PhD Thesis Proposal

Modelling and Characterization of reconfigurable microwave components using integrated junctions on semi-conductor substrate.

Abstract:

Given the proliferation of standards in telecommunication systems, tunability is becoming a priority both in terms of integration and cost. A single tunable system needs to be able to work according to several standards. Therefore, two solutions appear to the designer, the first one is to multiply the number of components (such as filter or antenna) by the standards or the second one is to use tunable devices.

Therefore, **the microwave devices flexibility is a priority because it allows to miniaturize the systems size and to reduce the manufacturing cost**. A tunable function (filter or antenna) in planar technology is a passive distributed device to which some active tunable elements are soldered. At least one characteristic of the device can therefore be varied (the central frequency and/or the bandwidth in the case of a filter; or the resonant frequency, the radiating pattern or the polarization mode in the case of an antenna).

Nowadays, it exits many solutions to make tunable devices but the use of semicondutors components soldered on a low losses dielectric substrate predominates and this for many reasons such as the commutation time, the bias voltage, the well-mastered manufacturing process and the electrical performances. Because passive devices are distributed in order to propagate the electromagnetic wave, they are often designed on a dielectric substrate to minimize losses. However, the addition of the tunable elements causes some additional losses and disturbances (some parasitic effects can arise due to the packaging or the interconnection and discontinuities between active and passive parts). Finally, these tunable functions reduce the flexibility of the design (because of the size and localization of the active tuning elements) and manufacturing (because of drilling and via metallization).

A novel and innovative solution to co-design tunable microwave devices (such as switches, tunable filters, reconfigurable antennas…) has been developed [1]–[6]. The co-design method makes possible to build both the tunable element and the passive distributed component on the same silicon substrate. With a bias voltage, the tunable element which is an N^+PP^+ junction, acts as an ON / OFF switches and makes an electrical short circuit in the substrate thickness. Thanks to the semiconductors properties, this co-design between the passive and active parts allows to integrate the active element in the substrate, removing the constraints related to the tuning elements and drilling of via holes. In a same design flow, this co-design permits to optimize the microwave function in terms of size and quality factor. The concept permits to choose the doped areas size, position and shape to offers a greater flexibility in the tunable devices design.

Nowadays, in terms of modelling, it exits on one hand some solutions to simulate the electrical behavior of the semiconductors junctions and on the other hand, some solutions to predict the electromagnetic behavior of the microwave devices. However, the size difference between the active and the passive components gives some difficulties to simulate a global tunable function. Therefore, to overcome this problem, a co-simulation solution has been proposed based on a weak coupling between the electrical simulations of the active element and the electromagnetic simulations.

Based on the innovative method of co-designing tunable microwave functions, the thesis work will make it possible to propose new solutions for **accurate co-simulation combining**

charge transport of semiconductor junctions and global electromagnetic behavior of devices. Based on the concepts demonstrated by previous works, the work will also consist in characterizing tunable components, such as switches, firstly in terms of power handling, switching time and non-linearities, and this according to the size and shapes of the doped zones as well as the thicknesses of the substrates and the types of junctions. Then, based on the first results, more complex tunable components will be considered in order to improve the performance of these devices (reduction of the losses of the passive function, improvement of the quality factor of the active elements, improvement of the power handling, etc.). Finally, the degrees of freedom related to this co-design will make it possible to propose new topologies of microwave devices (in terms of semiconductor junctions and global tunable functions) as well as to respond to the problems of new applications of communicating systems related to the frequency increase.

The demonstrators will be made on silicon substrate at the laboratory GREMAN at the university of TOURS.

Keywords : PIN diodes, Reconfigurable antenna, reconfigurable filter, semi-conductor junctions, silicon, switch, varactor diodes.

Supervisors: Rozenn Allanic, Denis Le Berre, Cédric Quendo

Candidate Profile - Master Degree or equivalent
- European Union citizenship

Skills : Semiconductor physics (PIN diodes, Varactor diodes), Simulation and Modelization of microwave devices, Measurement (oscilloscope, network analyzer), Silvaco, HFSS, Comsol Multiphysics.

How to apply? Send a CV and motivation letter before April 12, 2023 by e-mail to Rozenn.Allanic@univ-brest.fr

Starting Date: Around October 2023

Références :

[1] R. Allanic *et al.*, “Temperature Dependence of Tunable Resonators on FR4 and Silicon,” in *Proc. Asia–Pacific Microwave Conf.*, 2017, pp. 8–11.
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[6] C. Quendo, R. Allanic, D. Le Berre, and Y. Quéré, “Novel Approaches to Design Tunable Devices,” in *IEEE 18th Wireless and Microwave Technology Conference (WAMICON)*, 2017.