Use of carbon nanotubes for passive RF devices.

Abstract

As devices get more connected and communication increase in density, new challenges arise. The usual frequency bands used are getting crowded by the number of applications, and the relatively low working frequencies limit the available bandwidth and speed. Applications are now implemented in the GHz, but next generation devices shift towards higher frequencies into the millimetre band (30-300GHz), seeking larger bandwidths, smaller devices and antenna size and improvement in spatial resolution. (High bitrate communications, Backhaul, radars, imaging, bio-sensors…)

These emerging devices have a need for passive framework for feeding and supporting while keeping the efficiency high, the dimensions short and the bandwidth large. The problematic of this thesis is to devise an innovative way to answer those needs.

Some solutions have of course emerged in the literature, and the plan here is to fork from those pre-existing results. Most solutions revolve around using vertically aligned micro/nano-structures to guide a wave or to reduce wave velocity. The idea is to introduce Vertically-Aligned Carbon Nanotube Forests into those designs, for they display inherently conductive anisotropy while improving from the previous solutions in terms of density and equivalent conductivity and ease of fabrication.

As passive devices cover a broad range of devices, the focus will be on some of the simplest devices, to pave the way for this technology. In a first step a simple slow-wave micro-strip transmission line using VA-CNTs is considered, which showcases the possibility to reduce significantly wave velocity propagation in the line, thus reducing the dimensions without the use of high-k dielectrics. Work on the topic demonstrate significant size reduction of devices at a given frequency.

In a second step, another type of transmission line is considered: SIW and SW-SIW. Waveguides large dimensions' stop being a collateral at higher frequencies -with dimensions going bellow the millimetre- while exhibiting relatively better parameters per unit length than other propagation solutions. The feasibility of a SIW using VA-CNT forests is demonstrated through theoretical simulation and fabrication. A solution including a similar setup to the micro-strip line is investigated to assert the effects and possibility of slow-wave in waveguides using only bottom-up processes.

Finally, as an extension of the problematic, some diverse and more complex topologies are considered such as filters, antenna arrays feedings or interposers.