PhD offer

At IETR (Institut d'électronique et des technologies du numérique) UMR CNRS 6164, France

BROADBAND AND MULTI-BAND METASURFACE ANTENNAS

Project context

A more efficient use of licensed spectrum will not suffice to reach the predicted data rates and ways forward at sub-terahertz (sub-THz) frequencies (above 100 GHz) are under study [1], [2]. More precisely, the 275-350 GHz band (already standardized by IEEE [1]) exploits an atmospheric transmission window with attenuation <10 dB/Km [2] and spans a total bandwidth (BW) that allows one to attain huge capacities with simple modulation schemes. Therefore, the use of sub-THz bands will be crucial to enable ultra-large BW wireless, with seamless connectivity to the core network and the cloud. Despite exploiting atmospheric transmission windows, *sub-THz wireless links must compensate the relatively low power provided by room-temperature sources and the free-space propagation losses* [2]. *High-gain antennas are thus needed* to minimize the amount of power radiated into directions in which it will not be received. Besides satisfying the link budget and providing broad BWs, RF front-ends must be amenable for integration on the chassis of vehicles, in smart urban furniture, and on buildings and rooms' walls. To that end, individual sensors and instruments must be replaced by ultra-thin, surface-based, functional systems equivalent to smart skins. Currently, this change of paradigm is mostly impaired by the use of bulky antenna topologies, like reflectors or lenses.

Objectives of the PhD offer

In this context, *the main objective of this project will be to leverage the advantages offered by modulated metasurfaces (MTSs) to provide ultra-thin, broad-band and directive antennas* at J-band (220-325 GHz) [1]. To the best of our knowledge, this constitutes a new approach for the design of high-gain antennas in the sub-THz range.

In modulated MTS antennas, a dominantly transverse magnetic (TM) surface-wave (SW) interacts with a periodically-modulated tensor impedance surface, typically implemented by sub-wavelength elements [3]. The interaction of the SW with the periodic modulation brings the (−1) indexed Floquet mode into the visible region, which becomes a leaky-wave (LW) with the desired radiation properties. This class of antenna can provide high gains with ultra-thin structures and a very simple feeding scheme, which constitutes a major advantage for sub-THz architectures. *Their main drawback is a relatively narrow BW in gain, which has so far precluded their use for broadband applications* (wideband sensing, 5G communications, etc.).

In this project, we will build on our previous experience on broadband and multi-band metasurface antennas [4]-[5] to deal with this crucial issue. To overcome the physical bounds in the gain-BW product of single-port MTS antennas, we will explore MTS apertures, with a limited number of input ports, through which we can sense the electromagnetic environment.

[1] "IEEE standard for high data rate wireless multi-media networks--amendment 2: 100 Gb/s wireless switched point-to-point physical layer," IEEE Std 802.15.3d-2017, 1-55 (2017).

[2] T. Nagatsuma, G. Ducournau, and C. Renaud, "Advances in terahertz communications accelerated by photonics" *Nature Photon.*, **10**, 371–379 (2016).

[3] D. González-Ovejero et al., "Additive manufactured metal-only modulated metasurface antennas," *IEEE Trans. Antennas Propag.*, **66**(11), 6106-6114 (2018).

[4] M. Faenzi, D. González-Ovejero, and S. Maci, "Wideband active region metasurface antennas," *IEEE Trans. Antennas Propag.*, **68**(3), 1261-1272 (2020).

[5] M. Faenzi, D. González-Ovejero, and S. Maci, "Overlapped and sequential metasurface modulations for bi-chromatic beams generation", *Appl. Phys. Lett.*, **118**, 181902, (2021).

Work context

This thesis is part of the French national project AROMA funded by the Agence Nationale de la Recherche (ANR) under the JCJC programme. This interdisciplinary project will be carried out at IETR – UMR CNRS 6164 (www.ietr.fr) and it will strongly involve two of IETR's technological platforms:

1) nR (NanoRennes) platform, https://www.ietr.fr/en/nr-nanorennes-platform with experience in microfabrication.
2) M²ARS (Manufacturing Measurement Analysis of Radiating Systems) platform https://www.ietr.fr/en/m2ars-manufacturing-measurement-analysis-radiating-systems-platform, with experience in advanced antenna metrology and prototyping.

The PhD student will carry out a thorough literature review and the analysis and design of the modulated MTS. Last but not least, special attention will be paid to finding the most appropriate materials and fabrication techniques. By the end of the project, at least one prototype will be fabricated and measured at IETR´s World-class testing facilities.

Candidate

Required education level: Master or equivalent degree in electrical engineering, photonics or physics.
Duration: 36 months.
Required background: antenna theory, microwave engineering, antenna arrays, periodic structures, Terahertz radiation. Knowledge of French is not required.

Deadline to apply as soon as possible (no later than December 31, 2022).

Apply at: https://emploi.cnrs.fr/Offres/Doctorant/UMR6164-DAVGON-008/Default.aspx?lang=EN

To apply please use the link above to send your motivation letter, CV, and recommendation letters (optional).

Contact persons

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All the candidatures are evaluated. However, due to the large number of applications typically received, only the short-listed candidates will be contacted.