Innovative Design of Metamaterial Printed WAIMs through a System−by−Design Approach

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Abstract

An innovative approach is proposed for the synthesis of *WAIM* structures able to compensate the inter-element coupling effects limiting the maximum scanning angles of active electronically-scanned arrays (*AESA*s). The *WAIM* is composed by a metasurface represented by a regular grid of microstrip printed unit cells organized according to an hexagonal lattice. Accordingly, the geometrical descriptors of the unit cells are synthesized through a System-by-Design (*SbD*) approach aimed at minimizing the antenna input reflections caused by impedance mismatching when the array is steered. Some numerical results are shown in order to assess the effectiveness of the proposed design methodology.

1 GUIDA D'ONDA CIRCOLARE - LATTICE ESAGONALE (SbD approach)

Dielettrici considerati nelle seguenti analisi:

Dielettrico	ε	$tan\,\delta$	d
tipo1=$NY9208$	2.08	0.0006	$0.508 \cdot 10^{-3}$
tipo2	2.08	0.6	$0.508 \cdot 10^{-3}$
tipo3	2.08	1	$0.508 \cdot 10^{-3}$
tipo4	2.08	1	$1.524 \cdot 10^{-3}$

Essendo ε la permettività elettrica, $tan\,\delta$ fattore di dissipazione e d lo spessore.

Per il materiale $NY9208$ è stato scelto di usare lo spessore più sottile tra quelli disponibili per le simulazioni di partenza.

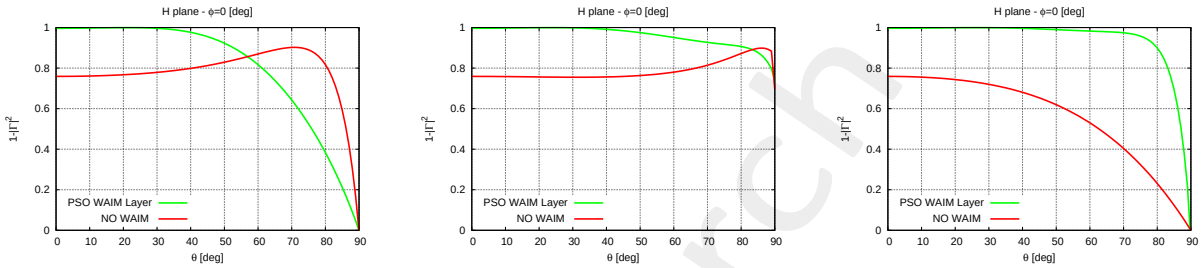
Nelle 3 simulazioni presentate di seguito, si va a modificare come unico parametro, solamente il fattore di dissipazione del materiale $tan\,\delta$.

Nella simulazione 4 si va a modificare lo spessore del materiale.

1.1 FORMA: Croce "2" (5 croci) - DIELETTRICO: TIPO 1 = NY9208

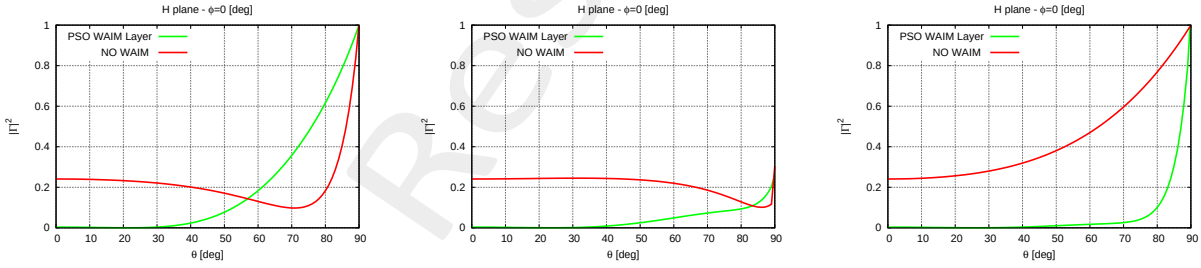
Dielettrico:

- tipo: NY9208
- spessore: 0.508e-3
- $\varepsilon = 2.08$
- δ =0.0006
- ρ =1000.0 $[kg/m^3]$



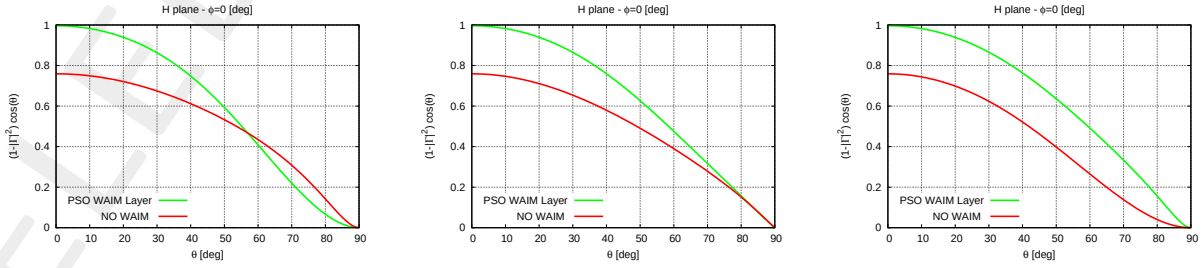
a) b) c)

Figure 1: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E



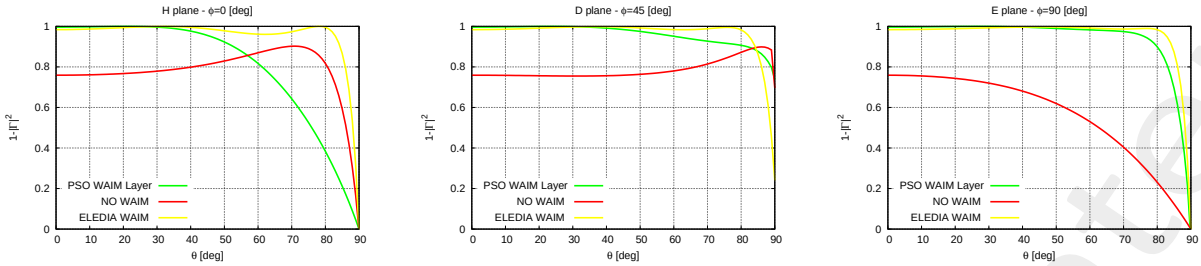
a) b) c)

Figure 2: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



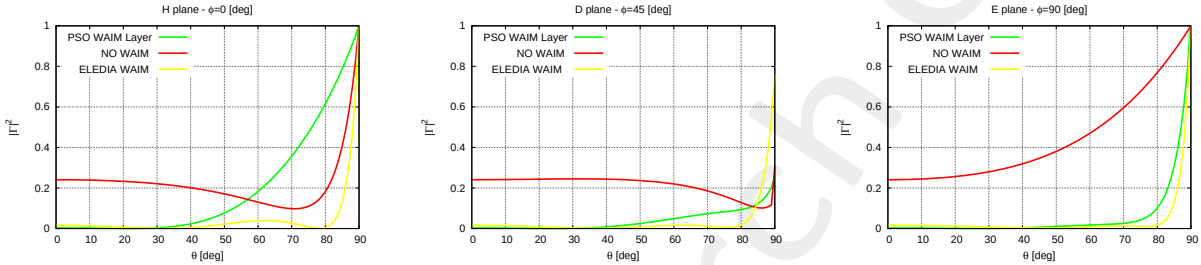
a) b) c)

Figure 3: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E



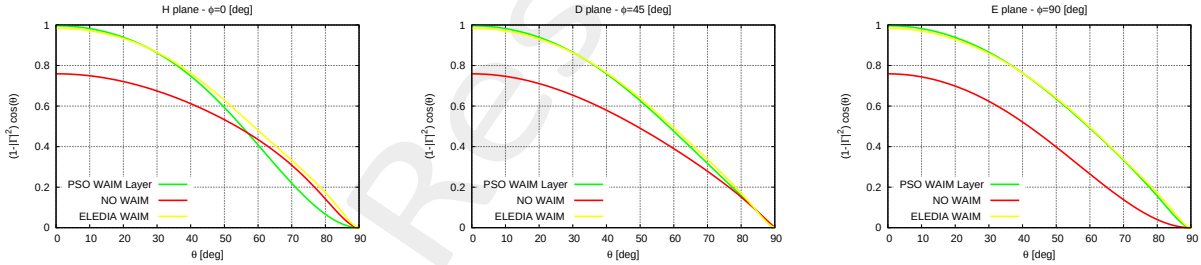
a) b) c)

Figure 4: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 5: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 6: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

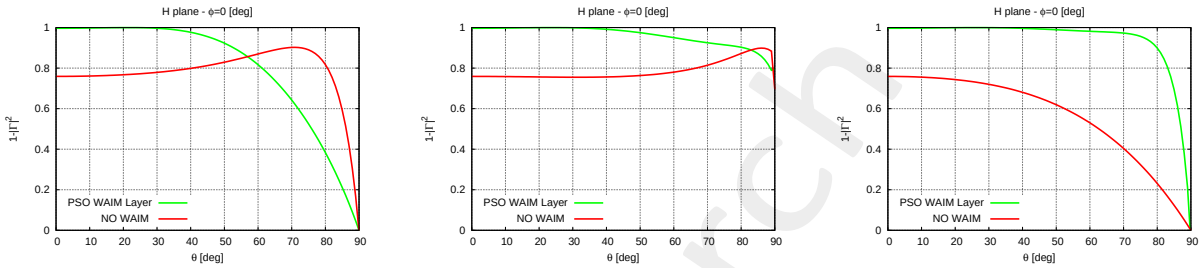
Note:

- Utilizzando il dielettrico NY9208 si riesce ad ottenere le stesse performances della casistica senza dielettrico.

1.2 FORMA: Croce "2" (5 croci) - DIELETTRICO: TIPO 2

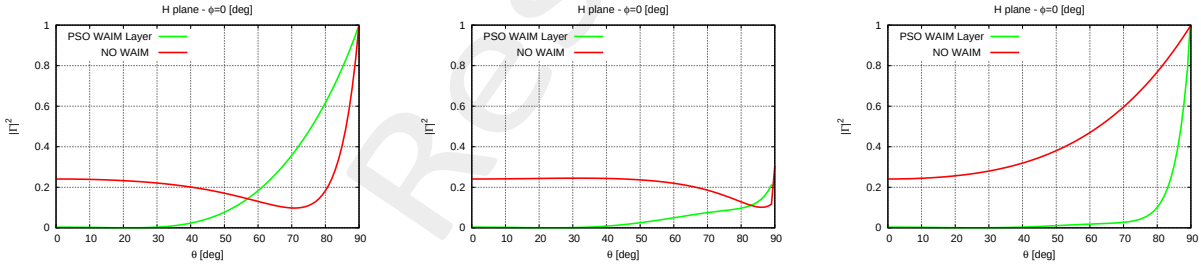
Dielettrico:

- tipo: 2
- spessore: 0.508e-3
- $\varepsilon = 2.08$
- δ =0.6
- ρ =1000.0 $[kg/m^3]$



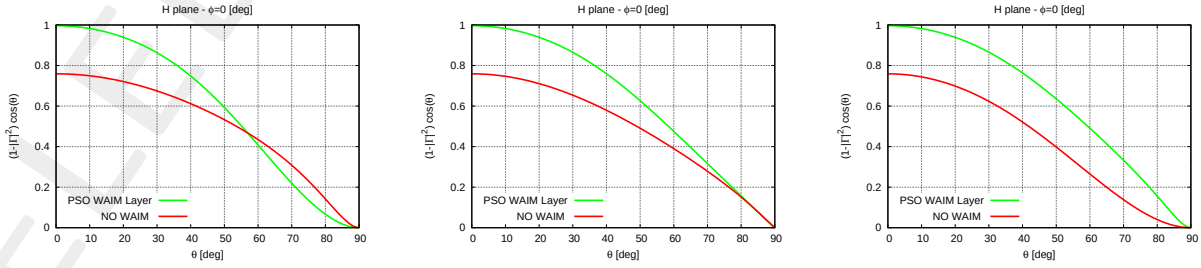
a) b) c)

Figure 7: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E



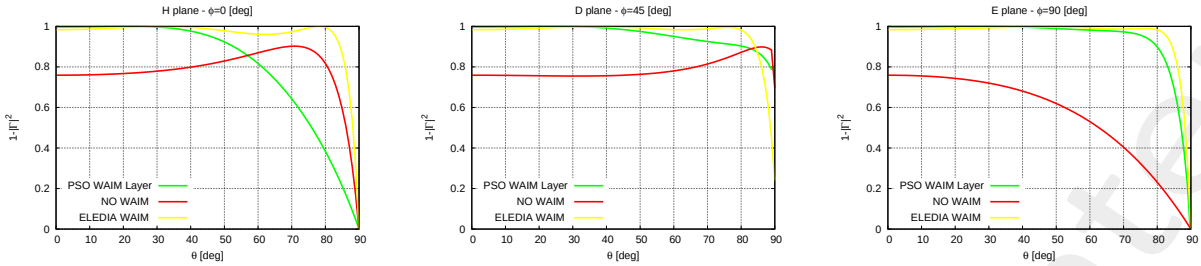
a) b) c)

Figure 8: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



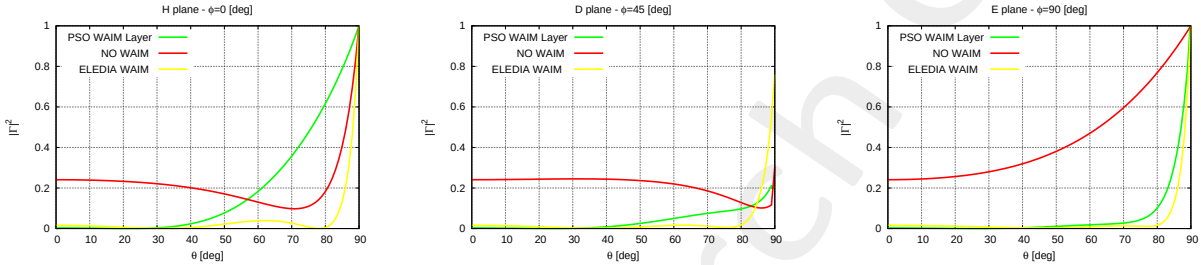
a) b) c)

Figure 9: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E



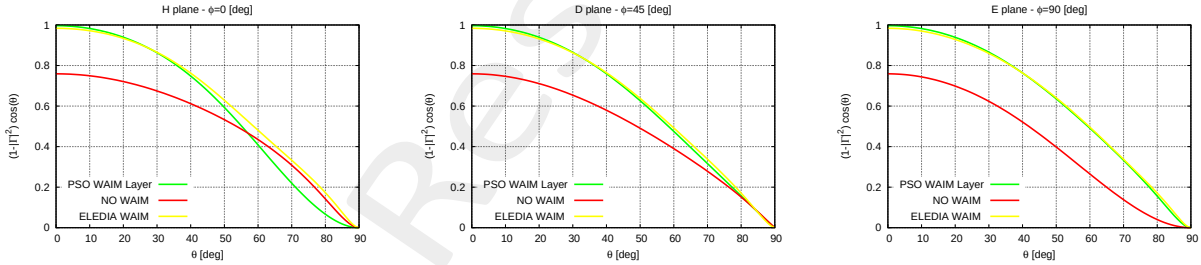
a) b) c)

Figure 10: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 11: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 12: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

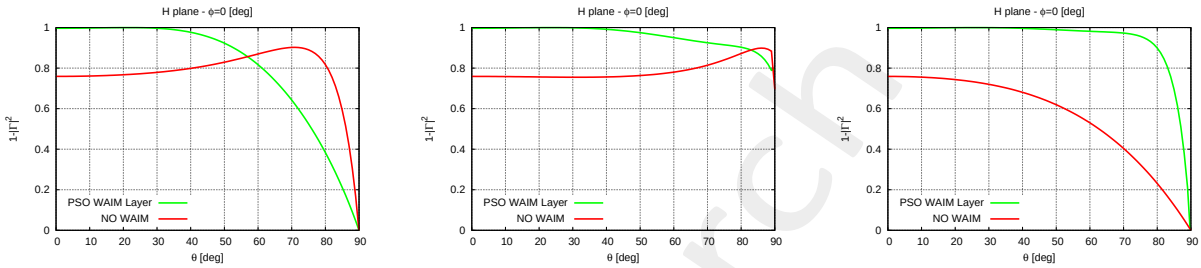
Note:

- Per quanto riguarda la Fitness, si riesce a raggiungere lo stesso esatto valore del caso senza dielettrico: $1.4590 \cdot 10^{-2}$

1.3 FORMA: Croce "2" (5 croci) - DIELETTRICO: TIPO 3

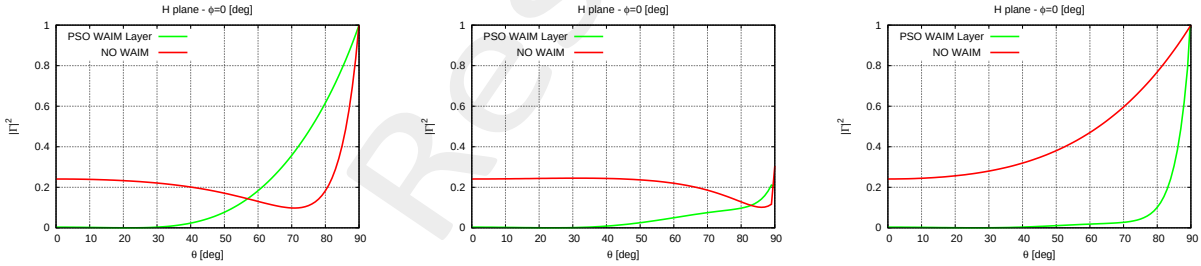
Dielettrico:

- tipo: 3
- spessore: 0.508e-3
- $\varepsilon = 2.08$
- δ =1
- ρ =1000.0 $[kg/m^3]$



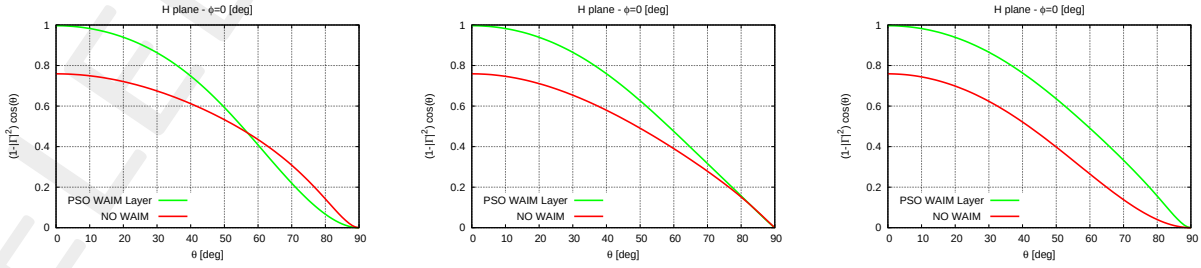
a) b) c)

Figure 13: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E



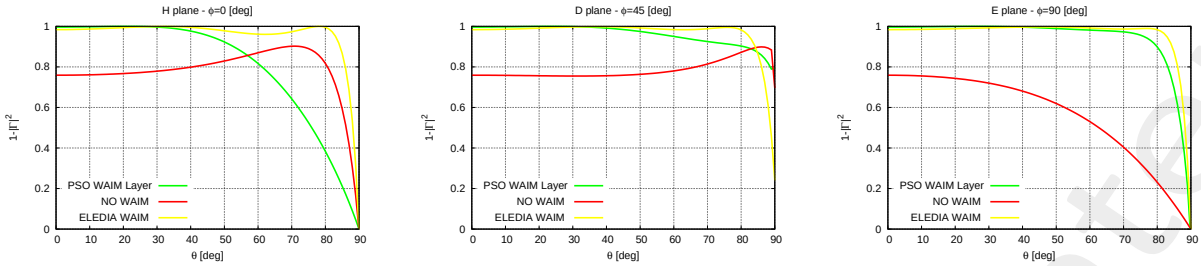
a) b) c)

Figure 14: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



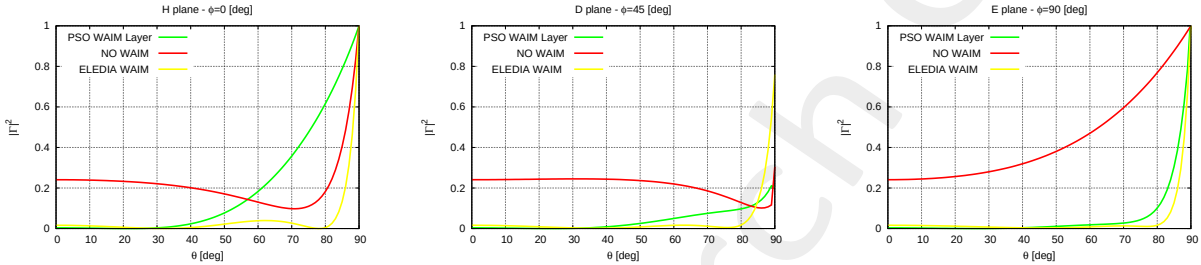
a) b) c)

Figure 15: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E



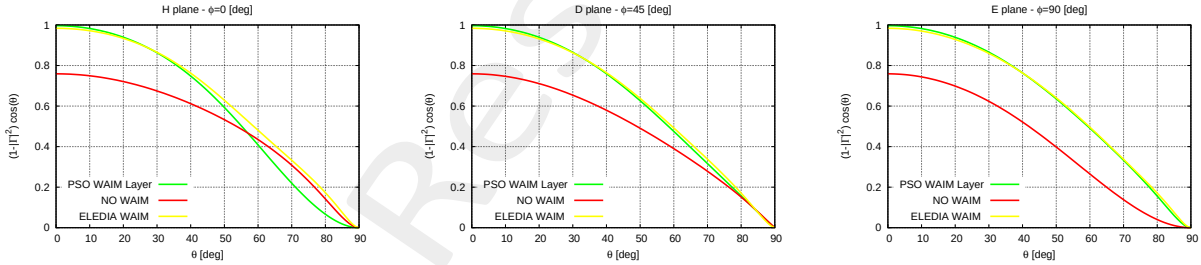
a) b) c)

Figure 16: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 17: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 18: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

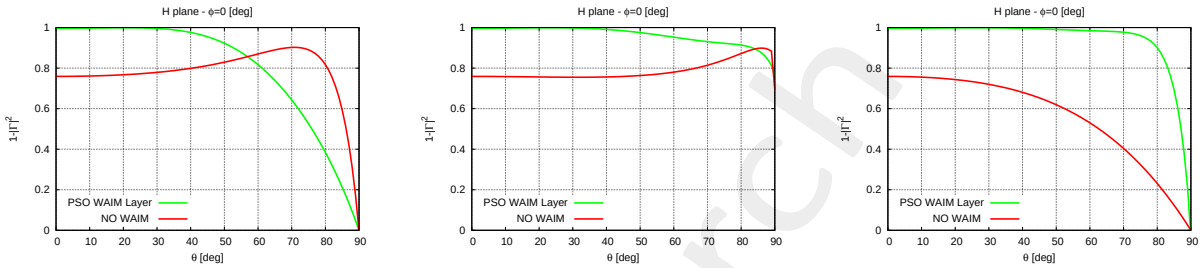
Note:

- Non ci sono peggioramenti nelle prestazioni simulate, anche avendo usato un dielettrico con molte perdite.

1.4 FORMA: Croce "2" (5 croci) - DIELETTRICO: TIPO 4

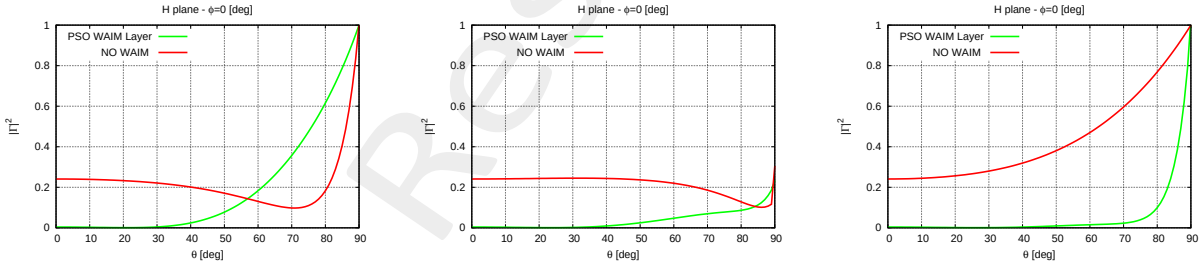
Dielettrico:

- tipo: 4
- spessore: 1.524e-3
- $\varepsilon = 2.08$
- δ =1
- ρ =1000.0 $[kg/m^3]$



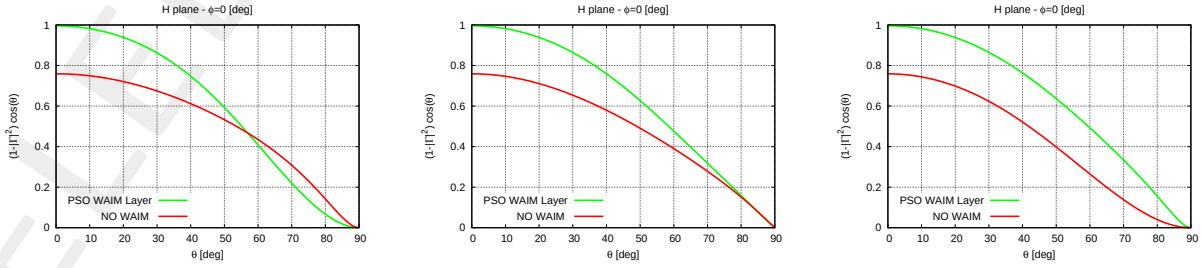
a) b) c)

Figure 19: Coefficiente di Trasmissione, a) Piano H, b) Piano D, c) Piano E



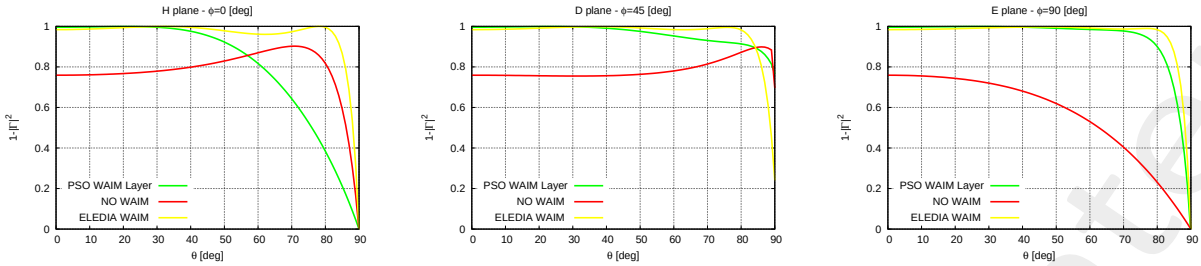
a) b) c)

Figure 20: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



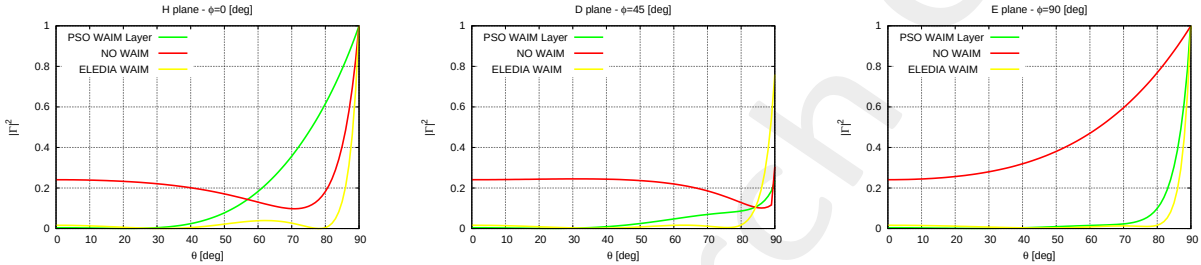
a) b) c)

Figure 21: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E



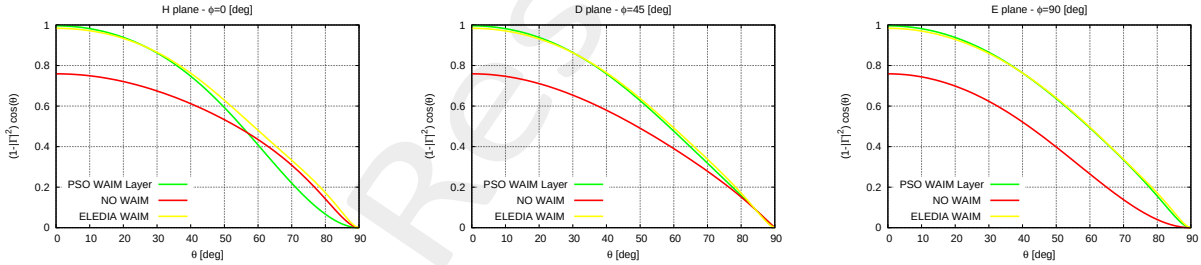
a) b) c)

Figure 22: Coefficiente di Trasmissione , a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 23: Coefficiente di Riflessione, a) Piano H, b) Piano D, c) Piano E



a) b) c)

Figure 24: Coefficiente di Trasmissione $\cdot \cos(\theta)$, a) Piano H, b) Piano D, c) Piano E

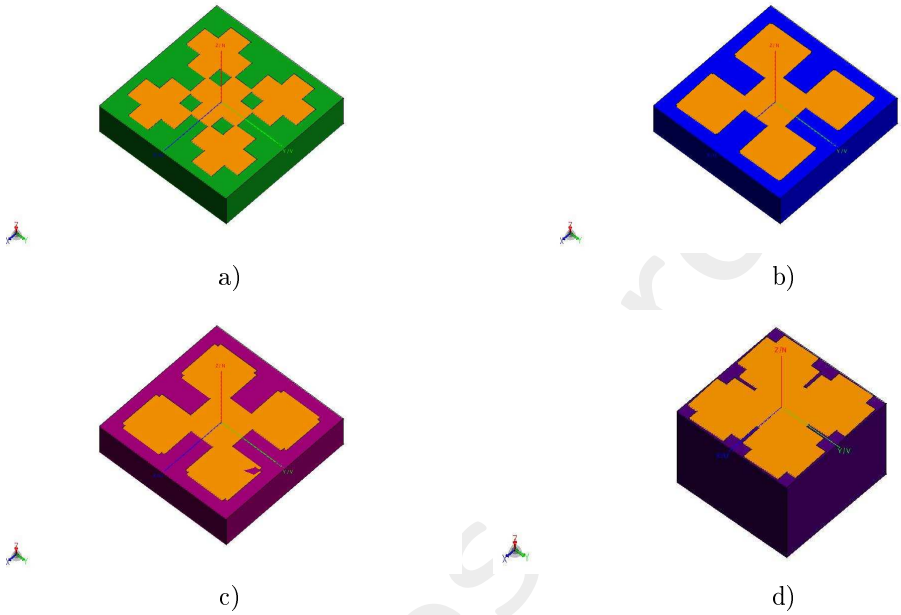
Note:

- Non ci sono peggioramenti nelle prestazioni simulate, anche avendo usato un dielettrico con molte perdite.

1.5 Unit cell shape

Nei 4 casi si ottengono celle elementari leggemente diverse, anche se da figura non è molto visibile.

	Dielettrico			
	Tipo 1	Tipo 2	Tipo 3	Tipo4
CrossLength	1.56550156E-03	1.30000000E-03	1.20604620E-03	1.30000000E-03
CrossWidth	3.34851647E-04	6.77710283E-04	6.97563402E-04	1.00000005E-03
TiltAngle	0.00000000E+00	1.04337764E+00	1.82698011E-01	1.90046072E-01



a) b)

c) d)

Table 1: Optimal Unit cells, a) using NY9208, b) lossy dieletric type2, c) lossy dielectric type3, d) lossy dielectric type4

References

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