

Radiocommunications, Electromagnetism and Microwave Engineering Research Group (GIMRE)

Dr. David Sánchez-Hernández, Dipl.-Ing., Ph.D., CEng, MIEEE, MIEE
Technical University of Carthagene
Antiguo Cuartel de Antigones
E-30202 Cartagena, SPAIN
Tel. + 34 968 325 317 Fax + 34 968 325 973
E-mail: david.sanchez@upct.es
Web: <http://www.gimre.upct.es>

Abstract – The main activities, research lines and results of the Radiocommunications, Electromagnetism and Microwave Engineering Research Group (GIMRE) at the Technical University of Carthagene are portrayed. With just 8 years of activity, GIMRE is reaching maturity as a high-scientific achievement R&D group in the Region of Murcia, Spain.

Index Terms—Integrated antennas, microwave heating, electromagnetic dosimetry, diversity and MIMO.

I. INTRODUCTION

In August 1998, the Government of the Region of Murcia (Spain) decided the creation of a new School for Telecommunications Engineering within the Technical University of Carthagene, and in early February 1999 commanded Dr. David Sánchez-Hernández as Vice-Dean for the task of attracting young and experienced PhDs to start up research groups linked to the new School. Let me remind you that in Spain microwave and antenna engineering is mainly taught at the Telecommunication Schools. There is no doubt that parachuting into such a task concentrates the mind. Thus, David brought along 5 microwave-related researchers among some other specialists through inter-university agreements, and the seed of a new group, named Electromagnetism and Microwave Engineering Research Group (GIMRE) was planted. Antennas, electromagnetic fields, microwaves and industrial applications of microwave and RF heating were placed among the teaching subjects at both Dipl.-Ing. and Ph.D programs, and several research lines started.

After 8 years the team is now well established, has served as the basis for new research groups and has a large number of on-going projects with well-equipped facilities, including network and spectrum analyzers, a dosimetric assessment testing system (DASY4), two anechoic chambers and a reverberation chamber, and it is currently recognized as a group of excellence and high-standard scientific achievement by the Regional R&D Evaluating Agency (*Fundación Séneca*,

Ref. AR 42-02681/FS/02) and with excellent national reputation. A picture of GIMRE members is shown below.



Fig. 1. GIMRE research group.

Research results include over 40 published papers at ISI journals, participation with over 80 conference contributions and 5 patents, 3 of them being exploited. GIMRE has also authored or co-authored 5 books and is currently writing 3 others for *Prentice Hall*, *IEE Power and Energy Series* and *American Scientific Publishers*, all in the fields of microwave and antenna engineering, yet related to the different research lines at GIMRE. GIMRE has received the prestigious *R&D J. Langham Thompson Premium*, awarded by the IEE, the *accésit* to the *Isaac Peral y Caballero Prize* for high-quality technology transfer activities and some other national awards. GIMRE members are also evaluating UE research projects and co-operating with the review of scientific papers at *IEEE Transactions on Antennas and Propagation*, *IEEE Transactions on Microwave Theory and Techniques*, *IEEE Transactions on Vehicular Technology*, *Electronics Letters*, *IEE Proceedings on Microwaves, Antennas and Propagation*, *International Journal of Electronics* and the *International*

Journal of Microstructure and Materials Properties. Likewise, GIMRE members belong to the Editorial Boards of the *European Microwave Conference (EuMC)* and the *International Conference on Microwave and High Frequency Heating, (AMPERE)*. Detailed information can be found at the group's web page <http://www.gimre.upct.es>

Three main research lines have been developed at GIMRE: microwave heating, radioelectric emissions and dosimetry and advance antenna design and development, briefly described below.

II. MICROWAVE HEATING RESEARCH

With an extensive experience, four important projects are currently under way in the group at the moment related to this research line. The use of microwave energy as an alternative for conventional pesticides in disinfecting processes of soil and food products is being investigated with mixed private and public funding by the European Regional Development Fund (ERDF) and the Spanish Ministry of Science and Technology National Research Programme [1]. The end of the possibility for using Methyl Bromide as a pesticide during 2005 and onwards has prompted a petition for UE funds, jointly with the Valencian Institute for Food Research, for a large scale development of a patent-protected prototype developed at GIMRE. Likewise, private funding is allowing research on leather drying using microwaves, and two prototypes have been built with microwaves assisted by hot air [2].

More recently, a privately-funded project on modelling of combined microwave/hot air drying for construction materials has been started in cooperation with the Technical University of Valencia. Another project funded by the Spanish National Research Programme related to the design of multimode multifed auto-matching structures used in industrial microwave systems by means of experimental validation of simulated results has recently finished successfully [3]. The in-house developed software includes hybridization of Maxwell and heat and mass transfer equations, and provided important conclusions on limitations of mode-stirrers for multimode cavities, published at several journals [4-5].

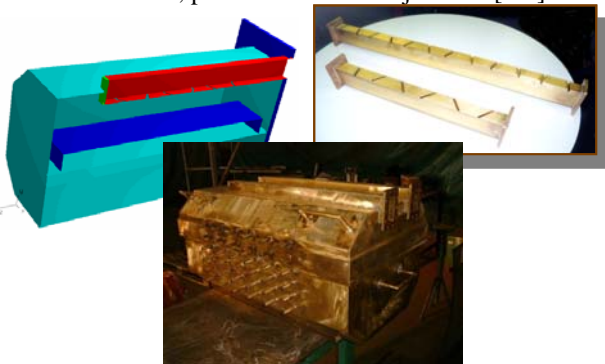


Fig. 2. The multi-feeding technique. Design and construction.

Notwithstanding the need for confidential protection over some private-funded research projects under way at Carthagene, we can mention that one of them is related to the use of novel multiplanar material for reduced dichroic RCS in conformed-to-NATO standards while the other has the aim of minimizing electromagnetic interference within a real

electromagnetic hostile environment. It is worth mentioning here that Carthagene holds the command brain of the Spanish Navy at the Mediterranean Sea and that the biggest Spanish warship and solo submarine factory is located in the bay of Carthagene.



Fig. 2. The patent-protected rice disinfecting microwave unit at work.

III. RADIOELECTRIC EMISSIONS AND DOSIMETRY

In this line of research we intend to minimize SAR values, which is an indication of the speed at which the human body absorbs EM energy. In 2001 GIMRE obtained a seat at the Spanish National Board for Radioelectric Emissions of COIT, sharing decision-taking procedures with other eight appointed experts. Previously, the group had published the first Spanish report on mobile dosimetry, and developed and patented novel antenna structures that reduce radioelectric emissions. The good reputation at national level of GIMRE in this research area made the *Colegio Oficial de Ingenieros de Telecomunicación*, to appoint GIMRE to develop the Spanish protocol for measuring radioelectric emissions from mobile communications towers. The Protocol was also delivered to the European Commission through the Joint Research Centre at Ispra (Italy) in the framework of a UE Project and to CENELEC, and it is currently the basis for an European consensus on a common Protocol. A summary of this Protocol was published at the IEE Proceedings on Microwaves, Antennas & Propagation [6].



Fig. 3. Radioelectric emissions mobile unit at work.

GIMRE is also a full member of AENOR (Spanish Normalization Agency) in several committees, and has been appointed official Spanish representative at CENELEC

TC106X Committee (Electromagnetic Fields in the Human Environment). Moreover, when four kids were prognosticated leukaemia in Valladolid in a school very close to a radiocommunications site, the Commission of Independent Experts, funded by the Spanish Ministry of Health and by the Regional Government of Castilla-y-León selected GIMRE within all research groups in Spain to properly evaluate the emissions at and around the school. A final report and some GIMRE answers to health experts' questions can be found at <http://www.jcyl.es/garciaquintana>. The report was incorporated to the EMF and health related research performed by COST-281. With funding from the Spanish Ministry of Science and Technology, GIMRE is continuously developing new methods for reducing Specific Absorption Rate values in mobile units, as well as minimizing radioelectric emissions from mobile communications base stations. With private funding, GIMRE has up to now coordinated the correct evaluation of over 1200 mobile digital communications base stations in Spain, and predicted emissions values of several new UMTS and WiFi sites. For evaluating radioelectric emissions and SAR, GIMRE operates with the only DASY4 equipment fully available in Spain.



Fig. 4. DASY4 Dosimetric Assessment System at Carthagene.

IV. ADVANCE ANTENNA DESIGN AND DEVELOPMENT

The constant evolution of the mobile phone market determines more stringent constraints for terminal antenna design, as the size of the terminals shrinks rapidly, while the functionalities of the handsets are ever increased. Multi-band operation, which is nowadays almost a common standard, requires the use of enhanced radiating elements. Moreover, other aspects such as small size, weight, and integration have a great relevance for the final design, while material and assembling costs must be kept as low as possible. Similar breakthroughs are expected for base station antennas, yet space is not such a constraining factor. In this research line GIMRE is developing advanced multiband radiating elements for wireless communications systems at both the handset [7],

wherein GIMRE holds intellectual property of a killer spur-line technique [8], and the base station scenarios. In these designs, either diversity or MIMO techniques are employed in the new elements. A novel base station antenna for WiFi systems is the latest development.

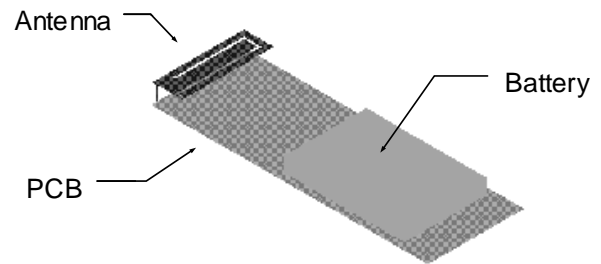


Fig. 5. Integrated handset antennas developed at Carthagene.



Fig. 6. Patented WiFi basestation.

The WiFi basestation array has been recently patented and it is already installed and exploited, performing within a 4 to 12-fold increase in system capacity compared to current commercial units. This line of research is now directed with several private-funded contracts and two public funded projects. MIMO performance is design by software and evaluated in the RC800 reverberation chamber at Carthagene, pictured below.



Fig. 7. RC800 Reverberation chamber at Carthagene.

V. CONCLUSIONS

A considerable effort has been made, and still continues, to perform high quality R&D at Carthagene under the auspices of GIMRE. Given the 'size of the canvas', so much is still straightforward for GIMRE. Yet, with over 5 journal publications a year and a steady-state scenario of 5 on-going simultaneous projects, GIMRE is now reaching maturity at the Technical University of Carthagene, and 2006 may be a year for gaining international reputation.

REFERENCES

- [1] Sánchez-Hernández, D., et al., 'Microwave energy as a viable alternative to Methyl Bromide and other pesticides for rice disinfection industrial processes', Fourth International Working Conference on Alternatives to Methyl Bromide, Seville, pp. 159, 162, 2002.
- [2] Monzó-Cabrera, J., Catalá-Civera, J.M. and Sánchez-Hernández, D., 'A Model For Microwave-Assisted Drying of Leather: Development And Validation', Journal of Microwave Power and Electromagnetic Energy, Vol. 39, pp. 53-64, 2004.
- [3] Monzó-Cabrera, J., Escalante, J., Díaz-Morcillo, A., Martínez-González, A. and Sánchez-Hernández, D., 'Load Matching in Multimode Microwave-Heating Applicators Based on the Use of Dielectric Layer Moulding with Commercial Materials', Microwave and Optical Technology Letters, Vol. 41, no. 5, pp. 414-417, 2004.
- [4] Plaza-González, P., Monzó-Cabrera, J., Catalá-Civera, J.M. and Díaz-Morcillo, A., 'A New Approach for the Prediction of the Electric Field in Multimode Microwave Applicators with Mode Stirrers', IEEE Transactions on Magnetics, Vol. 40, no. 3, pp. 1672-1678, 2004.
- [5] Requena-Pérez, M.E., Pedreño-Molina, J.L., Monzó-Cabrera, J. and Díaz-Morcillo, A., 'Multimode Cavity Efficiency Optimization By Optimum Load Location: Experimental Approach', IEEE Transactions on Microwave Theory and Techniques, Vol. 53, pp. 2114-2119, 2005.
- [6] Martínez-González, A., Fernández-Pascual, A., de los Reyes, E., Gabriel, C., van Loock, W.- and Sánchez-Hernández, D., 'A practical procedure for the verification of compliance of digital mobile radio base stations to the limitations of exposure of the general public to electromagnetic fields', IEE Proceedings on Microwaves, Antennas and Propagation, Vol. 149, pp. 218-228, 2002.
- [7] Martínez-Vázquez, M., Litschke, O., Geissler, M., Heberling, D., Martínez-González, A. and Sánchez-Hernández, D., 'Integrated planar multiband antennas for personal communications handsets', IEEE Transactions on Antennas & Propagation, Vol. 54, pp. 384-391, 2006.
- [8] Sánchez-Hernández, D. and Robertson, I., 'Analysis and design of a dual-band circularly polarised microstrip patch antenna', IEEE Transactions on Antennas & Propagation, Vol. 43, pp. 201-205, 1995.

PATENTS

- [1] ES 2156832. Antena impresa de banda dual. Sánchez. 1999
- [2] ES 2164014. Método y aplicador de microondas para procesos industriales de desinsectación de grano de cereal, y cámara correspondiente. 2000
- [3] ES 2185463. Antena dual para terminales móviles. 2000
- [4] P-200401298. Procedimiento de polimerización de resinas aplicadas sobre el mármol mediante el uso de microondas. 2004
- [5] P-E9902216. Antena impresa de banda dual para comunicaciones inalámbricas. 2006

RECENT PUBLIC-FUNDED PROJECTS

- [1] Multimodal and multified structures for microwave industrial applications. Simulation techniques and experimental validation (MULT²MIC). Funding Institution: CICYT. TIC2001-2778-C02-02.
- [2] Application of microwave energy to drying techniques for industrial processes within conventional building industries. Funding Institution: Fundación Séneca (Murcia Region). IV 01894/CV00
- [3] Design and production of novel antennas for third generation mobile communications base stations and handheld terminals which reduce

radioelectric emissions. (DISMÓVIL3G). Funding Institution: MCYT. FIT-070000-2001-501.

- [4] Production and marketing of novel antennas for third generation mobile communications base stations and handheld terminals which reduce radioelectric emissions. (DISMÓVIL3G). Funding Institution: MCYT. FIT-070000-2002-262.
- [5] Human exposure to radiation from GSM and GPRS/UMTS base stations across Europe. Funding Institution: Joint Research Centre (UE)
- [6] Diseño y evaluación de técnicas MIMO en redes inalámbricas comerciales (MIMOWIFI). Funding Institution: CICYT. FIT-330200-2004-190.
- [7] Estudio de viabilidad del empleo de radiación microondas en los procesos de eliminación de microorganismos en productos alimenticios previamente envasados (CATMO). Funding Institution: Fundación Séneca (Murcia Region). 2104SU063.
- [8] Desarrollo de técnicas de medida y equipos portátiles para la caracterización dieléctrica y magnética de materiales con aplicaciones a frecuencias de microondas (PORMUEPS). Funding Institution: CICYT. TEC2004-05037-C02-02/MIC.
- [9] Cámara de reverberación para medida de parámetros de antenas y terminales móviles. Funding Institution: Ministry of Industry. UPCA05-23-001.
- [10] Diseño y evaluación de técnicas MIMO en redes inalámbricas comerciales (MIMOWIFI). Funding Institution: Ministry of Industry. FIT-330210-2005-2)
- [11] Desarrollo de nuevos elementos radiantes para redes inalámbricas de ámbito residencial y rural (NUEVARED). Funding Institution: Fundación Séneca (Murcia Region). 2105SU0033.
- [12] Desarrollo tecnológico para mejora sustancial del proceso en la fabricación de abrasivos aplicando energía microondas (MICROABRA). Funding Institution: Ministry of Industry. CIT-020500-2005-6.

RECENT PRIVATE-FUNDED PROJECTS

- [1] Testing and verification of base stations radioelectric emissions. Funding company: Retevisión Móvil S.A. 2002
- [2] Development of technologies for new enhanced materials with special properties with electromagnetic waves. Funding company: Izar Construcciones Navales S.A. 2002
- [3] Polymerisation and microwave-electromagnetism assisted drying. Funding company: CTM Región de Murcia. 2003
- [4] Verificación de emisiones radioeléctricas en UMTS. Funding company: Telefónica Móviles España S.A. and ITACA. 2003.
- [5] Pre-ensayos de medida de TAE (SAR) de antena prototipo para terminal móvil. Funding company: Fractus S.A. 2003.
- [6] Evaluación y Minimización de la Tasa de Absorción Específica en Antenas Inteligentes para Sistemas UMTS empleando el evaluador dosimétrico DASY4. Funding company: Telefónica Móviles España, S.A. 2004.
- [7] Diseño de materiales multicapa con propiedades selectivas en frecuencia para el ocultamiento de buques frente a emisiones de radar y radomos de mimetización de estaciones base de telefonía móvil. Funding company: Izar Construcciones Navales S.A. 2004.
- [8] Aplicación de energía microondas a los procesos de eliminación de microorganismos en productos alimenticios envasados. Funding company: HRS Spiratube. 2004.
- [9] UMTS base station monitoring and settings. Funding company: Retevisión Móvil S.A. 2006.

MEMBERS

Dr. David Sánchez-Hernández, Dipl.-Ing., Ph.D., CEng, MIEEE, MIEE
Dr. Antonio M. Martínez-González, Dipl.-Ing., Ph.D., MIEE
José Fayos-Fernández, Dipl.-Ing.
Juan F. Valenzuela-Valdés, Dipl.-Ing.
Miguel A. García-Fernández, Dipl.-Ing.
Álvaro Belda-Sanchíz, Dipl.-Ing.
Sara García-Ruiz, Dipl.-Ing.
Daniel López-Buendía, Dipl.-Ing.
Francisco García-Medina, Dipl.-Ing.