Metasurface-Based Radome for Wearable Antenna at 24GHz

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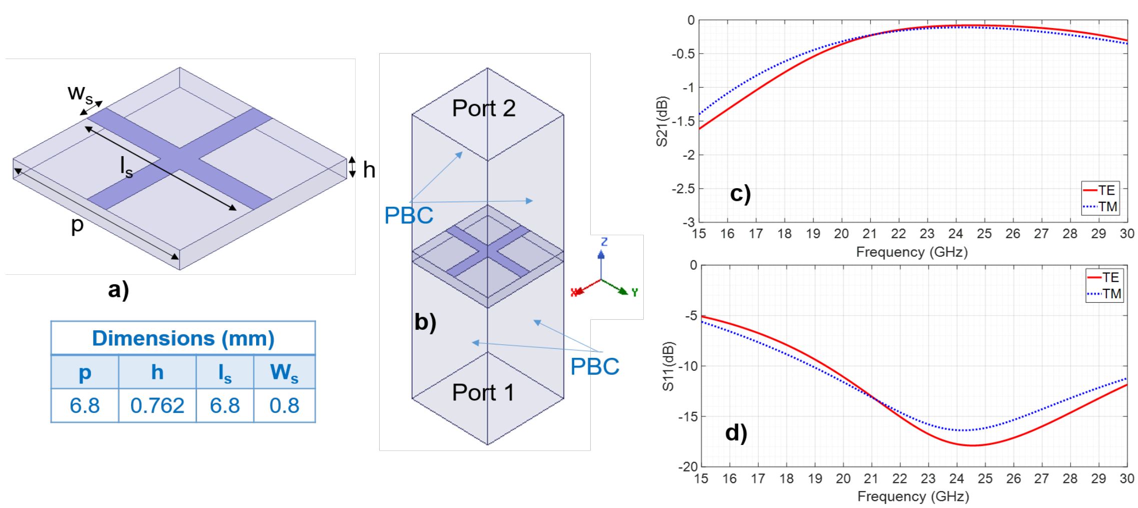
Abstract: A metasurface-based radome (metaradome) is designed to protect a wearable grid array antenna (GAA) for imaging applications in 24.05GHz-24.25GHz. It provides high transmission and low reflection within the GAA operation frequency band in a wide angular range under oblique incidence. The GAA with metaradome. preserves the GAA operation band and radiation parameters. The overall device' size is 40 x 40 x 3.162 mm^3. The envisioned application is collision avoidance in aid to visually impaired people at medium-long distance.

A radome should protect the antenna with minimal impact on its performance. Ideally it should be electrically invisible, that is, fully transparent and lossless. In practice a radome must ensure high transmission and low reflection and absorption within the antenna operation frequency band. In addition, radiation scattered from the radome may elevate antenna sidelobes, which can lead to reduction in gain and directivity. In recent years it has been proposed to use metasurfaces to be combined with radomes to reduce their negative effects on antenna performance, or even as radomes themselves [1], giving rise to the term metaradome or metadome [2]. In this work, a metasurface-based radome has been designed to be located much closer to the antenna than a radome of the same material and without degrading the performance of the antenna. In this way, the antenna is protected while maintaining a lightweight, compact and fully operational design for the intended application. Figure 1 shows the metasurface unit cell geometry and dimensions on RO3003 dielectric substrate, the simulation set-up using Floquet ports and master-slave boundary conditions and the retrieved transmission and reflection coefficient for both TE and TM polarized incident plane-waves. It can be highlighted that very high transmission and very low reflection is achieved in the band of interest (24.05GHz-24.25GHz), as intended.



Dimensions (mm)			
p	h	l_s	W_s
6.8	0.762	6.8	0.8

Figure 1. Metaradome: a) Unit cell; b) Simulation set-up; c) Transmission coefficient; d) Reflection coefficient

The angular stability of a metasurface usable as a radome is crucial. The designed metaradome is fully angularly stable under oblique incident TE and TM polarized plane waves up to θ=45º and highly stable up to θ=50º, considering both transmission and reflection coefficients.

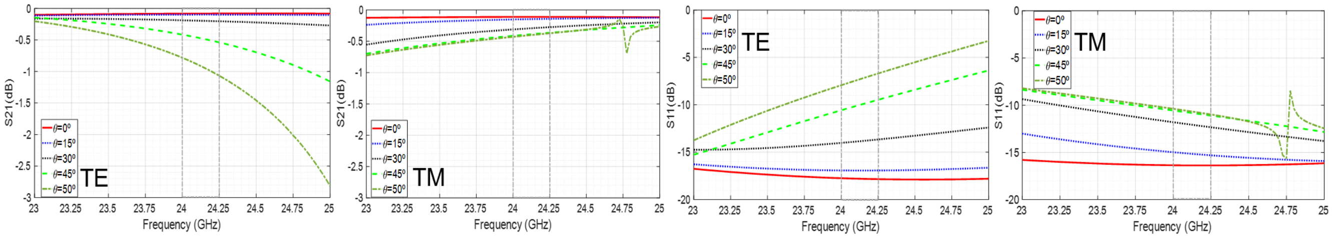
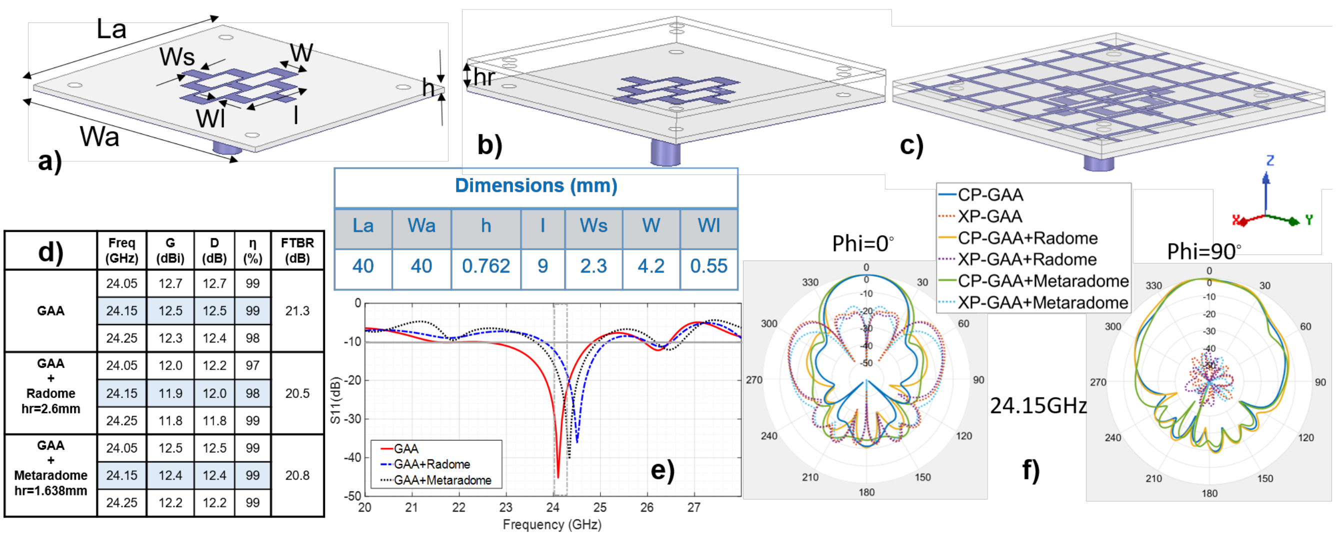


Figure 2. Angular stability of the metaradome for Phi=0º under TE and TM polarized incident plane waves

For the intended application a trade-off solution between-range and coverage area has to be adopted. A suitable Grid Array Antenna (GAA) [3] was designed on RO3003 substrate. In Figure 3 it can be observed that a metaradome can be arranged at closer distance from the GAA than a radome (1.638mm vs 2.6mm) and better preserving the operational properties of the GAA. Thus a protected and compact wearable antenna is achieved.



Dimensions (mm)

La	Wa	h	l	Ws	W	Wl
40	40	0.762	9	2.3	4.2	0.55

d)	Freq (GHz)	G (dBi)	D (dB)	η (%)	FTBR (dB)
GAA	24.05	12.7	12.7	99	21.3
	24.15	12.5	12.5	99	
	24.25	12.3	12.4	98	
GAA + Radome hr=2.6mm	24.05	12.0	12.2	97	20.5
	24.15	11.9	12.0	98	
	24.25	11.8	11.8	99	
GAA + Metaradome hr=1.638mm	24.05	12.5	12.5	99	20.8
	24.15	12.4	12.4	99	
	24.25	12.2	12.2	99	

Figure 3. GAA under study: a) GAA; b) GAA+radome; c) GAA+Metaradome; d) Radiation properties; e) Reflection coefficient S11(dB); f) Radiation pattern cuts.

This research was funded by Ministerio de Ciencia, Innovación y universidades of Spanish Government under project META-IMAGER PID-2021-122697OB-100 and by Gobierno del Principado de Asturias under project AYUD-2021-51706.

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