CFEL SCIENCE

# SEMINAR

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## Nanolitre 1H NMR and MRI detectors for applications in the life sciences


The analysis of inductive NMR detection reveals that miniaturisation can potentially help to improve a sensor's signal-to-noise ratio (SNR). Early reports in the 1990's, initiated by Olson et al. in 1995 [1], and based on hand-crafted microcoils, confirmed this prediction, and showed that millimolar sensitivity for nanolitre sample volumes is in principle possible. Building upon these impressive early achievements, my collaborators and I have focused on enabling mass producible miniaturised NMR detectors and systems that show adequate spectroscopic performance. At the intersection of the demands of NMR-compatibility and performance, and requirements imposed by microfabrication methods [2,3], I will show that we have, through extensive simulations and manufacturing process improvements, progressively improved B0- and B1-homogeneity, sample handling, filling factor, detector SNR, and system functionality [4-9]. The cocktail of implementation ideas will cover: Wirebonding and inkjetting as metal micro-structuring methods [2,3], and building upon these processes, an NMR micro-detector with multi-level microfluidic lab-on-a-chip integration [8], a 7-channel micro phased array system [4], signal multiplexing based on a custom 4.3 x 3.4 mm2 CMOS chip [7], a Helmholtz microdetector with disposable sample holder [9], a 100% fill factor microcoil with disposable capillary sample holder [6], and a magic angle coil spinning micro-detector [5]. The application demonstrations will cover: Spectroscopy of nanolitre volume samples at low concentration, and NMR-microscopic imaging of cells, skin biopsies, and brain slices. Our current work is focusing on the further co-integration of functionality, such as microgradients, or multiple RF channels, and the customisation of the chip laboratory platforms towards the specific needs of various applications. As an outlook, I will speculate on where our journey may lead to.



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[2] K. Kratt et al., A fully MEMS-compatible process for 3D high aspect ratio micro coils obtained with an automatic wire bonder, JMM 20(1), p. 015021, 2010.
[3] D. Mager et al., An MRI Receiver Coil Produced by Inkjet Printing Directly on to a Flexible Substrate, IEEE Transactions on Medical Imaging 29(2), pp. 482-487, Feb. 2010.
[4] O. G. Gruschke et al., Lab on a chip phased-array MR multi-platform analysis system, Lab Chip 12(3), pp. 495-502, 2011.
[5] V. Badilita et al., Microfabricated Inserts for Magic Angle Coil Spinning (MACS) Wireless NMR Spectroscopy, PLoS ONE 7(8), p. e42848, 2012.
[6] O. G. Gruschke et al., Water-soluble sacrificial layer enables ultra low-cost LOC integration of magnetic resonance microcoils with 100% filling factor, 17th International Conference on Solid-State Sensors, Actuators and Microsystems (Transducers & Eurosensors XXVII), pp. 132-134, 2013.
[7] M. Jouda et al., CMOS 8-channel frequency division multiplexer for 9.4 T magnetic resonance imaging, 9th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME), pp. 25-28, 2013.
[8] R. C. Meier et al., Microfluidic integration of wirebonded microcoils for on-chip applications in nuclear magnetic resonance, JMM 24(4), p. 045021, 2014.
[9] N. Spengler et al., Micro-fabricated Helmholtz coil featuring disposable microfluidic sample inserts for applications in nuclear magnetic resonance, JMM 24(3), p. 034004, 2014.


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