-8 coil on the front of the substrate resonates at the ^{1}H frequency with the magnetic field parallel to the substrate. A spiral coil on the back of the substrate resonates at the ^{13}C frequency with the magnetic field perpendicular to the substrate. Faraday shield elements are incorporated into the design to suppress the electric field at the ^{13}C frequency.



Cross-section schematic of (A) ^{13}C-optimized probe and (B) ^{1}H-^{13}C dual-optimized probe. Sensitivity is compromised as the distance of the coil from the sample increases. (C) The ^{1}H-^{13}C double-resonance coil. A spiral resonator for the ^{13}C frequency is on the back of the substrate, while a figure-8 resonator for ^{1}H and Faraday shield elements are included on the front of the substrate.



Results and Discussion

A 1.5-mm probe simultaneously optimized for ^{1}H and ^{13}C sensitivity is in being built using the double-resonance coils. The arrangement of coils in this probe is shown in figure B.

The probe is being evaluated using the 14.1 T Agilent spectrometer at the University of Florida. Initial NMR tests have demonstrated a high-resolution lineshape of 0.97/24.4/41.5 Hz at the 50%/0.55%/0.11% height of a $CHCl_3$ peak. Following complete characterization, the probe will soon be available through the AMRIS user program.

Acknowledgements

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References

[1] Ramaswamy, V.; Hooker, J.W.; Withers, R.S.; Nast, R.E.; Brey, W.W. and Edison, A.S., Development of a ^{13}C-Optimized 1.5-mm High Temperature Superconducting NMR Probe, J. Magn. Reson., 235, 58-65 (2013)

[2] Brey, W.W.; Edison, A.S.; Ramaswamy, V. and Hooker, J.W., NMR RF Probe Coil Exhibiting Double Resonance, U.S. Patent No. 8,779,768 (2014)