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ENrG Inc. Ceramic Technology for Clean Energy

PRODINTEC

ULTRA-THIN COMPACT FLEXIBLE ANTENNA FOR IoT APPLICATIONS

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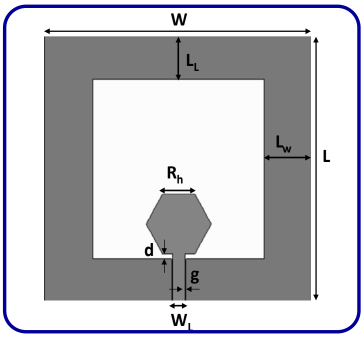
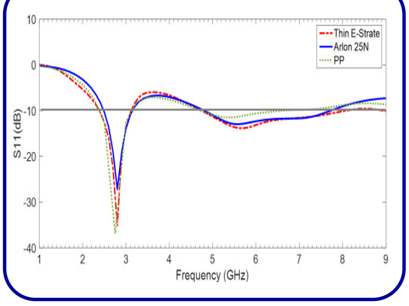
INTRODUCTION

- **Motivation:** Large market foreseen for **5G & IoT wearable electronics**. Design & fabrication of **integrable flexible/miniaturized antennas** greatly interesting while **challenging**.
- Advances concerning **new materials** and **innovative manufacturing techniques** are key steps towards wearable 5G electronics [1]-[6].
- **WLAN frequency bands** generally **preferred for IoT** (know-how, lower propagation losses).
- **Goal:** To design and manufacture an **ultra-thin flexible antenna based on novel ceramic material** (ENrG Thin E-Strate) for IoT at 2.7GHz and 5.8GHz, comparing dimensions and performance with conventional substrates (rigid ARLON 25N and flexible PP).



Subs-trate	Dimensions (mm)								
	W	L	h	W_L	g	d	R_h	L_L	L_W
Thin E-Strate	66	62	0.04	3	0.26	1.2	8	10	12.0
Arlon 25N	70	69	0.80	4	0.23	1.5	7	13	14.5
PP	70	69	0.45	4	0.15	1.5	8	12	13.0



DIELECTRIC SUBSTRATES FOR THE DESIGN OF THE ANTENNA

- **Ultra-thin flexible ceramic: Zirconia based ENrG's Thin E-Strate**
  - **Flexible**, robust, light-weight; high Tª and thermal shock tolerance; **impermeable** to gases & moisture; chemically inert; **easily coated with metals** and high wear and abrasion resistances.
  - Available in sheet, wafer or ribbon formats with thicknesses of 20 and 40 µm.
  - Electromagnetic characterization (ε_r and tanδ):
    - ε_r =26 at 100KHz and ε_r =28 at 10GHz; tanδ=0.0048 at 2.6GHz
    - **ε_r =22 and tanδ=0.001 used in simulation** accounting for further characterization & fabrication method.
- **Alternative conventional materials:**
  - **ARLON 25N**: Rigid. ε_r=3.38, tanδ=0.0025 (replaceable by Rogers 4003C)
  - **Polypropylene (PP)**: Flexible ε_r=2.26, tanδ=0.002 [7]

CPW-FED SLOT MONOPOLE ANTENNA DESIGN

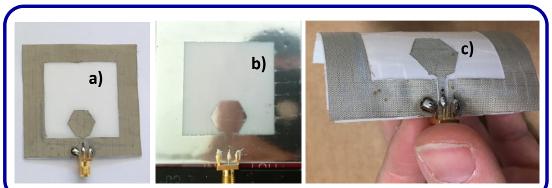
- **CPW-feeding** with **50Ω** reference impedance**.**
- Geometry: **radiating slot** surrounding hexagonal shaped patch.
- Parametric study: W, L, R_h, d, L_W and L_L
- Optimized dimensions: FEM based 3D electromagnetic simulations.
  - Total size on ENrG's Thin E-Strate: 40.92cm² (15% **smaller** & **much thinner**)
  - Total size on ARLON 25N and PP: 48.3cm².

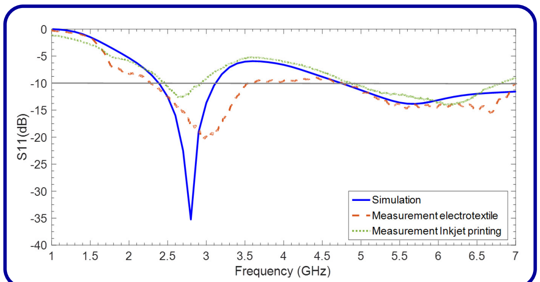
Subs-trate	Lower band				Upper band			
	Freq (GHz)		BW		Freq (GHz)		BW	
	f_{Low}	f_{Up}	Total (MHz)	%	f_{Low}	f_{Up}	Total (MHz)	%
Thin E-Strate	2.383	3.118	735	27	4.754	8.013	3259	51
Arlon 25N	2.490	3.151	661	23	4.808	7.739	2930	47
PP	2.385	3.136	751	27	4.737	6.620	1883	33

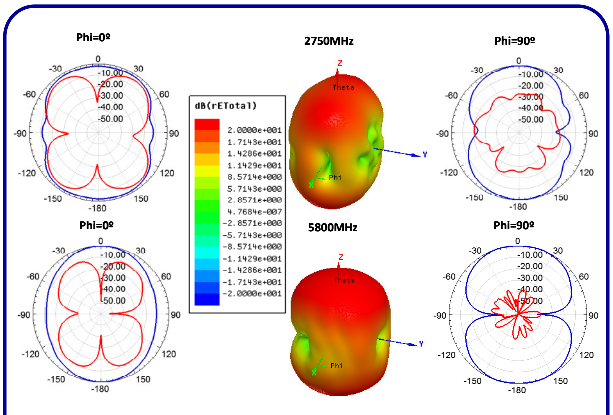
Freq. (GHz)	Thin E-Strate			Arlon 25N			PP		
	G (dB)	D (dB)	η (%)	G (dB)	D (dB)	η (%)	G (dB)	D (dB)	η (%)
2.45	4.10	4.46	92	3.87	4.48	87	4.14	4.51	92
2.75	4.52	4.56	99	4.54	4.61	98	4.57	4.61	99
3.00	4.27	4.49	95	4.55	4.78	95	4.54	4.80	94
5.00	4.09	4.47	92	4.33	4.72	91	4.63	4.97	92
5.80	5.19	5.40	95	5.83	6.06	95	5.44	5.75	93
6.50	5.87	6.16	94	6.62	6.88	94	6.36	6.75	91
7.00	6.60	6.91	93	7.49	7.72	95	7.21	7.60	91
7.50	7.21	7.54	93	7.90	8.16	94	7.75	8.17	91

FABRICATED ANTENNA ON NOVEL MATERIAL

- **Dielectric substrate:** Zirconia based flexible **ENrG's Thin E-Strate**
- **Conductive parts of the antenna:**
  - **Electrotextile**: Shieldit Super with laser micromachinning (LPKF protolaser S).
  - **Silver ink**: GenesInk Smart Ink S-CS01130 with Inkjet printing (Dimatix DMP-2831).
- **Experimental characterization of return losses:**
  - **Proper matching** with **both metallizations.**
  - Electrotextile provides better performance though both techniques improvable.
  - Better agreement compared to simulation for the upper frequency band







Simulated radiation pattern cuts (normalized, in dB): H plane (left) and E plane (right); CP and XP; at 2.75GHz & 5.8GHz for ENrG's Thin E-Strate.

CONCLUSIONS

- Ultra-thin compact flexible CPW-fed slot monopole antenna, suitable for IoT applications around 2.75GHz and 5.8GHz, obtained using ENrG's Thin E-Strate.
- This **novel ceramic** dielectric provides, respectively **20 times and 11.25 times thinner antenna** compared to Arlon 25N and flexible PP, while resulting in **more than 15% size reduction**.
- Prototypes fabricated using 2 metallization techniques and proper return losses results obtained.

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