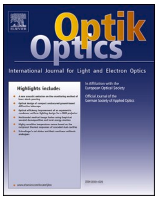
Optik - International Journal for Light and Electron Optics 267 (2022) 169708

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.com/locate/ijleo



Broadband 3-D shared aperture high isolation nine-element antenna array for on-demand millimeter-wave 5G applications

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ARTICLE INFO

Keywords:
Array antennas
Metasurface (MTS)
Isolation wall
5G
Shared aperture
Three dimensional (3-D)

ABSTRACT

The paper presents the results of a novel 3-D shared aperture 3 × 3 matrix antenna-array for 26 GHz band 5 G wireless networks. Radiation elements constituting the array are hexagonal-shaped patches that are elevated above the common dielectric substrate by 3.35 mm and excited through a metallic rod of 0.4 mm diameter. The rod protrudes through the substrate of 0.8 mm thickness. It is shown that by isolating each radiating element in the array with a wall suppresses unwanted electromagnetic (EM) wave interactions, resulting in improvement in the antenna's impedance matching and radiation characteristics. Moreover, the results show that by embedding hexagonal-shaped slots in the patches improve the antenna's gain and radiation efficiency performance. The subwavelength length slots in the patches essentially transform the radiating elements to exhibit metasurface characteristics when the array is illuminated by EM-waves. The proposed array structure has an average gain and radiation efficiency of 20 dBi and 93%, respectively, across 24.0–28.4 GHz. The isolation between its radiation elements is greater than 22 dB. Compared to the unslotted array the improvement in isolation between radiating elements is greater than 11

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https://doi.org/10.1016/j.ijleo.2022.169708
Received 22 September 2021; Received in revised form 29 April 2022; Accepted 19 July 2022

dB, and the gain and efficiency are better than 10.5 dBi, and 25%, respectively. The compact array has a fractional bandwidth of 16% and a form factor of 20 × 20 × 3.35 mm^3.

1. Introduction

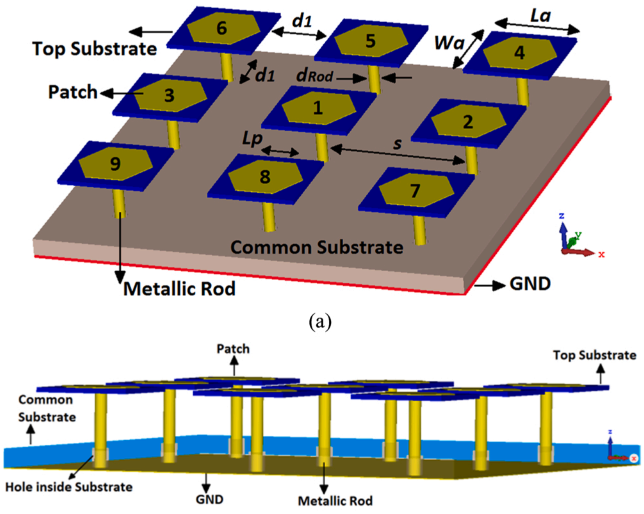
Worldwide deployment of 5 G wireless communication systems is currently underway [1]. Unlike the previous generations of cellular systems, 5 G offers benefits of faster internet connectivity and capability to link with thousands of devices [2]. This technology makes the realization of Internet of Things (IoT) or Internet of Everything (IoE) possible as well as the creation of new 'smart' services capable of providing information in real-time. The frequency bands used in the initial phase of 5 G deployment are between 700 MHz and 3.8 GHz. This frequency band were originally used for previous generations of mobile technology. The demand for bandwidth is expected to grow with greater usage of 5 G. This demand can only be met by using the millimeter-wave 5 G spectrum at 26 GHz. The large data transmission capacity [3] of the millimeter-band is associated with a high loss resulting from propagation, atmospheric loss, pathloss, dielectric-loss, radiation-loss, and metallic loss in transmission-lines [4,5], To compensate for such loss, research is now focused on antenna array technologies at the millimeter-wave band [6–9].

In this paper, a novel 3-D shared aperture 3 × 3 antenna array concept is proposed for 5 G millimeter-wave applications operating over 24–28.4 GHz. The antenna array consists of hexagonal-shaped patches that are perched above a common substrate and excited using metallic rods through the substrate. Individual antennas are decoupled from each other with an isolation wall to prevent unwanted mutual coupling that can degrade the overall far-field performance of the antenna. To enhance the gain and radiation efficiency of the antenna the patches are made to exhibit metasurface chacteristics. This is achieved by loading the patches with hexagonal-shaped concentric slots of decreasing diameters. The feeding structure of the proposed array makes it amenable to either single aperture or shared aperture antenna applications as it covers a relatively wide bandwidth. This is achieved by grouping together individual antennas in the array to form sub arrays that are used to cover a specific portion of the total bandwidth for different applications on time/frequency shared basis [10,11].

2. 3D shared aperture nine-element antenna array

Geometry of the proposed 3-D shared aperture nine element antenna array is shown in Fig. 1. The array consists of hexagonal-shaped patches that are constructed on the base dielectric substrate (Rogers RT5880) with a thickness of 0.2 mm, dielectric constant of 2.2, and tanδ of 0.0009. The radiating patches are elevated above the dielectric substrate by 3.35 mm using a metallic rod of 0.4 mm diameter. The base substrate of 0.8 mm thickness has a ground-plane. The metallic rods protrude through the base substrate and are insulated from the ground-plane metallization layer. Each antenna is exited through the metallic rods. By raising the antenna above the substrate effectively reduces surface current interactions between adjacent antennas which can drastically undermine the antenna's characteristics. The structural parameters of the array are listed in Table 1. The overall size of the proposed basic antenna array is 20 × 20 × 3.35 mm^3.

Theoretical modeling of such an array is provided in [12]. To validate the design of the proposed antenna array it was constructed and analyzed using two very different 3-D electromagnetic solvers, namely, CST Microwave Studio and Ansoft HFSS. The numerical EM-solver by Ansoft HFSS is based on frequency-domain finite-element method (FEM), and CST Microwave Studio is based on a



(a)

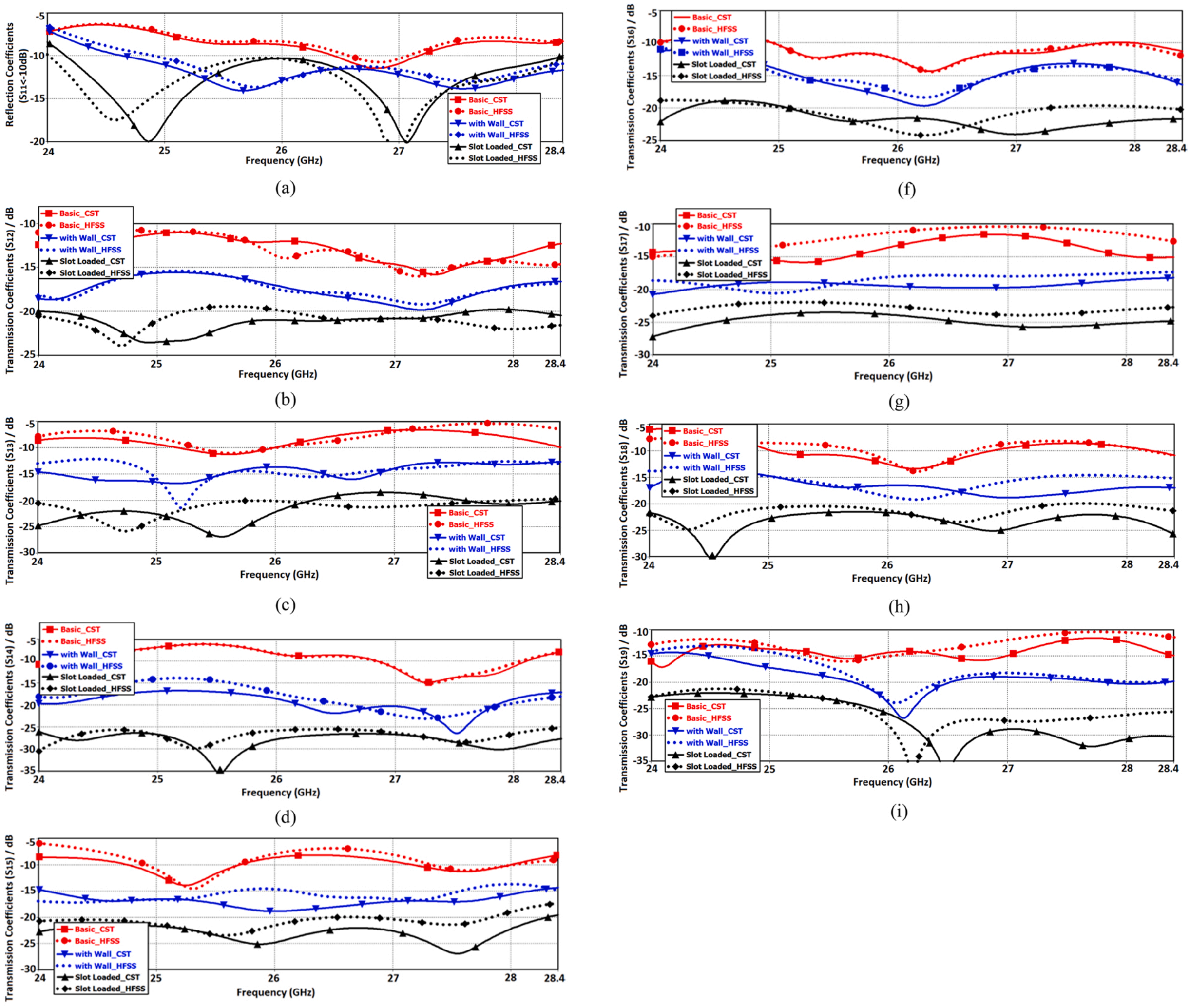
(b)

Fig. 1. 3-D shared aperture nine element 3 × 3 array antennas, (a) isometric top-view, and (b) side view.

Table 1
Geometrical Parameters of the Array (units in millimeters).

Length	Width	La	Wa	Lw	Ww	Lp
20	20	4	4	5	5	1.75
dhole	drod	Hrod	Hw	hs_1	hs_2	d_1
0.5	0.2	3.35	2	0.8	0.2	3
d_2	s	g	Ws	Wml	form factor	
2	7	0.25	0.08	0.2	20 × 20 × 3.35	

Note: *Ws* and *Wml* represent the width of the slots and meandered-lines, respectively. Some parameters are annotated in Fig. 4 & 5.



(a) (b) (c) (d) (e) (f) (g) (h) (i)

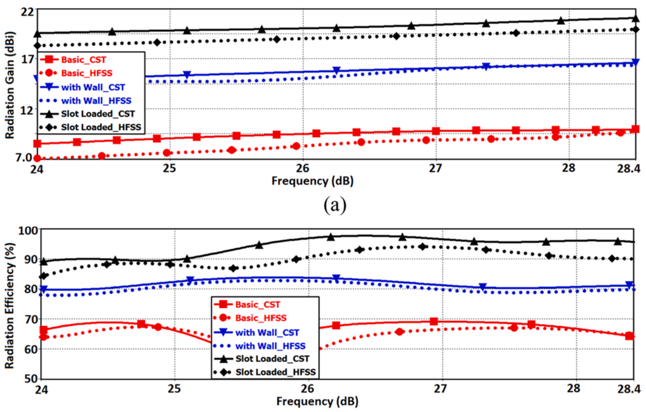
Fig. 2. Active S-parameter response of the proposed antenna array, (a) reflection-coefficient (S_{11}), (b) transmission-coefficient between antennas #1&#2 (S_{12}), (c) transmission-coefficient between antennas #1&#3 (S_{13}), (d) transmission-coefficient between antennas #1&#4 (S_{14}), (e) transmission-coefficient between antennas #1&#5 (S_{15}), (f) transmission-coefficient between antennas #1&#6 (S_{16}), (g) transmission-coefficient between antennas #1&#7 (S_{17}), (h) transmission-coefficient between antennas #1&#8 (S_{18}), and (i) transmission-coefficient between antennas #1&#9 (S_{19}).

time-domain finite integration technique (FIT) method.

The active S-parameters in Fig. 2(a) shows that the proposed basic antenna array exhibits an impedance bandwidth of 700 MHz and operates across 26.5–27.2 GHz, which corresponds to a the fractional bandwidth (FBW) of 2.6%. The transmission-coefficient response between the radiation elements is shown in Fig. 2(b)-(i). These results show that the average isolation between the patches #2 to #9

Table 2
S-Parameters Of The Various Antenna Array Structures.

Antenna Arrays	Reflection coefficient (S_{11} <−10 dB)							
Basic array	26.5–27.2 GHz (700 MHz & 2.6% FBW)							
Array with wall	24.8–28.4 GHz (3.6 GHz &13.5% FBW)							
Array with slots	24.0–28.4 GHz (4.4 GHz & 16.8% FBW)							
Improvement of slot array c.f. basic array	3.7 GHz & 14.2% FBW							
Antenna Arrays	**Average transmission coefficient (dB)**							
	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}	S_{19}
Basic array	12	6	11	7	11	12	10	13
Array with wall	17	14	20	17	16	18	16	19
Array with slot load	23	22	27	22	23	24	23	30
Improvement of slot array c.f. basic array	11	16	16	15	12	12	13	17



(a)

(b)

Fig. 3. Radiation properties of the antenna array, (a) gain, and (b) efficiency.

Table 3
Radiation Characteristics With CST.

Average gain (dBi)	
Basic array	9.5
Array with wall	15.7
Array with slot load	20.5
Improvement of slot array c.f. basic array	10.5
Average efficiency (%)	
Basic array	68
Array with wall	82
Array with slot load	93.5
Improvement of slot array c.f. basic array	25

relative to patch #1, i.e., the isolation between patches #1&#2 is 12 dB, #1&#3 is 6 dB, #1&#4 is 11 dB, #1&#5 is 7 dB, #1&#6 is 11 dB, #1&#7 is 12 dB, #1&#8 is 10 dB, and #1&#9 is 13 dB. The results are summarized in Table 2.

The radiation characteristics of the proposed antenna array are shown in Fig. 3. It can be observed from this figure that an average gain and efficiency achieved over the antenna's operating frequency band of 26.5–27.2 GHz are 9.5 dBi and 68%, respectively. The radiation characteristics of the antenna array are summarized in Table 3.

Mutual coupling effects between the closely spaced radiating elements can cause unwanted distortion in the radiation characteristics of the array. This can adversely affect the overall far-field performance of the antenna array. Therefore, to suppress the near-field radiation emanating from each antenna in the array, an isolation wall wrapped around the individual antennas, as shown in Fig. 4. The wall is made from a perfect electric conductor. This simple technique does not affect the overall size of the antenna.

The active S-parameters and radiation properties of the array with the isolation wall are shown in Figs. 2 and 3. These results show that with the isolation wall the impedance bandwidth of the antenna array improves by a factor of four across 24.8–28.4 GHz, which corresponds to a fractional bandwidth of 13.5%. The transmission-coefficient response in Fig. 2(b)-(i) show that the improvement in the average isolation between antennas #1&#2 is 5 dB, #1&#3 is 8 dB, #1&#4 is 9 dB, #1&#5 is 10 dB, #1&#6 is 5 dB, #1&#7 is 6 dB, and #1&#8 is 6 dB, and #1&#9 is 6 dB. These results are compared with the basic array in Table 2.

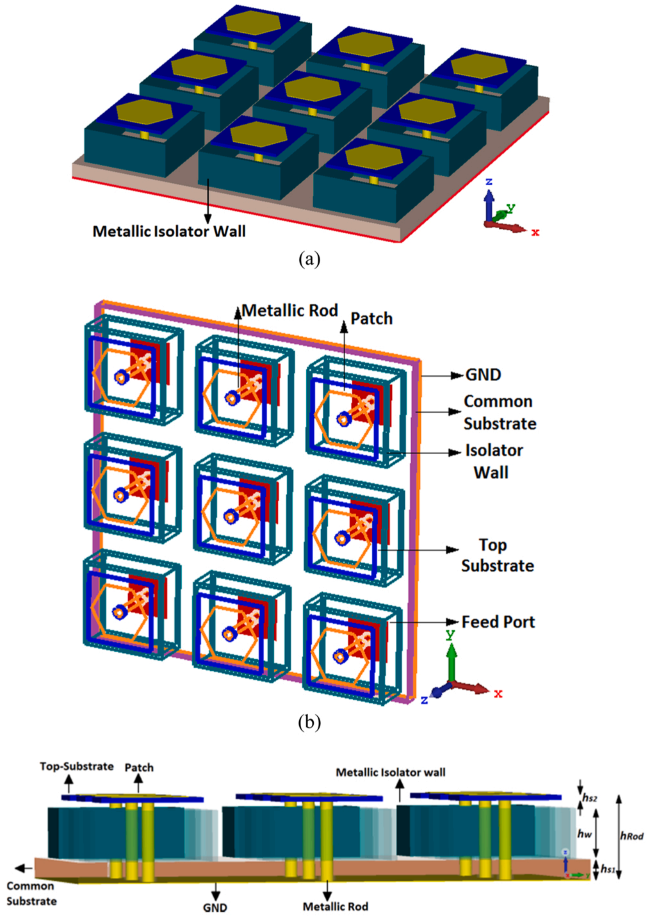


Fig. 4. Antenna Array with the isolation walls, (a) isometric top-view, (b) schematic top-view to show the location of each structural element, and (c) side-view.

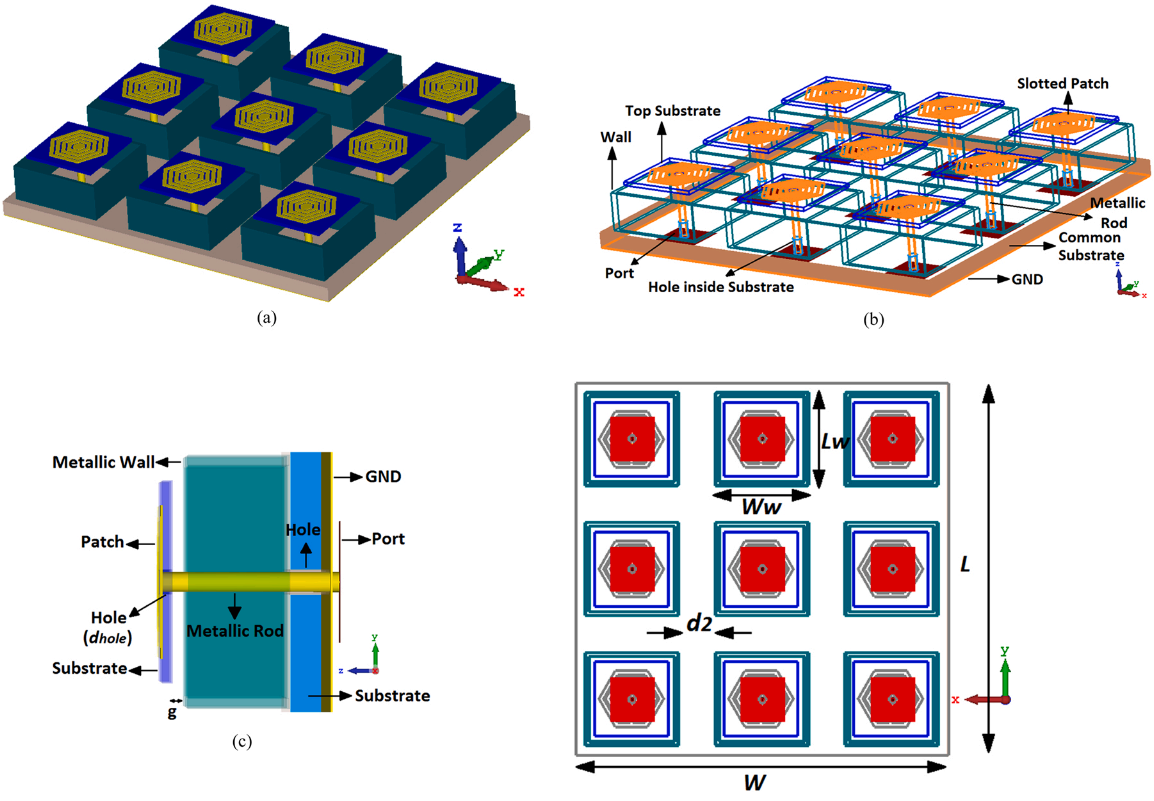
Fig. 3 shows that CST predicts the average gain and efficiency of the antenna array to be 20.5 dBi and 93.5%, respectively, over 24.8–28.4 GHz. Compared to the basic array this corresponds to an average improvement in gain and efficiency of 10.5 dBi and 25%, respectively. With HFSS the average gain and efficiency are 19.2 dBi and 85%, respectfully. These results are compared in Table 3.

In order to improve the antenna's performance, the hexagonal-shaped patches are loaded with hexagonal-shaped slot rings of decreasing diameter, as shown in Fig. 5. The rings are of subwavelength circumference and the width of the slots is 0.08 mm. When the slot loaded patches are exposed to EM-waves they behave like a metasurface as described in [13–15] that has an effect of magnify the aperture of the antenna array. Results from the 3-D EM-solvers, i.e., CST Microwave Studio and Ansoft HFSS, in Figs. 2 and 3 demonstrate that by introducing the slots the array's performance is improved. This is achieved without increasing the physical size of the antenna array. Moreover, the results show that the slots increase the array's impedance bandwidth by 4.4 GHz. Compared to the basic array in Fig. 1 the bandwidth is increased by a factor of approximately six.

Fig. 2(b)-(i) show the average isolation improvement of the antennas #2 to #9 relative to antenna #1 in respectively order is: 11 dB, 16 dB, 16 dB, 15 dB, 12 dB, 12 dB, 13 dB, and 17 dB. The average isolation of the slotted patches in sequence from #2 to #9 with respect to antenna #1 is: 23 dB, 22 dB, 27 dB, 22 dB, 23 dB, 24 dB, 23 dB, and 30 dB. Fig. 3 shows that with the slot loaded patch the gain and radiation efficiency improve significantly compared to the basic array in Fig. 1. On average the gain increases by 10.5 dB and the efficiency increases by 25%. These results are compared in Table 2.

The radiation characteristics of the proposed antenna array structure in its various forms, i.e., basic 'with' and 'without' the isolation wall and metasurface slots, are compared in Table 3. It is shown that the array structure with the isolation wall and metasurface provides superior antenna performance. The excellent correlation between the two different 3-D numerical solvers shows the viability of the proposed array for millimeter-wave applications such as 5 G wireless communications.

Comparison of the proposed antenna with the previously published antenna arrays operating in the same band is presented in Table 4. The comparison parameters include dimensions, substrate properties, bandwidth (BW), radiation gain, and efficiency. The comparison shows that the key performance of gain and efficiency are not possible with the other array approaches reported thus far considering the compact footprint area of the proposed array antenna.



(a) (b) (c) (d)

Fig. 5. Proposed array antennas with isolation walls and loaded with metasurface slots, (a) isometric top-view, (b) schematic top-view to show the location of the geometrical parameters, (c) side view with zoomed single antenna to better displaying the feeding mechanism, and (d) schematic bottom-view to show the precise location of the structural parameters.

Table 4
Proposed Antenna Array Compared With Other Arrays Reported In Literature.

Ref.	Size (mm^2)	Substrate	Bandwidth /freq. range (GHz)	Gain (dBi)	Eff. (%)
[16]	20 × 20	Two different layers: (i) 1 mm FR4 (ii) 0.254 mm RO4350B	5.25 / 24.25–29.5	Max. 10	Max. 85
[17]	99.2 × 17.45	0.254 mm Rogers 5880	6.78 /24.35–31.13	Max. 19.88	Max. 86
[18]	27 × 25	0.508 mm Roger 4003 C	5 / 24–29	Max. 9	–
[19]	130 × 90	0.508 mm RO4003C	3 / 28–3	Max. 9.6	–
This work	**20 × 20**	**0.8 mm Rogers RT5880**	**4.4 / 24.0–28.4**	**Max. 21**	**Max. 98**

3. Conclusion

A novel and compact nine element antenna array with shared aperture configuration is shown to exhibit high-gain and high radiation efficiency at the millimeter-wave 5 G band. The 3 × 3 matrix antenna array is composed of hexagonal-shaped patches that are suspended above a common substrate and excited by metallic rods through the substrate. To minimize the adverse effects of mutual coupling between the radiators the individual antenna elements in the array were surrounded with a metallic wall. The patches were embedded with hexagonal-shaped slots to transform them to a metasurface. The proposed array structure exhibits an average gain and efficiency of 20 dBi and 93%, respectively, with isolation between the radiating ellements better than 22 dB.

Declaration of Competing Interest

The authors confirm that they do not have conflict of interest.

Acknowledgment

Dr. Mohammad Alibakhshikenari acknowledges support from the CONEX-Plus programme funded by Universidad Carlos III de Madrid and the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No. 801538. Also, this work was supported by Project RTI2018-095499-B-C31, funded by the Ministerio de Ciencia, Innovación y Universidades, Gobierno de España (MCIU/AEI/FEDER, UE).

References

[1] T.S. Rappaport, Y. Xing, G.R. MacCartney, A.F. Molisch, E. Mellios, J. Zhang, Overview of millimeter wave communications for fifth-generation (5G) wireless networks—with a focus on propagation models, IEEE Trans. Antennas Propag. vol. 65 (12) (2017) 6213–6230.
[2] W. Hong, K.-H. Baek, Y. Lee, Y. Kim, S.-T. Ko, Study and prototyping of practically large-scale mmWave antenna systems for 5G cellular devices, IEEE Commun. Mag. vol. 52 (9) (2014) 63–69.
[3] D. Lockie, D. Peck, High-data-rate millimeter-wave radios, IEEE Microw. Mag. vol. 10 (5) (2009) 75–83.
[4] J. Zhu, S. Liao, S. Li, Q. Xue, 60 GHz Wideband high-gain circularly polarized antenna array with substrate integrated cavity excitation, IEEE Antennas Wirel. Propag. Lett. vol. 17 (5) (2018) 751–755.
[5] J. Wu, Y.J. Cheng, Y. Fan, Millimeter-wave wideband high-efficiency circularly polarized planar array antenna, IEEE Trans. Antennas Propag. vol. 64 (2) (2016) 535–542.
[6] S.K. Agrawal and K. Sharma, "5G millimeter wave (mmWave) communications," 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom), Mar. 2016, pp. 3630– 3634.
[7] M. Alibakhshikenari, B.S. Virdee, A.A. Althuwayb, et al., Study on on-chip antenna design based on metamaterial-inspired and substrate-integrated waveguide properties for millimetre-wave and THz integrated-circuit applications, J. Infrared, Millim., Terahertz Waves vol. 42 (2021) 17–28.
[8] L. Wei, R.Q. Hu, Y. Qian, G. Wu, Key elements to enable millimeter wave communications for 5G wireless systems, IEEE Wirel. Commun. vol. 21 (6) (2014) 136–143.
[9] V.L. Nguyen, P. Lin, R. Hwang, Enhancing misbehavior detection in 5G vehicle-to-vehicle communications, IEEE Trans. Veh. Technol. vol. 69 (issue 9) (2020) 9417–9430.
[10] S.J. Li, Y.B. Li, L. Zhang, Z.J. Luo, B.W. Han, R.Q. Li, X.Y. Cao, Q. Cheng, T.J. Cui, Programmable controls to scattering properties of a radiation array, Laser Photonics Rev. vol. 15 (2000449) (2021) 1–9.
[11] S.J. Li, Y.B. Li, R.Q. Li, Q. Cheng, T.J. Cui, Digital-coding-feeding metasurfaces for differently polarized wave emission, orbit angular momentum generation, and scattering manipulation, Adv. Photonics Res. vol. 1 (2020) 2000012.
[12] M. Alibakhshikenari, B.S. Virdee, et al., Singular integral formulations for electrodynamic analysis of metamaterial-inspired antenna array, IEEE Antennas Wirel. Propag. Lett. vol. 20 (2) (2021) 179–183.
[13] S.S. Bukhari, J. Vardaxoglou, W. Whittow, A metasurfaces review: definitions and applications, Appl. Sci. vol. 9 (2727) (2019) 1–14.
[14] Z. Wang, C. Li, Y. Yin, A meta-surface antenna array decoupling (MAAD) design to improve the isolation performance in a MIMO system, IEEE Access vol. 8 (2020) pp.61797-61085.
[15] W. Zhang, C. Song, R. Pei, Y. Huang, J. Zhou, Broadband metasurface antenna using hexagonal loop-shaped unit cells, IEEE Access vol. 8 (2020) 223797–223805.
[16] I. Lima de Paula, et al., Cost-effective high-performance air-filled siw antenna array for the global 5G 26 GHz and 28 GHz bands, IEEE Antennas Wirel. Propag. Lett. vol. 20 (2) (2021) 194–198.
[17] M. Khalily, R. Tafazolli, P. Xiao, A.A. Kishk, Broadband mm-wave microstrip array antenna with improved radiation characteristics for different 5G applications, IEEE Trans. Antennas Propag. vol. 66 (9) (2018) 4641–4647.
[18] M. Borhani Kakhki, M. Mantash, A. Kesavan, M.M. Tahseen, T.A. Denidni, Millimeter-wave beam-tilting vivaldi antenna with gain enhancement using multilayer FSS, IEEE Antennas Wirel. Propag. Lett. vol. 17 (12) (2018) 2279–2283.
[19] M. Mantash, A. Kesavan, T.A. Denidni, Beam-tilting endfire antenna using a single-layer FSS for 5G communication networks, IEEE Antennas Wirel. Propag. Lett. vol. 17 (1) (2018) 29–33.

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Ernesto Limiti is a full professor of Electronics in the Engineering Faculty of the University of Roma Tor Vergata since 2002, after being research and teaching assistant (since 1991) and associate professor (since 1998) in the same University. Ernesto Limiti represents University of Roma Tor Vergata in the governing body of the MECSA (Microwave Engineering Center for Space Applications), an inter-universitary center among several Italian Universities. He has been elected to represent the Industrial Engineering sector in the Academic Senate of the University for the period 2007–2010 and 2010–2013. Ernesto Limiti is actually the president of the Consortium "Advanced research and Engineering for Space", ARES, formed between the University and two companies. Further, he is actually the president of the Laurea and Laurea Magistrale degrees in Electronic Engineering of the University of Roma Tor Vergata. The research activity of Ernesto Limiti is focused on three main lines, all of them belonging to the microwave and millimetre-wave electronics research area. The first one is related to characterisation and modelling for active and passive microwave and millimetre-wave devices. Regarding active devices, the research line is oriented to the small-signal, noise and large signal modelling. Regarding passive devices, equivalent-circuit models have been developed for interacting discontinuities in microstrip, for typical MMIC passive components (MIM capacitors) and to waveguide/coplanar waveguide transitions analysis and design. For active devices, new methodologies have been developed for the noise characterisation and the subsequent modelling, and equivalent-circuit modelling strategies have been implemented both for small and large-signal operating regimes for GaAs, GaN, SiC, Si, InP MESFET/HEMT devices. The second line is related to design methodologies and characterisation methods for low noise circuits. The main focus is on cryogenic amplifiers and devices. Collaborations are currently ongoing with the major radioastronomy institutes all around Europe within the frame of FP6 and FP7 programmes (RadioNet). He is actively involved in research activities with many research groups, both European and Italian, and he is in tight collaborations with high-tech italian (Selex - SI, Thales Alenia Space, Rheinmetall, Elettronica S.p.A., Space Engineering …) and foreign (OMMIC, Siemens, UMS, …) companies. He contributed, as a researcher and/or as unit responsible, to several National (PRIN MIUR, Madess CNR, Agenzia Spaziale Italiana) and international (ESPRIT COSMIC, Manpower, Edge, Special Action MEPI, ESA, EUROPA, Korrigan, RadioNet FP6 and FP7 …) projects. Regarding teaching activities, He is a member of the committee of the PhD program in Telecommunications and Microelectronics at the University of Roma Tor Vergata, tutoring an average of four PhD candidates per year.