Paraelectric perovskite $(Sr_2Ta_2O_7)_{100-x}(La_2Ti_2O_7)_x$ ceramics: application to dielectric resonator antennas

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With the advent of small low-profile communication devices, Dielectric Resonator Antennas (DRAs) became promising candidates to replace traditional antennas; this is mainly attributed to the fact that DRAs do not suffer from conduction losses and are characterized by high radiation efficiency when excited properly. Moreover, resonant frequencies below 6 GHz can be achieved when using dielectric materials with high permittivity's and low dielectric losses. In this case, higher order modes is excited which impart higher gain and providing efficient radiation in the direction normal to its ground plane. Moreover, the merging of neighbouring modes will result into enhanced bandwidth. Indeed, for cylindrical resonators, the theoretical resonant frequency (f) of the excited modes is given by the relation proposed by Stuart Long et al. [1].

In this study, a new perovskite material, with the formulation $(Sr_2Ta_2O_7)_{100-x}(La_2Ti_2O_7)_x$ (hereafter named as STLTO) [1], is proposed to integrate DRAs as the dielectric part that operates in a higher order mode is proposed. The STLTO materials are synthesized as ceramics with the composition (x) ranging from 0 to 3. The different dielectric characterizations, performed from 1 kHz to 20 GHz, highlight a variation of the permittivity and the dielectric losses as a function of x, with the lowest losses obtained for the compositions $x \leq 1.5$ that is for the STLTO paraelectric phases. These ones were used as dielectric in DRAs.

The electromagnetic simulations of the DRA structure were carried out using the commercial software CST Microwave Studio. A cylindrical STLTO resonator, with a permittivity $\varepsilon' = 83$ and losses $\tan\delta = 5.10^{-3}$, has been employed, having a radius $R = 7.95$ mm and a thickness $d = 2.32$ mm. The STLTO resonator is excited by a copper microstrip line of width $W_f = 3.5$ mm and of length $L_f = 20$ mm (Figure 1.a). Along the microstrip line axis, the overlap distance (D) between the resonator center and the extremity of the microstrip line defines the coupling and the specific excited modes.

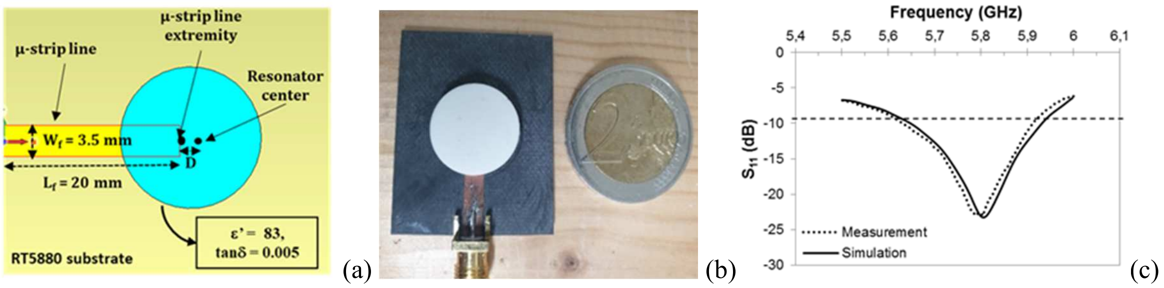

Figure 1. (a) Geometry, (b) first prototype and (c) reflection coefficient evolution as a function of the frequency, of the simulated and measured STLTO-based DRA.

The DRA prototype was simulated, produced (Figure 1.b) and measured (Figure 1.c). A good agreement between simulation and measurement is denoted. The achieved DRA structure operates at a frequency of 5.8 GHz; the impedance matching is obtained between 5.64 GHz and 5.93 GHz which corresponds to a bandwidth of 290 MHz (4.9 %) (for $S_{11} < -10$ dB), associated to a maximum gain of 6.4 dBi. Measurements show a maximum efficiency of 80 % at the resonant frequency of the antenna.

Realization and measurement of DRAs including several STLTO compositions with $x < 1.5$ will be presented in the final version. It should confirm the potential of STLTO materials for the miniaturization of microwave components, such as compact dielectric resonator antennas.

References

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