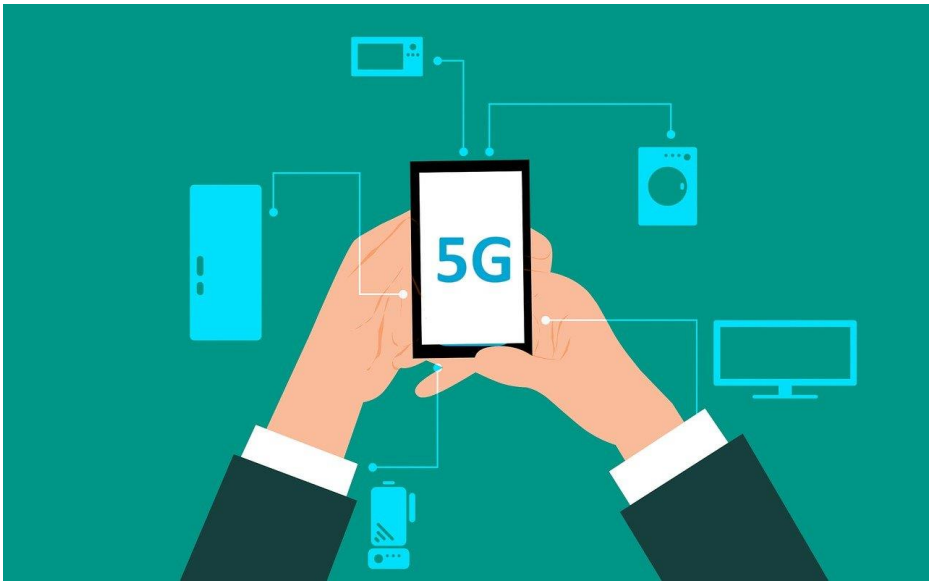
TECHNOLOGIE 5G

Bulletin de veille scientifique : Avril 2024



Objectifs : réaliser une veille scientifique sur la technologie 5G

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Généralités

The determinants of legislation for radiofrequency electromagnetic fields (RF-EMFs) with the onset of 5G: An empirical analysis with a worldwide cross-sectional dataset.

Recuero Virto L, Czerwiński M, Froidevaux J. *Risk Anal*. 2024 Mar 31.

The unprecedented exposure of radiofrequency electromagnetic field (RF-EMF) to humans from mobile communications raises serious public concern about the possibility of unexpected adverse health effects and has stimulated authorities to adopt precautionary exposure limits. These limits are distinctly different across countries, and the causes of these differences are unclear from the literature. This article is the first empirical analysis on the determinants of RF-EMF exposure legislation, using a novel cross-sectional database of 164 countries worldwide. The analysis shows that decentralization and mobile competition in countries with low mobile network deployment tend to promote more stringent RF-EMF exposure limits across the dataset with 164 countries. In more decentralized countries, the regions had a greater influence on national legislation and could accommodate local demands with the advent of mobile technology in the 2000s. In contrast, decentralization and mobile competition in countries with high levels of mobile network deployment tend to relax RF-EMF exposure limits in the sample of 61 countries with fifth-generation (5G) technology. Indeed, restrictive RF-EMF exposure limits are constraining 5G deployment in a context of the widespread adoption of mobile-broadband technologies. These results should be useful for policymakers and mobile operators alike to anticipate the outcome of legislation in countries that have yet to introduce 5G technology. The results should also be useful when reviewing policies and strategies for the implementation of the upcoming 6G technology in frequency bands that will be increasingly higher (above 6 GHz up to THz for very local usage), and hence where the health effects on humans are less well studied.

Lien vers l'article

Extension of simple multi-attribute rating technique in uncertainty environment for 5G industry evaluation: Egyptian new administrative capital as a case study.

Mohamed M, Ali AM, Abdel-Basset M, Abouhawwash M, Askar SS, Tantawy AA. *Heliyon*. 2024 Apr 15;10(7):e29033.

As is well-known, multicriteria decision-making (MCDM) approaches can aid decision-makers in identifying the optimal alternative based on predetermined criteria. However, it is a big challenge to apply this approach in complex applications such as 5th generation (5G) industry assessment because criteria are challenging and trade-offs between them are hard. Also, assessment of the 5G industry involve strong uncertainty. So, this study is the first to evaluate the 5G industry using a new neutrosophic simple multi-attribute rating technique (N-SMART). Since neutrosophic set considers truth-degree, indeterminacy-degree, and falsity-degree, it is a more accurate instrument for evaluating uncertainty. The 5G assessment issue exemplifies the validity and great performance of our proposed method as: (1) its ability to deal with uncertainty phenomena; (2) its simplicity; and (3) its enhanced capacity to discern alternatives. Also, by considering the 5G service provided in the Egyptian New Administrative capital as a case study, the results showed that Ericsson 5G is the best choice and Nokia 5G is the worst choice.

Lien vers l'article

Author Correction: Effect of social influence, environmental awareness, and safety affordance on actual use of 5G technologies among Chinese students.

Shahzad MF, Xu S, Khan KI, Hasnain MF. *Sci Rep*. 2024 Apr 11;14(1):8460.

Lien vers l'article

Looking back to look forward: 5G/COVID-19 conspiracies and the long history of infrastructural fears.

Frith J, Campbell S, Komen L. *Mob Media Commun*. 2023 May;11(2):174-92.

Almost as soon as the COVID-19 pandemic began spreading throughout much of the world, conspiracies arose that blamed the virus on the deployment of fifth-generation cellular networks (5G) infrastructure. These conspiracies had significant consequences, including protests against 5G and the destruction of 5G infrastructure. This article uses a media genealogy approach to place the 5G/COVID-19 conspiracies within the long and recurring cycle of conspiracies focused on mobile infrastructure. Placed within that broader history, this article argues that the 5G/COVID-19 conspiracies should have been unsurprising, and these types of infrastructural conspiracies should be a more significant part of mobile media and communication (MMC) research because infrastructures are an often invisible, yet crucial, part of the mobile practices studied within MMC research. The article concludes by theorizing about why mobile infrastructures are such a frequent target for conspiracy theories and argues that researchers should begin planning now for combatting the conspiracies that will almost inevitably arise when the next generation of mobile infrastructure gets linked to fears about public health.

Lien vers l'article

Performances et sécurité

A Blockchain-Assisted Security Protocol for Group Handover of MTC Devices in 5G Wireless Networks.

Ma R, Zhou J, Ma M. *Sensors (Basel)*. 2024 Apr 6;24(7).

In the realm of the fifth-generation (5G) wireless cellular networks, renowned for their dense connectivity, there lies a substantial facilitation of a myriad of Internet of Things (IoT) applications, which can be supported by the massive machine-type communication (MTC) technique, a fundamental communication framework. In some scenarios, a large number of machine-type communication devices (MTCD) may simultaneously enter the communication coverage of a target base station. However, the current handover mechanism specified by the 3rd Generation Partnership Project (3GPP) Release 16 incurs high signaling overhead within the access and core networks, which may have negative impacts on network efficiency. Additionally, other existing solutions are vulnerable to malicious attacks such as Denial of Service (DoS), Distributed Denial of Service (DDoS) attacks, and the failure of Key Forward Secrecy (KFS). To address this challenge, this paper proposes an efficient and secure handover authentication protocol for a group of MTCDs supported by blockchain technology. This protocol leverages the decentralized nature of blockchain technology and combines it with certificateless aggregate signatures to mutually authenticate the identity of a base station and a group of MTCDs. This approach can reduce signaling overhead and avoid key escrow while significantly lowering the risk associated with single points of failure. Additionally, the protocol protects device anonymity by encrypting device identities with temporary anonymous identity markers with the Elliptic Curve Diffie-Hellman (ECDH) to abandon serial numbers to prevent linkage attacks. The resilience of the proposed protocol against predominant malicious attacks has been rigorously validated through the application of the BAN logic and Scyther tool, underscoring its robust security attributes. Furthermore, compared to the existing solutions, the proposed protocol significantly reduces the authentication cost for a group of MTCDs during handover, while ensuring security, demonstrating commendable efficiency.

Lien vers l'article

The concept of optimal planning of a linearly oriented segment of the 5G network.

Kovtun V, Grochla K, Zaitseva E, Levashenko V. *PLoS One*. 2024;19(4):e0299000.

In the article, the extreme problem of finding the optimal placement plan of 5G base stations at certain points within a linear area of finite length is set. A fundamental feature of the author's formulation of the extreme problem is that it takes into account not only the points of potential placement of base stations but also the possibility of selecting instances of stations to be placed at a specific point from a defined excess set, as well as the aspect of inseparable interaction of placed 5G base stations within the framework of SON. The formulation of this extreme problem is brought to the form of a specific combinatorial model. The article proposes an adapted branch-and-bounds method, which allows the process of synthesis of the architecture of a linearly oriented segment of a 5G network to select the best options for the placement of base stations for further evaluation of the received placement plans in the metric of defined performance indicators. As the final stage of the synthesis of the optimal plan of a linearly oriented wireless network segment based on the sequence of the best placements, it is

proposed to expand the parametric space of the design task due to the specific technical parameters characteristic of the 5G platform. The article presents a numerical example of solving an instance of the corresponding extremal problem. It is shown that the presented mathematical apparatus allows for the formation of a set of optimal placements taking into account the size of the non-coverage of the target area. To calculate this characteristic parameter, both exact and two approximate approaches are formalized. The results of the experiment showed that for high-dimensional problems, the approximate approach allows for reducing the computational complexity of implementing the adapted branch-and-bounds method by more than six times, with a slight loss of accuracy of the optimal solution. The structure of the article includes Section 1 (introduction and state-of-the-art), Section 2 (statement of the research, proposed models and methods devoted to the research topic), Section 3 (numerical experiment and analysis of results), and Section 4 (conclusions and further research).

Lien vers l'article

Dynamic resource allocation in 5G networks using hybrid RL-CNN model for optimized latency and quality of service.

Karuppiyan M, Subramani H, Kandasamy Raju S, Maradi Anthonymuthu Prakasam M. *Network*. 2024 Apr 9:1-25.

The rapid deployment of 5G networks necessitates innovative solutions for efficient and dynamic resource allocation. Current strategies, although effective to some extent, lack real-time adaptability and scalability in complex, dynamically-changing environments. This paper introduces the Dynamic Resource Allocator using RL-CNN (DRARLCNN), a novel machine learning model addressing these shortcomings. By merging Convolutional Neural Networks (CNN) for feature extraction and Reinforcement Learning (RL) for decision-making, DRARLCNN optimizes resource allocation, minimizing latency and maximizing Quality of Service (QoS). Utilizing a state-of-the-art "5G Resource Allocation Dataset", the research employs Python, TensorFlow, and OpenAI Gym to implement and test the model in a simulated 5 G environment. Results demonstrate the effectiveness of DRARLCNN, showcasing an impressive R(2) score of 0.517, MSE of 0.035, and RMSE of 0.188, surpassing existing methods in allocation efficiency and latency. The DRARLCNN model not only outperforms existing methods in allocation efficiency and latency but also sets a new benchmark for future research in dynamic 5G resource allocation. Through its innovative approach and promising results, DRARLCNN opens avenues for further advancements in optimizing resource allocation within dynamic 5G networks.

Lien vers l'article

Deployment Protection for Interference of 5G Base Stations with Aeronautical Radio Altimeters.

Duan Z, Ma Z, Bai J, Wang P, Xu K, Yuan S. *Sensors (Basel)*. 2024 Apr 5;24(7).

In this manuscript, we present a novel deployment protection method aimed at safeguarding aeronautical radio altimeters (RAs) from interference caused by fifth-generation (5G) telecommunication base stations (BSs). Our methodology involves an integrated interference model for defining prohibited zones and utilizes power control and angle shutoff methods to mitigate interference. First, to ensure reliable protection, we define both horizontal and vertical prohibited zones and investigate their variations to immunize RA against 5G interference. Second, we validate the effectiveness of the model in various operational scenarios, analyzing the influence of factors such as

base station types, antenna parameters, flight altitude, and aircraft attitudes to cover a wide range of real-world scenarios. Third, to mitigate interference, we propose and analyze the power control and angle shutoff methods through simulation for the RMa prohibited zone. Our results demonstrate the efficacy of the deployment protection method in safeguarding RAs from 5G interference, providing guidance for interference protection during civil aviation operations and base station deployment near airports.

Lien vers l'article

A 26-28 GHz, Two-Stage, Low-Noise Amplifier for Fifth-Generation Radio Frequency and Millimeter-Wave Applications.

Ben Hammadi A, Doukkali MA, Descamps P, Niamien C. *Sensors (Basel)*. 2024 Mar 31;24(7).

This paper presents a high-gain low-noise amplifier (LNA) operating at the 5G mm-wave band. The full design combines two conventional cascode stages: common base (CB) and common emitter (CS). The design technique reduces the miller effect and uses low-voltage supply and low-current-density transistors to simultaneously achieve high gain and low noise figures (NFs). The two-stage LNA topology is analyzed and designed using 0.25 µm SiGe BiCMOS process technology from NXP semiconductors. The measured circuit shows a small signal gain at 26 GHz of 26 dB with a gain error below 1 dB on the entire frequency band (26-28 GHz). The measured average NF is 3.84 dB, demonstrated over the full frequency band under 15 mA current consumption per stage, supplied with a voltage of 3.3 V.

Lien vers l'article

Achieving Ultra-Broad Microwave Absorption Bandwidth Around Millimeter-Wave Atmospheric Window Through an Intentional Manipulation on Multi-Magnetic Resonance Behavior.

Liu C, Xu L, Xiang X, Zhang Y, Zhou L, Ouyang B, et al. *Nanomicro Lett*. 2024 Apr 22;16(1):176.

The utilization of electromagnetic waves is rapidly advancing into the millimeter-wave frequency range, posing increasingly severe challenges in terms of electromagnetic pollution prevention and radar stealth. However, existing millimeter-wave absorbers are still inadequate in addressing these issues due to their monotonous magnetic resonance pattern. In this work, rare-earth La(3+) and non-magnetic Zr(4+) ions are simultaneously incorporated into M-type barium ferrite (BaM) to intentionally manipulate the multi-magnetic resonance behavior. By leveraging the contrary impact of La(3+) and Zr(4+) ions on magnetocrystalline anisotropy field, the restrictive relationship between intensity and frequency of the multi-magnetic resonance is successfully eliminated. The magnetic resonance peak-differentiating and imitating results confirm that significant multi-magnetic resonance phenomenon emerges around 35 GHz due to the reinforced exchange coupling effect between Fe(3+) and Fe(2+) ions. Additionally, Mössbauer spectra analysis, first-principle calculations, and least square fitting collectively identify that additional La(3+) doping leads to a profound rearrangement of Zr(4+) occupation and thus makes the portion of polarization/conduction loss increase gradually. As a consequence, the La(3+)-Zr(4+) co-doped BaM achieves an ultra-broad bandwidth of 12.5 + GHz covering from 27.5 to 40 + GHz, which holds remarkable potential for millimeter-wave absorbers around the atmospheric window of 35 GHz.

Lien vers l'article

Antennes

A compact and efficiently designed two-port MIMO antenna for N78/48 5G applications.

Srinubabu M, Venkata Rajasekhar N. *Heliyon*. 2024 Apr 15;10(7):e28981.

A tightly packed irregular polygon with a distinctive protruding strip, specifically tailored for the N78/48 application, enhances a highly compact and effectively designed two-port MIMO (multiple-input, multiple-output) antenna. Its dimensions measure 20x31.5 × 1.6 mm3, with ε(r) being 4.4 of FR-4 substrate, and it impressively delivers an extensive impedance bandwidth (S(xx) < -10 dB) spanning the 3.25-3.85 GHz range. The design incorporates a MIMO antenna with closely spaced elements, merely 1.5 mm (0.012 λ(0)) apart. The microstrip inserts a feeding line with a partially truncated ground, a grounded stub, and a side stubs embedded in the ground plane, which improve isolation. Positioning T shaped decoupling elements between radiators helps the antenna's bandwidth enhance and improves isolation (S(21)) across the band. Extensive validation of the antenna's performance has been carried out through comprehensive s-parameter analysis, closely mirroring the results obtained through measurements. Despite its compact form, this antenna efficiently minimizes coupling, achieving S(21) levels exceeding -19.25 dB throughout the band. Notably, the antenna attains an impressive peak gain of 3.3 dBi and exhibits a radiation efficiency of 92%. A total affective reflection coefficient (TARC) that starts at-10 dB, a MEG of 0.481 dB, and a channel capacity loss (CCL) of 0.3016 bits/s/Hz are some of the things that make up its MIMO diversity performance. The envelope correlation coefficient (ECC) is 0.0089. It's particularly suitable for 5G-NR sub-6GHz requirements, offering an efficient and compact solution.

Lien vers l'article

Four port tri-circular ring MIMO antenna with wide-band characteristics for future 5G and mmWave applications.

Munir ME, Nasralla MM, Esmail MA. *Heliyon*. 2024 Apr 30;10(8):e28714.

MIMO (Multiple-Input-Multiple-Output) antenna systems are promising for fifth-generation (5G) networks, offering lower latency and higher data rates. These systems utilize millimeter-wave (mmWave) frequency bands for efficient transmission and reception of multiple data simultaneously, enhancing overall efficiency and performance. This article presents a compact size, wide band tri-circular ring mmWave MIMO antenna with suitable performance characteristics for next-generation communication systems. The MIMO system consists of a tri-circular ring patch with slots on a ground plane. The four elements of the antenna are arranged together in the polarization diversity configuration with overall dimensions of 23×18×0.254 mm(3), and designed on a 0.254 mm thin, flexible RO5880 substrate with a relative permittivity of 2.3 using Computer Simulation Technology (CST) 2022. The proposed antenna design shows the impedance bandwidth of 14 GHz with isolation >18 dB throughout the 26-40 GHz resonance band. The obtained gain is 6.6 dBi at 28 GHz with radiation efficiency > 90%. Several MIMO parameters are also investigated, such as Envelope Correlation Coefficient (ECC), Mean Effective Gain (MEG), Diversity Gain (DG), Total Active Reflection Co-efficient (TARC), and Channel Capacity Loss (CCL), and are found to be within the accepted limits for a practical MIMO system. Furthermore, the fabricated MIMO antenna was tested, and the measured results aligned favorably with the simulated results, confirming the suitability of the proposed design. Through the obtained results, the mmWave MIMO antenna is suitable for practical 5G as well as mmWave

applications due to its lightweight, simple design, and wideband characteristics, which cover the 5G frequency bands of 26, 28, 32, and 38 GHz.

Lien vers l'article

Development of a metasurface-based slot antenna for 5G MIMO applications with minimized cross-polarization and stable radiation patterns through mode manipulation.

Hamlbar Gerami H, Kazemi R, Fathy AE. *Sci Rep*. 2024 Apr 5;14(1):8016.

This paper presents an approach for designing metasurface antennas using the characteristic mode analysis method for 5G mm-wave multiple input-multiple output (MIMO) systems. The proposed metasurface antenna consists of a 3 × 3 array of modified patches with additional slits and stubs, which are fed by a coupling slot. This configuration reshapes surface currents and improves the radiation performance across a broad frequency range. The design offers significant advantages such as reduced antenna size, minimized influence of higher-order modes, and maintained low cross-polarization (XP) level. Experimental results demonstrate that the proposed metasurface-based slot antenna provides a bandwidth of 29.6% (23-31 GHz) with a return loss better than 10 dB. It achieves a peak gain of 9.43 dB and exhibits an XP level below - 26 dB and - 48 dB at ϕ = 0∘ and ϕ = 90∘ planes, respectively. The physical dimensions of the antenna are 0.9λ(0) × 0.9λ(0) × 0.08λ(0), where λ(0) is the free space wavelength at 27 GHz, resulting in an approximately 41% reduction compared to the conventional metasurface patch antenna. Moreover, the design proves to be well-suited for MIMO systems, enabling close placement of antenna elements without degrading their radiation patterns. The experimental results in 1 × 2 and 2 × 2 MIMO configurations represent that the isolation between antenna elements are better than 18 dB and 21 dB, respectively. The performance of the antennas remains stable in both configurations, effectively addressing concerns such as beam squint and eliminating the common issue of beam splitting observed in conventional metasurface MIMO antennas. Moreover, the envelope correlation coefficient value in both MIMO configurations is lower than 0.003. This significant advancement offers a promising solution for compact 5G mm-wave massive MIMO applications.

Lien vers l'article

Architecture réseau

5G Indoor Positioning Error Correction Based on 5G-PECNN.

Yang S, Zhang Q, Hu L, Ye H, Wang X, Wang T, et al. *Sensors (Basel)*. 2024 Mar 19;24(6).

With the development of the mobile network communication industry, 5G has been widely used in the consumer market, and the application of 5G technology for indoor positioning has emerged. Like most indoor positioning techniques, the propagation of 5G signals in indoor spaces is affected by noise, multipath propagation interference, installation errors, and other factors, leading to errors in 5G indoor positioning. This paper aims to address these issues by first constructing a 5G indoor positioning dataset and analyzing the characteristics of 5G positioning errors. Subsequently, we propose a 5G Positioning Error Correction Neural Network (5G-PECNN) based on neural networks. This network employs a multi-level fusion network structure designed to adapt to the error characteristics of 5G through adaptive gradient descent. Experimental validation demonstrates that the algorithm proposed

in this paper achieves superior error correction within the error region, significantly outperforming traditional neural networks.

Lien vers l'article

CLPREM: A real-time traffic prediction method for 5G mobile network.

Wu X, Wu C. *PLoS One*. 2024;19(4):e0288296.

Network traffic prediction is an important network monitoring method, which is widely used in network resource optimization and anomaly detection. However, with the increasing scale of networks and the rapid development of 5-th generation mobile networks (5G), traditional traffic forecasting methods are no longer applicable. To solve this problem, this paper applies Long Short-Term Memory (LSTM) network, data augmentation, clustering algorithm, model compression, and other technologies, and proposes a Cluster-based Lightweight PREdiction Model (CLPREM), a method for real-time traffic prediction of 5G mobile networks. We have designed unique data processing and classification methods to make CLPREM more robust than traditional neural network models. To demonstrate the effectiveness of the method, we designed and conducted experiments in a variety of settings. Experimental results confirm that CLPREM can obtain higher accuracy than traditional prediction schemes with less time cost. To address the occasional anomaly prediction issue in CLPREM, we propose a preprocessing method that minimally impacts time overhead. This approach not only enhances the accuracy of CLPREM but also effectively resolves the real-time traffic prediction challenge in 5G mobile networks.

Lien vers l'article

Efficacité énergétique

Aucun article dans ce bulletin.

Autres équipements

Discussion and Demonstration of RF-MEMS Attenuators Design Concepts and Modules for Advanced Beamforming in the Beyond-5G and 6G Scenario-Part 1.

Tagliapietra G, Giacomozzi F, Michelini M, Marcelli R, Sardi GM, Iannacci J. *Sensors (Basel)*. 2024 Apr 5;24(7).

This paper describes different variants of broadband and simple attenuator modules for beamforming applications, based on radio frequency micro electro-mechanical systems (RF-MEMS), framed within coplanar waveguide (CPW) structures. The modules proposed in the first part of this work differ in their actuation voltage, topology, and desired attenuation level. Fabricated samples of basic 1-bit attenuation modules, characterized by a moderate footprint of 690 × 1350 µm(2) and aiming at attenuation levels of -2, -3, and -5 dB in the 24.25-27.5 GHz range, are presented in their variants featuring both low actuation voltages (5-9 V) as well as higher values (~45 V), the latter ones ensuring larger mechanical restoring force (and robustness against stiction). Beyond the fabrication non-

idealities that affected the described samples, the substantial agreement between simulations and measurement outcomes proved that the proposed designs could provide precise attenuation levels up to 40 GHz, ranging up to nearly -3 dB and -5 dB for the series and shunt variants, respectively. Moreover, they could be effective building blocks for future wideband and reconfigurable RF-MEMS attenuators. In fact, in the second part of this work, combinations of the discussed cells and other configurations meant for larger attenuation levels are investigated.

Lien vers l'article

Attapulgite-Based Stable Superhydrophobic Coatings for Preventing Rain Attenuation of 5G Radomes.

Li Y, Yang B, Wei J, Li B, Mao M, Zhang J. *Langmuir*. 2024 Apr 9;40(14):7760-8.

Superhydrophobic coatings hold immense promise for various applications. However, their practical use is currently hindered by issues such as poor stability, high costs, and complex preparation processes. Here, we present the preparation of cost-effective and stable superhydrophobic coatings through fluorination of natural attapulgite (F-ATP) nanorods and subsequent solvent-induced phase separation of a silicone-modified polyester adhesive (SMPA) with the F-ATP nanorods dispersed in it. Phase separation of the F-ATP/SMPA system forms a uniform suspension of microaggregates, which can be easily utilized for preparing superhydrophobic coatings via spray coating. The coatings have a low-surface-energy hierarchical micro/nanostructure due to phase separation of SMPA and adhesion of F-ATP to it. Moreover, the effects of the solvent composition (i.e., phase separation degree of SMPA) and the SMPA/F-ATP mass ratio on the morphology, superhydrophobicity, and stability of the coatings were investigated. After systematic optimization, the coatings exhibit excellent static and dynamic superhydrophobicity as well as high mechanical, chemical, thermal, and UV aging stability. Finally, the coatings were applied to the 5G radome surface and showed good rain attenuation prevention performance. Thus, we are confident that the superhydrophobic coatings have great application potential due to their advantages of outstanding performance, straightforward preparation procedures, cost-effectiveness, etc.

Lien vers l'article

A 5G NR FR2 Beamforming System with Integrated Transceiver Module.

Bhatta A, Kamrojjaman M, Sim S, Kim JG. *Sensors (Basel)*. 2024 Mar 20;24(6).

This paper presents a 5G new radio (NR) FR2 beamforming system with an integrated transceiver module. A real-time operating module providing enhanced flexibility and capability has been proposed. The integrated RF beamforming system with an integrated transceiver module can be operated in 8Tx-8Rx mode configuration simultaneously. A series-fed structure 8 × 7 microstrip antenna array for compact size and improved directivity is employed in the RF beamforming module. The RF beamforming module incorporates a custom 28 GHz, eight-channel fully differential beamforming IC (BFIC). An eight-channel BFIC in a phased-array beamforming system offers advantages in terms of increased antenna density and improved beam steering precision. The RF beamforming module is integrated with an RF transceiver module that enables the simultaneous up-conversion and down-conversion of the baseband signal. The RF transmitter module consists of a transmitter, a receiver, a signal generator, a power supply, and a control unit. The RF beamforming system can scan horizontally from -50° to +50° with a step of 10°. To achieve an optimized beam pattern, a calibration was conducted. The transmit and receive conversion gain of around 20 dB is

achieved with the transceiver module. To verify the communication performance of the manufactured integrated RF beamforming system, a real-time wireless video transmission/reception test was performed at a frequency of 28 GHz, and the video file was transmitted smoothly in real time without interruption within a range of ±50°.

Lien vers l'article

Applications médicales et industrielles de la 5G

Applications industrielles

Aucun article dans ce bulletin.

Applications médicales

Feasibility and Safety of Percutaneous Puncture Guided by a 5G-Based Telerobotic Ultrasound System: An Experimental Study.

Yang L, Duan S, Zhang Y, Hao L, Wang S, Zou Z, et al. *Cardiovasc Intervent Radiol*. 2024 Apr 9.

PURPOSE: To evaluate the feasibility and safety of percutaneous puncture guided by a 5th generation mobile communication technology (5G)-based telerobotic ultrasound system in phantom and animal experiments. MATERIALS AND METHODS: In the phantom experiment, 10 simulated lesions were punctured, once at each of two angles for each lesion, under the guidance of a telerobotic ultrasound system and ultrasound-guided freehand puncture. Student's t test was used to compare the two methods in terms of puncture accuracy, total operation duration, and puncture duration. In the animal experiment, under the guidance of the telerobotic ultrasound system, an 18G puncture needle was used to puncture 3 target steel beads in the liver, right kidney, and right gluteal muscle, respectively. The animal experiment had no freehand ultrasound-guided control group. After puncture, a CT scan was performed to verify the position of the puncture needle in relation to the target, and the complications and puncture duration, etc., were recorded. RESULTS: In the phantom experiment, the mean accuracies of puncture under telerobotic ultrasound guidance and conventional ultrasound guidance were 1.8 ± 0.3 mm and 1.6 ± 0.3 mm ($P = 0.09$), respectively; therefore, there was no significant difference in the accuracy of the two guide methods. In the animal experiment, the first-attempt puncture success (the needle tip close to the target) rate was 93%. Polypnea occurred during one puncture. No other intraoperative or postoperative complications were observed. CONCLUSION: Puncture guided by a 5G-based telerobotic ultrasound system has shown good feasibility and safety in phantom and animal experiments.

Lien vers l'article

Evaluation (Mesure des niveaux d'exposition)

Méthodes d'évaluation

Aucun article dans ce bulletin.

Evaluation population générale

5G NR launching in Greece: Preliminary in situ and monitoring network measurements of electromagnetic fields exposure levels at rooftops.

Christopoulou MI, Kyritsi T, Yalofas A, Koutounidis D, Karabetsos E. *Bioelectromagnetics*. 2024 May;45(4):193-9.

In Greece, 5G New Radio (NR) has started launching in the end of 2020, at the 3400-3800 MHz (FR1) frequency band. Focusing on 117 Base Stations (BSs) which were already equipped with 5G NR antennas, in situ broadband and frequency selective measurements have been conducted at minimum three points of interest, at adjacent rooftops (when accessible). The points have been selected according to the sweeping method and the electric field strength (E) value has been stored on the selected worst-case scenario point. Spectrum analysis was conducted in the FR1, for the allocated spectrum that corresponds to each mobile communication provider, in order to get preliminary results concerning the contribution of the 5G NR emissions in the general public exposure levels. The vast majority of the in situ measurements has been conducted in urban environments from the beginning of 2021 until the mid of 2022, since in Greece 5G NR services launching started from the big cities. Additionally, a 5G NR BS, installed in a suburban environment (in the city of Kalamata) is thoroughly investigated during its pilot and regular operation, based on broadband and frequency selective measurements data derived by the National Observatory of Electromagnetic Fields (NOEF) monitoring sensor network. In situ measurement data within the 5G NR frequency range are verified via the NOEF's output. The 5G NR contribution to the total E-field levels is assessed in time, from pilot to regular operation of the BS. In all cases, compliance with the reference levels for general public exposure is affirmed.

Lien vers l'article

Is the sustainability of exposure to non-ionizing electromagnetic radiation possible?

Calvente I, Núñez MI. *Med Clin (Barc)*. 2024 Apr 26;162(8):387-93.

Technological advances imply an increase in artificially generating sources of electromagnetic fields (EMF), therefore, resulting in a permanent exposure of people and the environment (electromagnetic pollution). Inconsistent results have been published considering the evaluated health effects. The purpose of this study was to review scientific literature on EMF to provide a global and retrospective perspective, on the association between human exposure to non-ionizing radiation (NIR, mainly radiofrequency-EMF) and health and environmental effects. Studies on the health effects of 5G radiation exposure have not yet been performed with sufficient statistical power, as the exposure time is still relatively short and also the latency and intensity of exposure to 5G. The safety standards only

consider thermal effects, do not contemplate non-thermal effects. We consider relevant to communicate this knowledge to the general public to improve education in this field, and to healthcare professionals to prevent diseases that may result from RF-EMF exposures.

Lien vers l'article

Evaluating radiofrequency electromagnetic field exposure in confined spaces: a systematic review of recent studies and future directions.

Ahsan Ashraf M, Celik T. *Radiat Prot Dosimetry*. 2024 Apr 20;200(6):598-616.

This study reviews recent research on Radiofrequency Electromagnetic Field (RF-EMF) exposure in confined environments, focusing on methodologies and parameters. Studies typically evaluate RF-EMF exposure using an electric field and specific absorption rate but fail to consider temperature rise in the tissues in confined environments. The study highlights the investigation of RF-EMF exposure in subterranean environments such as subways, tunnels and mines. Future research should evaluate the exposure of communication devices in such environments, considering the surrounding environment. Such studies will aid in understanding the risks and developing effective mitigation strategies to protect workers and the general public.

Lien vers l'article

Risques professionnels

Evaluating radiofrequency electromagnetic field exposure in confined spaces: a systematic review of recent studies and future directions.

Ahsan Ashraf M, Celik T. *Radiat Prot Dosimetry*. 2024 Apr 20;200(6):598-616.

This study reviews recent research on Radiofrequency Electromagnetic Field (RF-EMF) exposure in confined environments, focusing on methodologies and parameters. Studies typically evaluate RF-EMF exposure using an electric field and specific absorption rate but fail to consider temperature rise in the tissues in confined environments. The study highlights the investigation of RF-EMF exposure in subterranean environments such as subways, tunnels and mines. Future research should evaluate the exposure of communication devices in such environments, considering the surrounding environment. Such studies will aid in understanding the risks and developing effective mitigation strategies to protect workers and the general public.

Lien vers l'article

Effets biologiques et sur la santé

In silico

Aucun article dans ce bulletin.

In vitro

Transcriptional landscape of human keratinocyte models exposed to 60-GHz millimeter-waves.

Martin C, Evrard B, Percevault F, Ryder K, Darde T, Lardenois A, et al. *Toxicol In Vitro*. 2024 May;97:105808.

The use of millimeter waves (MMW) will exponentially grow in the coming years due to their future utilization in 5G/6G networks. The question of possible biological effects at these frequencies has been raised. In this present study, we aimed to investigate gene expression changes under exposure to MMW using the Bulk RNA Barcoding and sequencing (BRB-seq) technology. To address this issue, three exposure scenarios were performed aiming at: i) comparing the cellular response of two primary culture of keratinocytes (HEK and NHEK) and one keratinocyte derivate cell line (HaCaT) exposed to MMW; ii) exploring the incident power density dose-effect on gene expression in HaCaT cell line; and, iii) studying the exposure duration at the new ICNIRP exposure limit for the general population. With the exception of heat effect induced by high power MMW (over 10 mW/cm(2)), those exposure scenarios have not enabled us to demonstrate important gene expression changes in the different cell populations studied. Very few differentially genes were observed between MMW exposed samples and heat shock control, and most of them were significantly associated with heat shock response that may reflect small differences in the heat generation. Together these results show that acute exposure to MMW has no effects on the transcriptional landscape of human keratinocyte models under athermal conditions.

Lien vers l'article

Sur l'animal

A broadband multi-frequency microwave combined biological exposure setup.

Zhao X, Li Z, Liu X, Wang Y, Dong G, Liu Q, et al. *Rev Sci Instrum*. 2024 Apr 1;95(4).

With the rapid popularization of wireless electronic devices, there has been an increasing concern about the impacts of the electromagnetic environment on health. However, most research reports on the biological effects of microwaves have focused on a single frequency point. In reality, people are exposed to complex electromagnetic environments that consist of multiple frequency microwave signals in their daily lives. It is important to investigate whether multi-frequency combined microwave energies have different biological effects compared with single frequency microwave energy. Unfortunately, there are limited reports on this topic due to the lack of suitable platforms for research on multi-frequency microwave energy combined with biological exposure. To address this issue, this

study presents a setup that has a very wide working frequency bandwidth and can be compatible with single frequency and multi-frequency microwave combined exposure. Moreover, it can achieve relatively equal exposure to multiple biological samples at any frequency point in the working frequency range, which is crucial for electromagnetic biology research. The experimental results are in good agreement with the simulation results, confirming its capability to facilitate the study of complex electromagnetic environment effects on organisms.

Lien vers l'article

Sur l'homme

Is the sustainability of exposure to non-ionizing electromagnetic radiation possible?

Calvente I, Núñez MI. *Med Clin (Barc)*. 2024 Apr 26;162(8):387-93.

Technological advances imply an increase in artificially generating sources of electromagnetic fields (EMF), therefore, resulting in a permanent exposure of people and the environment (electromagnetic pollution). Inconsistent results have been published considering the evaluated health effects. The purpose of this study was to review scientific literature on EMF to provide a global and retrospective perspective, on the association between human exposure to non-ionizing radiation (NIR, mainly radiofrequency-EMF) and health and environmental effects. Studies on the health effects of 5G radiation exposure have not yet been performed with sufficient statistical power, as the exposure time is still relatively short and also the latency and intensity of exposure to 5G. The safety standards only consider thermal effects, do not contemplate non-thermal effects. We consider relevant to communicate this knowledge to the general public to improve education in this field, and to healthcare professionals to prevent diseases that may result from RF-EMF exposures.

Lien vers l'article

How to improve IARC's RF-EMF cancer hazard communication.

Wiedemann PM, Croft RJ. *Bioelectromagnetics*. 2024 May;45(4):200-5.

A crucial aspect of IARC's evaluation of the relative carcinogenicity of agents is the communication of its conclusions. The present paper addressed the experimental risk perception literature pertaining to IARC's radiofrequency electromagnetic field evaluation communication, and derived specific recommendations for improving it.

Lien vers l'article

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