Title:

«Multi-functional RF coils for 7T MRI based on 1D / 2D electromagnetic metamaterials»

Abstract:

In a brief overview, I'd like to address our various research activities at the University of Duiburg-Essen that are devoted to the enhancement and the molding of RF magnetic fields within ultra-high field MRI scanners at 7T. This includes the development of coil elements (at 298MHz) based on composite right-/left-handed (CRLH) 1D electromagnetic (EM) metamaterial transmission lines (i.e. EM *metalines*) operating in the zeroth order resonance (ZOR) to foster uniform RF magnetic field distributions along the scanner axis. Tailored EM metalines supporting quarter-wave or full-wave resonances are used either as dual-band coil elements for simultaneous $^{1}H/^{23}Na$ imaging or as metamaterial ring antenna. The latter is key to the *MetaBore*, which is a fully adaptive RF field control scheme based on a periodic axial arrangement of conformal metamaterial ring antennas in the framework of high-field traveling-wave MRI. With the 2D EM metamaterials (*metasurfaces*) we realized hard, soft and high-impedance surfaces (HIS) in order to enhance the uniformity and directivity of the RF magnetic field from e.g. overlaying (elongated) dipole elements (respective series resonant loops) towards the probe volume. Some designs may include simulation studies of the overall multichannel coil systems, which are carried out with our home-made, freely available and open electromagnetic 3D EC-FDTD solver *openEMS* (http://openems.de).
For the experimental verification of our coils we rely on close collaborations with the *Erwin L. Hahn Institute for Magnetic Resonance Imaging (ELH)* of our university's hospital in Essen as well as with the *Institute for Biometrics and Medical Informatics* at the *Otto-von-Guericke University in Magdeburg*, both equipped with a 7T MRI scanner (Siemens Magnetom).

Short Bio:

Daniel Erni received a diploma degree from the University of Applied Sciences in Rapperswil (HSR) in 1986, and a diploma degree from ETH Zürich in 1990, both in electrical engineering. Since 1990 he has been working at the Laboratory for Electromagnetic Fields and Microwave Electronics, ETH Zürich, where he got his Ph.D. degree in 1996. From 1995-2006 he has been the founder and head of the Communication Photonics Group at ETH Zürich. Since Oct. 2006 he is a full professor for General and Theoretical Electrical Engineering at the University of Duisburg-Essen, Germany (http://www.ate.uni-due.de/). His current research interests include advanced data transmission schemes (i.e., O-MIMO) in board-level optical interconnects, optical on-chip interconnects, ultra-dense integrated optics, nanophotonics, plasmonics (e.g. for optical antennas, advanced solar cell concepts, and biomedical applications), quantum optics, semiconductor lasers, optical and electromagnetic metamaterials (e.g. for multi-functional leaky wave antennas and advanced RF systems for high-field MRI imaging), microwave engineering and THz modeling (e.g. for chipless RFID tags and for THz material and surface characterization, cf. http://www.trrmarie.de), computational electromagnetics (cf. http://openems.de), applied electromagnetics (e.g. in marine electromagnetics and signature silencing), bioelectromagnetics (e.g. biological tissue modeling), and multiphysics modeling (e.g. electrostatics together with CFD in the framework of digital microfluidics for theranostics). On the system level Daniel Erni has pioneered the introduction of numerical structural optimization into dense integrated optics device design. Further research interests include science and technology studies (STS) as well as the history and philosophy of science with a distinct focus on the epistemology in engineering sciences. He is a Fellow of the Electromagnetics Academy, a member of the Center for Nanointegration Duisburg-Essen (CeNIDE), as well of Materials Chain, the Flagship Program of the University Alliance Ruhr, and member of the Swiss Physical Society (SPS), the German Physical Society (DPG), the Optical Society of America (OSA), Electrosuisse, and of the IEEE.