CONTENTS

Description

PART I

1. Title of the project

Design and realization of light weight shields to reduce electromagnetic interference (EMI) at microwave ranges (C and X band) with different geometries for customized applications like anechoic chamber, as terminations and stealth for strategic device camouflaging

2. Objective of the Project

Development of EMI shielding materials with thickness less than 4mm having an absorption of at least -20 dB and covering a bandwidth of approximately 2-4 GHz in X and C band. Light weight, conformal, high mechanical stability and cost effectiveness will be the other features of the developed material.

3. Implementing organization — Tezpur University, Tezpur, Assam, India

4. DIT sanction No. and Date — 1 (2)/2016-EMCD dated 30.03.2016.

5. (a) Total budget outlay, revised if any — Rs. 214.32 Lakh

   (b) Duration of project — 3 years

   (c) Date of completion and reasons for delay, if any — September 29, 2020 (Due to Covid – 19 pandemic)

6. Total Funds spent (Details at Annexure I)
7. Details of equipment/assets
8. Details of manpower (Details at per Annexure II)
9. Details of year-wise audited statement of accounts and utilization certificates (As per CFR 19/UC).

PART II

1. Project work and Achievements
   a) Executive Summary
      - **Scope of the project**

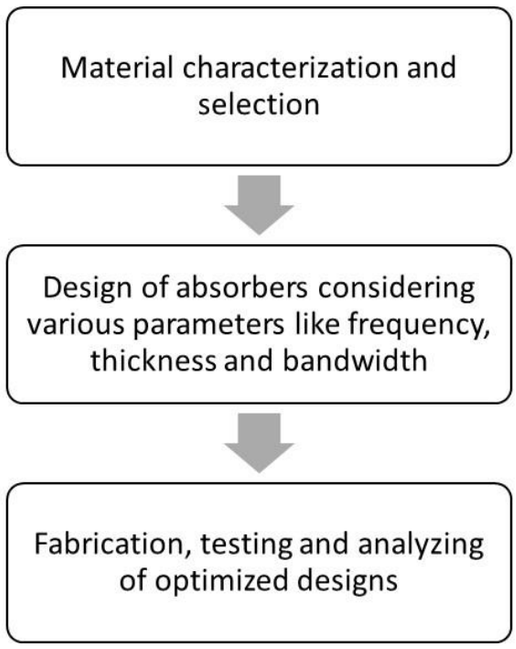
        The project was aimed to develop EMI shielding materials of different shapes and features, light weight and conformal, high mechanical strength with thickness about 4 mm to be used in-

        Strategic technology, in anechoic chamber and terminations in microwave and electronic devices.

      - **Project output**

        Both rigid and flexible EMI shielding materials were developed and successfully tested with absorption greater -20dB, thickness between 1 mm – 4.5 mm with thermal stability of about 300 °C at C-band and X-band.

- **Flow chart of processes/product development**



- **Product/process specifications**

The details are tabulated in the Table:1 below.

S.No.	Absorber type	Category	Frequency Range (-10dB BW)	Thickness	Possible applications
1	Rigid (Non-flexible)	MA-FR4-Cu	2 - 4 GHz	1.5 mm	Termination in S-band
2	Flexible	MA-Si-Ex	8.2 - 12.4 GHz	≥4.5 mm	Termination and tiles
3	Flexible	MA-LLDPE-CS	8.2 - 12.4 GHz	3.0 mm	Termination and tiles
4	Flexible	MA-LLDPE-CS-EG	8.2 - 12.4 GHz	3.0 mm	Termination and tiles
5	Flexible	MA-LLDPE-Ex	8.2 - 12.4 GHz	1.5 mm	Termination, tiles and tape
6	Flexible	MA-Si-Ex	8.2-12.4 GHz	≥ 4.5 mm	Absorber tiles
7	Flexible	MA-Si-CA	8.2-12.4 GHz	0.30 mm	Adhesive absorbing tape
8	Flexible	Si-DES gel	9-12 GHz	2.5mm	Adhesive absorbing tape

- **Other output**

  In-house development of free-space measuring set up which cost much less than the commercial ones.

- **Status of technology**

  Applied for patents and possible TOT.

- **Justification for the project**

  C-band and X-band frequency region finds wide use in wireless communication purposes. C-band provides communication link through satellite and enable connectivity across challenging terrain and remote territories. X-band is one of the common bands in like military communication

satellites (7.9 to 8.4 GHz for uplink & 7.25 to 7.75 GHz for downlink), precision approach radar (PAR) (9.0-9.2 GHz), terrestrial communication and networking (10.15 to 10.7 GHz), motion detectors (10.525 GHz), traffic light crossing detectors (10.4 GHz), weather radars (9.3-9.5 GHz) and also in medical sciences etc. The prolific usage of C-band and X-band frequency spectrum creates interference among themselves as well as for devices working in other operating frequency bands. To reduce the X-band interference, efficient microwave absorber is required. Further, the absorbers are to be mounted on conformal surfaces, so flexibility and thickness are important issues to be considered.

b) Project targets and achievements

Project targets	Achievements
a) Procurement and setting of equipment.	Procured, installed and tested.
b) Development of absorption testing set up.	Free-space measuring set up has been successfully developed in-house.
c) Calibration of instruments using standard samples.	Calibrated and tested with microwave absorber samples provided by Emerson and Cuming, Hyderabad.
d) Development of dielectric materials as reinforcers in large scale.	Expanded graphite (EG) as fillers are synthesized and characterized for confirmation.
e) Thermal characterization of the filler material.	Thermo-gravimetric analysis shows EG composites have thermal stability up to 250 °C.
f) Determination of complex permittivity and complex permeability.	Complex permittivity and permeability of the developed composites are determined using 85071E material measurement software in the X-band.
g) Simulation and development of different shaped dielectric absorbers using combination of developed dielectric materials with suitable polymers as matrix.	Composites of expanded graphite-silicone (EG-Si) and LLDPE-EG and LLDPE-Strontium ferrite are developed as absorbing materials.
h) Prototype studies to determine SE.	The developed absorbers with thickness about 4.5 mm show Reflection loss (dB) values > -20 dB.
i) Optimization of the reinforcers properties to improve absorption parameters.	Variation of filler percentages in the composites to change the shielding mechanism from reflective to absorptive. (5-11) wt. % EG-Si composites shows absorptive behavior.
j) To develop conformal shielding materials with good mechanical strength by manipulating the geometry.	Metamaterial unit cell structure designs are optimized with EG-Silicone composites to get a broadband absorption.
k) Analysis of results.	Completed. Please refer the progress report.

2. Additional Information

i) Details of patents registered, if any,

Applied for.

ii) Technological spin offs,

- **seeding of a major activity and how the project has helped in enhancing the technological base/capabilities in the country.**

It was successfully developed commercial, flexible, thin absorber tiles size (1 ft x 1 ft) with maximum absorption > -20 dB and termination in X-band and C-band with maximum absorption > -30 dB.

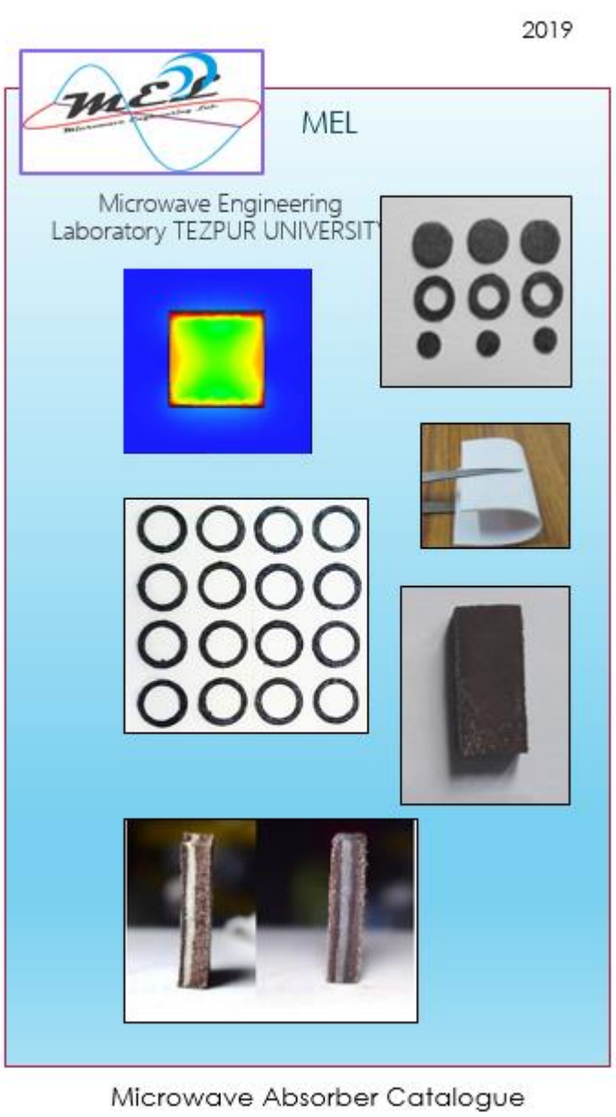
iii) Future areas for work

Tunable microwave absorber, and cloaking for portable systems and on-body applications.

ADDITIONAL INFORMATION REQUIRED FOR COMMERCIAL EXPLOITATION

1. Product/process developed

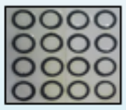
Products catalogue attached below.



Our Absorber Products

- MA-FR4-Cu

- MA-Si-Ex



- MA-LLDPE-CS
- MA-LLDPE-CS-EG
- MA-LLDPE-Ex

Product Name	Type	Frequency range (GHz)	Thickness (mm)
MA-Si-Ex	Flexible	8.2-12.4	4.0
MA-LLDPE-CS	Flexible	8.2-12.4	3.0
MA-LLDPE-CS-EG	Flexible	8.2-12.4	3.0
MA-LLDPE-Ex	Rigid	8.2-12.4	3.0
MA-Fr4-Cu	Rigid	2-4	1.5

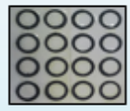
- Our absorbers are low profile
- MA-FR4-Cu has rigid FR4 substrate with metal back.
- MA-Si-Ex has Silicon as substrate which is very flexible and can withstand high temperature
- MA-LLDPE-CS, MA-LLDPE-CS-EG, MA-LLDPE-Ex has LLDPE as substrate

MEL, Tezpur University

Our Absorber Products

- MA-FR4-Cu

- MA-Si-Ex



- MA-LLDPE-CS
- MA-LLDPE-CS-EG
- MA-LLDPE-Ex

Product Name	Type	Frequency range (GHz)	Thickness (mm)
MA-Si-Ex	Flexible	8.2-12.4	4.0
MA-LLDPE-CS	Flexible	8.2-12.4	3.0
MA-LLDPE-CS-EG	Flexible	8.2-12.4	3.0
MA-LLDPE-Ex	Rigid	8.2-12.4	3.0
MA-Fr4-Cu	Rigid	2-4	1.5

- Our absorbers are low profile
- MA-FR4-Cu has rigid FR4 substrate with metal back.
- MA-Si-Ex has Silicon as substrate which is very flexible and can withstand high temperature
- MA-LLDPE-CS, MA-LLDPE-CS-EG, MA-LLDPE-Ex has LLDPE as substrate

Rigid Metamaterial Absorber

- MA-FR4-Cu

Features and benefits

- Thin
- Light weight

Technical specification	
Thickness	1.5 mm nominal
Maximum reflection loss	-27 dB

Material Characteristics

- Metallic square resonator on glass epoxy (FR4)
- Frequency range is S-band (2-4 GHz)
- Resonant frequency could be selected by changing the dimension of metamaterial unit cell.

Applications

- Can be used as particular point frequency absorption.

Availability

- It is available in user preferable sizes and thicknesses.
- Standard size is (15x15x0.15) cm

Instructions for Use

- It is designed to function directly in front of a metallic surface and additional metallic backed is attached to use in front of non-metallic surface like wood, and common plastic composites.

MEL, Tezpur University

Flexible Silicon Absorbers

- MA-Si-Ex

Features and benefits

- Flexible, Electrically non-conductive
- High thermal stability, high dielectric loss
- Water proof

Technical specification		
Decomposition temperature of silicone rubber	Thermo Galvanometric Analysis (TGA)	350° C
Elongation at break of silicone rubber	Universal Testing Machine (UTM)	1430 %
Tensile strength		4.5 MPa
Thickness		≥ 3.5 *mm* nominal
Absorption	≥ −10 *dB* or ≥ 90%	8.2-12.4 GHz
Environmental		Good general weather and chemical resistance
Colour		White

Applications

- It has been cast into transmission line attenuators and terminators
- It is being used for reducing crosstalk between adjacent antennas, shrouding antennas to improve the antenna patterns and undesired back lobes, as well as selective shadowing of parts of a target for RCS measurements.

Availability

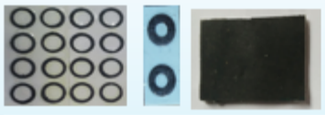
- It is available in user preferable sizes and thicknesses.
- Standard size is (15x15x0.35) cm

Instructions for Use

- It is designed to function directly in front of any surface.
- The absorber can be bonded to most substrates by using an RTV silicone based adhesive.

MEL, Tezpur University

Flexible LLDPE Absorbers



- MA-LLDPE-CS
- MA-LLDPE-CS-EG
- MA-LLDPE-Ex

Technical specification MA-LLDPE-CS		
Decomposition temperature of LLDPE	Thermo Galvanometric Analysis (TGA)	438.85° C
Thickness		3.0 mm nominal
Absorption	≥ −10 dB or ≥ 90%	8.87-12.4 GHz
Maximum reflection loss		-24 dB
Colour		Dark brown

Technical specification MA-LLDPE-CS-EG		
Decomposition temperature of LLDPE	Thermo Galvanometric Analysis (TGA)	438.85° C
Thickness		3.0 mm nominal
Absorption	≥ −10 dB or ≥ 90%	8.87-12.4 GHz
Maximum reflection loss		-24 dB
Colour		Dark brown

Technical specification MA-LLDPE-Ex		
Decomposition temperature of LLDPE	Thermo Galvanometric Analysis (TGA)	438.850 C
Tensile strength		12.55 MPa
Elongation at break of LLDPE		237 %
Water absorption		0.01 %
Thickness		1.5 mm nominal
Absorption	Full width half maxima	3.37%
Maximum reflection loss		-24.51 dB

It is available in user preferable sizes and thicknesses.
Standard size is (15x15x0.3) cm
It is designed to function directly in front of any surface.

2019 4

2. Specific use of the product/process

Refer to catalogue attached above.

3. Background information on the project (existing technology and alternatives in India).

The electromagnetic spectra especially from 0.3 GHz to 300 GHz frequency has been highly exploited in defense as well as by commercial industries. This has led to the need for either avoiding detection through camouflaging, as in military applications, or reducing the electromagnetic pollution to avoid interference.

Wireless technology usages have led the need to support simultaneous operation of different wireless system in the same environment without effecting the normal functioning of each individual system. To control this ever increasing EMI pollution, the demand on efficient EMI shielding is increasing. The EMI can be minimized by using radar absorbing material (RAM) which will reduce electromagnetic waves reflections and absorb them. The issues related to RAM are: to get an enhanced broadband absorption, to make the material light weight and environmentally inert. The absorber should have an easy processing technique, easily available raw material and to reduce the overall development cost. Thus the absorbers of EM waves are becoming increasingly important for applications outside special fields such as silent rooms, radar systems, and

military application. There are strict regulations on both emissions and immunity (or susceptibility) of EMI, thus shielding has become an integral part of product designs.

The main challenge is to design EMI shielding structures with broad frequency range of absorption with light weight, thin and good mechanical strength. Different applications require different shapes and structures of shields for easy mounting and handling conformability issues to get robust and compact systems. In addition, suppression of electromagnetic pollution should be independent of environmental variations.

To suppress electromagnetic interference, the electromagnetic-wave absorbers should essentially satisfy two important conditions. The first is the matched characteristics impedance of microwave absorber should be equal to each other thus low reflectivity at the air-absorber interface so as all the electromagnetic wave incident enters the material. Zero reflection at the air-absorber interface can be achieved by impedance matching condition, $\Omega_0 \approx 377\ \Omega$ (equation 2.50 and 2.51). Practical design relations of an absorber should evaluate the reflection loss value determining the effectiveness of microwave energy absorbed and from TLM simulation [16-17]. The reflection loss, RL, of a metal backed absorber is expressed as

$$RL = 20\log\left|\frac{Z_{in} - Z_0}{Z_{in} + Z_0}\right| \qquad (1)$$

Technically, reflection at the interface can be minimized by making input impedance of RAM close to that of free space.

$$Z_{in} = Z_0\sqrt{\mu_r/\varepsilon_r}\tan[\,j(2\pi fd/c)\sqrt{\varepsilon_r\mu_r}\,] \qquad (2)$$

Second, the material should be able to attenuate the incident electromagnetic wave rapidly through the material layer, thus reducing the emerging wave to an acceptable low magnitude. The power of the electromagnetic wave decays exponentially with distance, x, by the factor $e^{-\alpha x}$, where α is the attenuation constant of the material.

$$\alpha = \frac{\sqrt{2\pi f}}{c}\sqrt{(\mu_r''\varepsilon_r'' - \mu_r'\varepsilon_r') + \sqrt{(\mu_r''\varepsilon_r'' - \mu_r'\varepsilon_r')^2 + (\varepsilon_r'\mu_r'' + \varepsilon_r''\mu_r')^2}} \qquad (3)$$

From equations (1)-(3), the reflection loss of the absorber depends upon the intrinsic material parameter complex permittivity (ε_r), complex permeability (μ_r), and conductivity (σ_s). Thickness (d) is another important parameter influencing the reflection loss behavior of the absorber. The thickness of the absorber hampers its utility in various applications like in combat aircraft camouflaging, in electronic systems like microwave sensors, integrated circuits etc.

A detailed study of microwave absorption material has been carried out by our group in another project, entitled “Synthesis and Development of Broadband EMI Shielding Materials using Magneto-Dielectric-Nanoparticles” sanctioned by DIT with administration approval no. 1(01)/2010 M&C Dated 26.05.2010, which

focused on developing EMI shielding material, using magneto-dielectric inclusions in nano-dimensions in polymer matrix. The proposed EMI shielding materials were developed and tested out. The materials testify for both dielectric and magnetic properties and showed expected broadband SE in X band fulfilling the objective of light weight and corrosion resistant absorbers.

This venture proposes to modify the design of the EMI shields with different shape and features using the developed magneto dielectric inclusions or with hybrid combinations of dielectric and magnetic reinforcers for customized applications. The base matrix will be modified to get better flexibility and heat resistance. Desired designs for most of the applications are tiles, cylindrical shapes, where optimized multilayer structures are employed to give broader band of absorption. Absorbers with reduced weight are preferred having sufficiently good mechanical strength like perforated and PB structures etc.

4. Status of product/area in India

In past few decades a lot of works on development on EMI shielding material has been carried out and some of the references are reported [1-4]. Dattatray E. Kshirsagar et al. has reported the synthesis of carbon nanomaterial from pongamia glabra (Karanjal) oil, pyrolysed at temperature 800^{o}C to 900^{o}C to obtain the thin film of carbon nanomaterials on ceramic substrates [14]. Microwave absorption study done on this thin film of CNM at X band and maximum absorption found to be 90-95% in 8.60 GHz to 10.20 GHz range with a reflection coefficient of -27.42 dB to -36.90 dB.

In IIT, Delhi ,Verma A.; Mendiratta R.G.; Goel T.C.; Dube D.C have reported single layer microwave absorbers based on strontium ferrite-epoxy composites in the X-band (8–12.4 GHz) of microwave frequencies[15]. Permittivity ($\varepsilon_r' - j\varepsilon_r''$) and permeability ($\mu_r' - j\mu_r''$) of Co and Ti added strontium ferrite $SrCo_xTi_xFe_{12-2x}O_{19}$ (x = 0.1 to 0.9 in steps of 0.2), have been measured and a minimum reflection loss of -36.5 dB is observed for the composite with x = 0.3.

Some work has been reported by K.H. Prema et al. on synthesis of fine particles of nickel ferrite by the sol-gel technique and incorporated in ethylene propylene diene rubber (EPDM) and microwave absorption properties of rubber ferrite composites (RFCs) has been studied at X and S band frequencies [16].

S.M Abbas, A K Dixit, R Chatterjee, T C Geol. have reported the microwave absorption properties of nanosize polyaniline and found a minimum reflection loss of -30 dB (99.9% power absorption) at the central frequency of 10 GHz and the bandwidth (full width at half minimum) of 4.2 GHz over whole X-band (8.2 to 12.4 GHz) in a sample thickness of 3.0 mm [17].

A promising composite reinforcement can be expanded graphite (EG) flakes, with the characteristics of very low density ~ 0.005-0.01 g/cc, high electrical

conductivity ~104 S/cm, good thermal and mechanical properties with resistant to environmental corrosion [18-20].

In references [21, 22], it was shown that sintered barium ferrites with a magnetoplumbite structure (M-type: $BaFe_{12}O_{19}$) may be used as thin impedance matched electromagnetic wave absorbers in the GHz range.

The same group has prepared composite with expanded graphite (EG) and barium ferrite as filler and microwave absorption properties were studied in X-band (8.2–13.5 GHz) [9, 10]. A maximum reflection loss of −43 dB (>99% power absorption) at 12.4 GHz with a -10dB bandwidth of 1 GHz with thickness of 4 mm has been reported for single layer EG/NPR composite. Microwave absorption measurement is carried on a single layer absorber using nanosized barium ferrite in NPR matrix with varying compositions shows good absorption and a maximum absorption of -37.06 dB is obtained [10].

References:

1. Pinhoa, M. S., Gregoria, M. L., Nunes, R. C. R., Soares, B. G., “Aging effect on the reflectivity measurements of polychloroprene matrices containing carbon black and carbonyl- iron powder,” J Polym Degrad Stab, 73,1–5 (2001).
2. Knott, E. F., Shaeffer, J. F., Tuley, M. T., [Radar cross section], New York: Artech House, p. 9 (1993).
3. Carvalho, A., Gregori, M. L. and Chambers, B., “Determination of microwave intrinsic properties of hexaferrite samples,” Micro Opt Tech Lett, 16, 393–7(1997).
4. Petrov, V. M., Gagulin, V. V., “Microwave absorbing materials,” J Inorg Mater, 37, 93–8(2001).
5. EMI Shielding and Gaskets “http://www.lairdtech.com/Products/EMI-Solutions/EMI-Shielding/”.
6. Y.B. Feng, T. Qiu, C.Y. Shen, Absorbing properties and structural design of microwave absorbers based on carbonyl iron and barium ferrite, Journal of Magnetism and Magnetic Materials 318 (2007) 8–13.
7. G. Shen, Z. Xu, Y. Li, Absorbing properties and structural design of microwave absorbers based on W-type La-doped ferrite and carbon fiber composites, Journal of Magnetism and Magnetic Materials 301 (2006) 325–330.
8. T.Giannakopoulou, A. kontogeorgakos, G.Kordas, “single-layer microwave absorbers: influence of dielectric and magnetic losses on the layer thickness”, *J. Magn. Magn. Mater*., *vol.263, pp.173-181.2003*
9. J. P. Gogoi. N. S. Bhattacharyya and K. C. J. Raju, “Synthesis and microwave characterization of expanded graphite/novalc phenolic resin composite for microwave absorber applications,”*Composites Part B: Engineering*, **42**, pp.1291-1297, 2011.
10. S. Ozah and N. S. Bhattacharyya “Nanosized barium hexaferrite in Novolac Phenolic Resin as microwave absorber for X-band application”, *Journal of Magnetism and magnetic materials* **342**, pp. 92-99, 2013.
11. EMI Filters and RF Shielding Products, http://www.djmelectronics.com/rf-anechoic-chambers.html.
12. RF Absorbers, “http://www.djmelectronics.com/rf-absorber.html”
13. EMI shielding handbook, www.chomerics.com.

14. Dattatray E. Kshirsagar et al. " Electromagnetic Wave-Absorbing Properties of Pongamia Glabra Based-CNMs in the 8-12 GHz Range", *Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry,vol.37, pp.6,477 — 479, (2007)*
15. Verma A, Mendiratta R.G, Goel T.C., Dube D.C "Microwave Studies on Strontium Ferrite Based Absorbers", *journal of electroceramics, vol. 8, No. 3, pp. 203-208(6), 2002*
16. K.H. Prema et al. "Permittivity Characteristics in the X- and S-Band Frequencies of Microwave Absorbers Based on Rubber Ferrite Composites", Journal of Elastomers and Plastics, Vol. 40, No. 4, pp 331-346 (2008)
17. S.M Abbas, A K Dixit, R Chatterjee, T C Geol. "Preparation of nanosize polyaniline and its utilization for microwave absorbers", *J Nanosci Nanotechnol,vol. 7, No. 6, pp.2129-33, 2007*
18. Celzard A., Marechˆe, J. F., Furdin, G., and Puricelli, S. Electrical conductivity of anisotropic expanded graphite-based monoliths, J. Phys.D: Appl. Phys 33, 3094-3101, 2000.
19. Chen, G., Wu, D., Weng, W., He, B., and Yan, W. Preparation of polystyrene–graphite conducting nanocomposites via intercalation polymerization, J. Polym Int 50, 980-85, 2001.
20. Chen, G., Wu, C., Weng, W., Wu, D., and Yan, W. Preparation of polystyrene/graphite nanosheet composite, J. Polym Commun. 44, 1781-84, 2003.
21. K. Okayama et al., J. Magn. Soc. Jpn., vol. 22, pp. 297-300, 1998.
22. S. Sugimotoet. al., J. Magn. Soc. Jpn., vol. 23,pp. 611-613, 1999.

5. International status of technology/products/process

Most of the literature survey does not give details of the development process as this being a strategic research area. We acquired samples from Emerson and Cuming, Belgium from their agents in Hyderabad, and compared our products with them. The details are given below:

6. Suggested end users

Some of the possible users/companies have been enlisted below-

S. No.	Company/ Organization	Products	Absorber required/Use	Address/Contact
1.	Verdant Innovation Technology	Antennas, Radomes and Communication systems	1.C-RAM GDSS (1 GHz to 20 GHz) https://www.cumingmicrowave.com/pdf/310-Rubber%20Sheets/310-4%20C-RAM%20GDSS.pdf 2. C-Ram RGDS https://www.cumingmicrowave.com/pdf/330-	Verdant Telemetry & Antenna Systems Pvt. Ltd. *26/411* A,*Konthuruthy* Cochin - 682 013, INDIA Phone: 0091-484-2663104 Fax: 0091-484-2663576 Email: info@verdanttelemetry.com URL: www.verdanttelemetry.com

			Rigid%20&%20Castable%20Absorbers/330-2%20C-RAM%20RGD-S.pdf 3. C-Ram Flx https://www.cumingmicrowave.com/pdf/310-Rubber%20Sheets/310-2%20C-RAM%20FLX-800.pdf For Spiral Antennas	
2.	COMSAT Systems Pvt. Ltd.	Satellite Communication Antenna Systems	1.C-RAM HCGR 0.50 https://www.cumingmicrowave.com/pdf/360-Honeycomb%20&%20High%20Power/360-1%20C-RAM%20HC.pdf To reduce RF coupling of antennas	COMSAT SYSTEMS PVT.LTD Plot No. 22/A, I.D.A, Mallapur HYDERABAD, Telangana Pin Code 500 076 +91-40-27150484 / 27152329 Fax No. +91-40-27155045 Email: marketing@comsatsystems.co.in Email: johns@comsatsystems.co.in URL: http://www.comsatsystems.co.in/index.php/auth/home
3.	ICOMM Tele Limited	Telecom equipment, Defence equipment	1.C-RAM HCGR 0.50 https://www.cumingmicrowave.com/pdf/360-Honeycomb%20&%20High%20Power/360-1%20C-RAM%20HC.pdf 2. C-Ram RGDS https://www.cumingmicrowave.com/pdf/330-Rigid%20&%20Castable%20Absorbers/330-2%20C-RAM%20RGD-S.pdf	ICOMM Tele Limited Registered Office: Plot No. 40-46 Phase-I, IDA, Cherlapally Hyderabad - 500051. Telangana, India. Corporate Office: Megha Tower–2 S-2, Technocrats Industrial Estate Balanagar, Hyderabad – 500037. Telangana, India. Fax : +91-40-23552266 URL: http://www.icommtele.com/index.html
4.	Inotek Antennas	Base Station Antennas - GSM900, GSM1800, UMTS, Multiband, PCS Speciality Antennas - WiMax, Wi-Fi, Indoor, Disguised Antennas	1.Eccosorb - HR25 https://www.laird.com/sites/default/files/2018-11/RFP-DS-HR%20092815.pdf https://www.mouser.com/datasheet/2/987/HR-1591376.pdf	B-6/4 MIDC Butibori Industrial Estate, Nagpur (M.S), India Tel: +91 (0) 7104 265497 Fax: +91 (0) 7104 265497 Mob: +91 (0) 9958859060 Email: indsales@inotekantennas.com Web: www.inotekantennas.com
5.	Milestone India	Microwave synthesis, Microwave extraction, Microwave	RF high power absorbers For research purpose	EL-91,TTC Industrial Area, Electronic Zone, Mahape, Navi-Mumbai, India 022-67896600 www.milestone.co

		Digestions etc.		sales_bom@milestoneindia.co URL: https://milestoneindia.co/
6.	Commuincation Electronic Star Antenna	RF Antennas and accessories	1.Eccosorb - HR25 https://www.laird.com/sites/default/files/2018-11/RFP-DS-HR%20092815.pdf https://www.mouser.com/datasheet/2/987/HR-1591376.pdf 2.RF absorber RFID flexible https://docs.rs-online.com/f748/0900766b80f883bb.pdf	Commuincation Electronic 315, Vishwadeep Building, District Centre, Janakpuri, New Delhi (110058). Contact person: Mr. P.S. Malik Phone: +91 1125533230 Fax: +91 1125533230 Mobile:+91 9868128127 Email: info@starantenna.com URL: https://www.starantenna.com/
7.	NEC Technologies India Pvt. Ltd.	Communication platforms, Monitor and displays, Projector	1. Eccosorb FGM-40/ss3 (3-40 GHz) https://www.laird.com/sites/default/files/rfp-ds-fgm-092515.pdf	Headquater: A-31, 1st Floor, Lajpat nagar Part-II, New Delhi- 110024 Contact: https://contact.nec.com/http-in.nec.com_tb_root_contact/ URL: https://in.nec.com/
8.	Sanjay Technologies	Consumer Electronics, Medical Electronics, Textile Electronics, Industrial Electronics, Automotive Electronics, LED Lighting	1. Eccosorb FGM-40/ss3 (3-40 GHz) https://www.laird.com/sites/default/files/rfp-ds-fgm-092515.pdf	7/4C Mettupalayam Road, Narashimanaiken Palayam, Coimbatore - 641031, Tamil Nadu, INDIA Phone: +91 422 2460117 +91 422 2460441 +91 99400 05531 Mobile: +91 99400 05532 Email: info@sanjaytechnologies.co.in URL: http://www.sanjaytechnologies.co.in/
9.	Podrain Electronics Pvt. Ltd.	PCB assembly, box build/system integration and cable assemblies	1. Eccosorb FGM-40/ss3 (3-40 GHz) https://www.laird.com/sites/default/files/rfp-ds-fgm-092515.pdf 2. Board Mount EMI Enclosures RF Absorber CRS Tin SMD https://www.mouser.in/datasheet/2/987/DS_Eccosorb_BSR-1590456.pdf	Podrain Electronics Private Limited 92, 2nd Cross, Hosur Road, Garavebhavipalaya. Banglore - 560068 Phone Numbers +91 7411 001 030 +91 82964 93661 Email: info@podrain.com shyamc@podrain.com URL: https://podrain.com/index.html

7. Similar products/process in India

Some private companies do advertise for EMI shielding materials, but the standardization of product is not known. It is not clear whether they are importing it or developing themselves. As mentioned in 4. Some research paper from NPL,

IIT Delhi, IIT Roorkee, IIT Madras, IIT Kanpur, regarding different absorbers were found.

8. Whether the product is for import substation

The products are developed considering mass production with provision of custom designing to cater the needs of National requirements which may be considered for import.

9. Name & address of prospective entrepreneurs

We are looking for the entrepreneurs. Communication in this regard has been made with an entrepreneur group from Guwahati, Jorhat and Vidyut Yantra, Modi Nagar.

10. Safety and pollution aspects

Most of the ingredients of the developed Expanded graphite, Silicone, LLDPE and Strontium ferrite are non-toxic. However, some amount of NO_2 and SO_2 is produced while intercalating graphite flakes which are within toxic permissible limit (NO_2~25 ppm and SO_2 ~ 5.0 ppm) of the government [1, 2]. Care has to be taken for mass production. The absorber developed is corrosion resistant and inert to water and common reagents at room temperatures, but bio-degradability have to be studied in long run.

Reference: [1] http://www.atsdr.cdc.gov/mmg/mmg.asp?id=394&tid=69

[2] http://inspectapedia.com/sickhouse/gashaz.htm

11. Suggestion regarding terms for transfer of technology

The work has reached at a stage of transfer of technology. In future, end users and intermediate manufacturers will be contacted for the transfer of technology in consultation with MeitY.

12. Preparation of feasibility report

The EMI shielding product specifications are given in Table 1. For transferring technology, the report has to be developed case to case depending upon the requirements of the end-user.

ANNEXURES

I. Minutes of the Steering committee meeting
Attached as Annexure A.

II. Equipment photographs

Sl. No.	Equipment (procured)	Photo
1.	Microwave Synthesis System	

2.	Ultra Centrifugal Mill ZM 200	
3.	Mortar Grinder RM 200	
4.	Muffle Furnace	
5.	Hot Air Oven	
6.	Laboratory Centrifuge	

7.	3-D printer	
8.	Highly directive antenna	
9.	Dielectric probe kit	
10.	Spectrum analyzer	

11.	Work station	
12.	Vector network analyzer	

Sl. No.	Equipment (developed)	Photo
1.	X-band die mold with spacer	
2.	C-band die mold	
3.	1GHz-20GHz-band die mold	

4.	Moulder developed for 30 cm x 30 cm absorber preparation	
5.	Free-space measuring set up	

Laboratory I (Photograph)

Laboratory II (Photograph)

III. List of publications

i. Gogoi, Dhruba Jyoti, and Nidhi Saxena Bhattacharyya. "Embedded dielectric water “atom” array for broadband microwave absorber based on Mie resonance." *Journal of Applied Physics* 122.17 (2017): 175106.

ii. Borah, Dipangkar, and Nidhi S. Bhattacharyya. "Design and development of expanded graphite-based non-metallic and flexible metamaterial absorber for X-band applications." *Journal of Electronic Materials* 46.1 (2017): 226-232.

iii. Gogoi, Dhruba Jyoti, and Nidhi Saxena Bhattacharyya. "Metasurface absorber based on water meta “molecule” for X-band microwave absorption." *Journal of Applied Physics* 124.7 (2018): 075106.

iv. Gogoi, Dhruba Jyoti, and Nidhi Saxena Bhattacharyya. "Microwave metamaterial absorber based on aqueous electrolyte solution for X-band application." *Journal of Applied Physics* 125.12 (2019): 125107.

v. Borah, Dipangkar, and Nidhi S. Bhattacharyya. "Design, fabrication and characterization of flexible and ultrathin microwave metamaterial absorber." *2017 International Conference on Innovations in Electronics, Signal Processing and Communication (IESC)*. IEEE, 2017.

vi. Gogoe, D. J., and Nidhi S. Bhattacharyya. "Flexible microwave absorber based on strontium ferrite-rubber composite for X-band applications." *Int. J. Res. Eng. Technol* 6 (2017): 47.

vii. Borah, Dipangkar, and Nidhi S. Bhattacharyya. "Development of non-metallic and conformal dual band meta-skin and its absorption study for microwave applications." *Journal of Applied Physics* 122.5 (2017): 054503.

viii. Chakraborty, Soma, Nidhi S. Bhattacharyya, and Satyajib Bhattacharyya. "X-band composite microwave absorber using doped strontium ferrite." *2017 IEEE Applied Electromagnetics Conference (AEMC)*. IEEE, 2017.

ix. Chakraborty, Soma, Nidhi Saxena Bhattacharyya, and Satyajib Bhattacharyya. "Single layered wide bandwidth nanosized strontium hexa-ferrite filled LLDPE absorber in X-band." *Progress In Electromagnetics Research* 71 (2016): 137-152.

IV. Chemical characterization

XRD and TEM were carried out for microstructural analysis of the filler materials.

V. Cost calculation

Cost of multi-layered expanded graphite-silicone composite 1ftx1ft sample (for single tile) excluding man power and major equipment.

Sl. No.	Material	Quantity	Cost per unit (INR)	Total Cost(INR)
1.	RTV silicone (for top, middle and bottom layer)	365 ml	1.60	584.00
2.	Expanded graphite – silicone composite	625 square	5.84	183.00
3.	Utility(Power)	34.65 unit	7.70	266.80
4.	Fixed/Demand Charge of Power	12 kVA	130.00	1,560.00
			Total cost of developing an absorber (1ft x 1 ft) tile (INR)	2,594.00

Annexure I

HEADWISE BREAK-UP OF EXPENDITURE

Statement of Expenditure

(Period: From 30.3.2016 to 29-12-2020)

DeitY sponsored project: "Design and realization of light weight shields to reduce electromagnetic interference (EMI) at microwave ranges (C and X band) with different geometries for customized applications like anechoic chamber, as terminations and stealth for strategic device camouflaging"

Principal Investigator: Prof. Nidhi S. Bhattacharyya

Sl No.	Head	Fund Received (Rs.)				Total Received amount (Rs.)	Spent amount (Rs.)					Total Spent (Rs.)	Unspent amount (Rs.)
		2016-2017	2017-2018	2018-2019	2020-2021		2016-2017	2017-2018	2018-2019	2019-2020	2020-2021		
1	Capital Equipment and software	1,14,44,000.00	-	50,00,000.00	-	1,64,44,000.00	39,36,308.00	59,29,022.00	94,600.00	55,81,480.00	9,04,680.00	1,64,46,090.00	-2,090.00
2	Manpower	6,00,000.00	-	6,72,000.00	6,72,000.00	19,44,000.00	4,63,300.00	4,64,600.00	3,12,148.00	4,51,800.00	3,88,560.00	20,80,408.00	-1,36,408.00
3	Travel and Training	2,50,000.00	-	2,50,000.00	78,000.00	5,78,000.00	1,22,167.00	1,26,712.00	82,193.00	1,16,510.00	-	4,47,582.00	1,30,418.00
4	Consumable stores	2,00,000.00	-	2,00,000.00	1,00,000.00	5,00,000.00	2,00,000.00	35,074.00	0	1,33,968.50	0	3,69,042.50	1,30,957.50
5	Contingencies including TA/DA for PRSG meeting	4,50,000.00	-	4,66,000.00	4,50,000.00	13,66,000.00	4,50,000.00	3,15,087.00	9,42,030.50	0	6,760.00	17,13,877.50	-3,47,877.50
6	Overhead	-	-	6,00,000.00		6,00,000.00	1,87,500.00	-	1,87,500.00	0	-	3,75,000.00	2,25,000.00
7	Total	1,29,44,000.00		71,88,000.00	13,00,000.00	2,14,32,000.00	53,59,275.00	68,70,495.00	16,18,471.50	62,83,758.50	13,00,000.00	2,14,32,000.00	0
8	Interest earned	2,65,465.00	29,246.00	1,41,384.00	4,646.00	-	-	-	2,94,711.00*	-	1,46,030.00*	-	-

* Amount returned to the funding agency.

Principal Investigator

Finance Officer
Tezpur University

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No. - 305054

03.03.2021

Activate Windows
Go to Settings to

Annexure II

EQUIPMENT (IMPORTED) PROCEDURE FOR THE PROJECT

S. No.	Description	Manufacturer/ Supplier	Brief Specifications	Purchase Order No. & date	Date of Receipt	Total Cost	Duty * Paid	Condition G-good B-bad
1	Mortar Grinder (Mortar Grinder RM 200)	Manufacture: Retsch, GmbH, Germany Supplier: Verder Scientific private Limited Plot No 5A/10-11, 1st Floor IDA No. Uppal Mandal, 5-1-149, Nacharam - Mallapur Rd, Annapurna Colony, Mallapur, Hyderabad, Telangana 500076 E-mail: info@verder-scientific.co.in	Size reduction principle: Pressure, Friction Applications: grinding, mixing and triturating, dry and wet Feed material: soft, hard, brittle, pasty Material feed size: < 8 mm Final fineness: < 10 µm Batch size / feed quantity: 10 - 190 ml Grinding chamber volume: 700 ml Speed at 50 Hz (60 Hz) 100 min-1 Speed setting: Setting of pestle pressure vertical by adjusting knob + scale, horizontal by adjusting knob + visual/acoustic control Setting of scraper pressure by adjusting knob + visual control Setting of grinding time: digital, 1 - 99 min / continuous operation Power connection: 1-phase Protection code: IP 53 Power consumption:250 W (230 V, 50 Hz) / 290 W (120 V, 60 Hz) Dimension W x H x D Closed:400 x 480 x 370 mm Opened: 400 x 550 x 510 mm Net weight: ~ 24.2 kg Standards: CE	TU/11-1/Pur/Physics/2016-17/3360 Dated: 22.11.16	08/03/17	7,69,882.00 (INR) (Including duty)		Good
2	Ultra Centrifugal Mill ZM 200	Manufacture: Retsch, GmbH, Germany Supplier: Verder Scientific private Limited	Size reduction principle: impact, shearing Field of application: agriculture, biology, chemistry / plastics, construction materials, engineering / electronics, environment / recycling, food, geology / metallurgy, medicine / pharmaceuticals	TU/11-1/Pur/Physics/2016-17/3360 Dated: 22.11.16	08/03/17	7,59,761.00 (INR) (Including duty)		Good

		Plot No 5A/10-11, 1st Floor IDA No. Uppal Mandal, 5-1-149, Nacharam - Mallapur Rd, Annapurna Colony, Mallapur, Hyderabad, Telangana 500076 E-mail: info@verder-scientific.co.in	Feed material: soft, medium-hard, brittle, fibrous Material feed size: < 10 mm Final fineness: < 40 µm Batch size / feed quantity: 900 ml with standard cassette, 50 ml with mini-cassette Speed at 50 Hz (60 Hz): 6,000 - 18,000 rmp, free selectable Rotor peripheral speed: 31 - 93 m/s Rotor diameter: 99 mm Types of rotors: 6-tooth rotor / 12-tooth rotor / 24-tooth rotor / 8-tooth mini-rotor Material of grinding tools: stainless steel, titanium, steel 1.4404, stainless steel with wear-resistant coating Sieve sizes: trapezoid holes 0.08 / 0.12 / 0.20 / 0.25 / 0.50 / 0.75 / 1.00 / 1.50 / 2.00 mm round holes: 3.00 / 4.00 / 5.00 / 6.00 / 10.00 mm Setting of grinding time - Collector capacity: 900 ml with standard cassette 50 ml with mini-cassette Drive 3-phase asynchronous motor with frequency converter Electrical supply data: Voltages: 200-240 V Power connection: 1-phase Protection code: IP 20 Power consumption: 1300 W W x H x D closed: 410 x 515 x 365 mm Net weight:~ 38 kg Standards; CE					
3	Microwave	Manufacture:	Microwave cavity: 18/8 stainless steel	TU/11-	25/03/17	28550.00		Good

	Synthesis System	Milestone S.r.l. Via Fatebenefratelli, 1/5 24010 Sorisole (BG) - Italy phone: +39 035 573857 fax: +39 035 575498 / 4128028 VAT ID: IT01879330163 web: www.milestonesrl.com e-mail: analytical@milestonesrl.com Supplier: I. R. TECHNOLOGY SERVICES PVT. LTD. ECO SPACE Business Park , Block No 4B, 9th Floor, Unit No.- ESNT 4B 0903, New Town, Rajarhat, Kolkata –700156 PHONE : 033- 4036-1800 FAX: 91-33-4036-1888 E-MAIL:sales_cal@irtech.in	housing with multi-layer PTFE coating Large microwave cavity 43x 40x41(h) cm (70,5 L) Inlet/Outlet ports: Large flange with 36mm ID plus additional ports on side walls Chassis: Protected against acids and solvents with polymer coating Door: Completely made of 18/8 stainless steel Self-resealing pressure responsive door Multiple independent safety interlocks to prevent microwave emission in case of improper closer or misalignment Exhaust System: Built-in , located above the cavity & separated from electronics to prevent corrosion Microwave emission: Dual magnetron system with rotating diffuser for homogeneous microwave distribution Two 950 watt rated magnetrons , for a total of 1900 watt Continuous PID-controlled microwave emission at all power levels Emission and safety norms: EN61010-1:2001;EN61010-2-010:2003;UL61010-1:2004;CAN/CSA-C22.2N.61010-1:2004;CAN/CSA-C22.2N.61010-2-010:2004,IEC 61010-2-010:2003; EN61326-1:2006; CEI EN 61326-2-6:2006 Advanced features: Built-in software controlled digital camera Built-in turntable motor kit Built-in magnetic stirring Built-in infrared temperature sensor	1/Pur/Physics/2016-17/3359 Dated: 22.11.16		(EURO) (excluding duty)		
4	Muffle furnace	Genaxy Scientific Pvt. Ltd. 155-156 C block Community Centre Janakpuri, New Delhi-110058	Chamber Volume: 7 liters Temperature Range: 300 to 1200^{0}C Continuous operating range: 1150^{0}C Time to maximum temp: 60 minutes Interior chamber: Fiber board and refractory brick PID microprocessor control system with dual display Open wire heated system Double envelop construction	TU/11-1/Pur/Physics/2017-18/1201 Dated: 14.06.17	14/09/17	293416.00 (INR) (Including taxes and duty)		Good

			Int. Dimension:200*250*140mm Ext. Dimension:550*580*650mm 230Volt-50/60Hz					
5	Centrifuge	Zenith India Gauri Sova Complex Nepali Mandir Paltan Bazar Guwahati-781008	Maximum Speed:17300rpm Maximum RDF: 27440 Display: LED Complete with TWO rotor head of 6*50ml and 12*15ml	TU/11-1/Pur/Physics/2017-18/1200 Dated: 14.06.17	14/09/17	1,09,250.00 (INR) (Including taxes)		Good
6	Hot Air Oven	Zenith India Gauri Sova Complex Nepali Mandir Paltan Bazar Guwahati-781008	Made up of Stainless Steel body. Gap between the walls are filled with quality glass wool for proper insulation. The temperature is controlled by PID controller. Temp. range: room temp to 250^{0}C Accuracy is +/-1C Input Voltage:230Volts Single Phase Watt:2500W Inner Dimension: 605*605*605mm	TU/11-1/Pur/Physics/2017-18/1200 Dated: 14.06.17	14/09/17	1,54,554.25 (INR) (Including taxes)		Good
7	INOLAB COND	Zenith India Gauri Sova Complex Nepali Mandir Paltan Bazar Guwahati-781008	Conductivity measurement upto 1000 mSm/cm	TU/11-1/Pur/Physics/2017-18/5921 Dated: 22/03/2018	24/03/18	1,69,575.00 (INR) (Including taxes)		Good
8	CNC Mill	Vidyut Yantr Udyog, Modi Nagar Uttar Pradesh	CNC Mill, 3D printer, Laser engraver	TU/11-1/Pur/Physics/2017-18/5926 Dated: 24/03/2018	27/03/18	7,50,000.00 (INR) (Including taxes)		Good

9	Microwave Absorbers	Vidyut Yantr Udyog, Modi Nagar Uttar Pradesh	Microwave absorption upto 20 GHz	TU/11-1/Pur/Physics/2017-18/5954 Dated: 22/03/2018	28/03/18	84,000.00 INR) (Including taxes)		Good
10	Arronia Hyperlog Antenna	Scientific MechTech, Indore	Highly directional antenna	TU/11-1/Pur/Physics/2017-18/5529 Dated: 01/03/2018	28/03/18	19,95,649.00 (INR) (Including taxes)		Good
11	Pasternack RF Cables	Scientific MechTech, Indore	RF Cables upto 18 GHz	TU/11-1/Pur/Physics/2017-18/5524 Dated: 01/03/2018	28/03/18	4,77,065.00 (INR) (Including taxes)		Good
12	Material Measurement Suit with dielectric proble	Vishal Vyapar Vikash, Guwahati, Assam	Dielectric measurement probe set	TU/11-1/Pur/Physics/2017-18/5528 Dated: 01/03/2018	28/03/18	13,44,000.00 (INR) (Including taxes)		Good
13	Aaronia Spectran V5	Scientific MechTech, Indore	Spectrum analyzer	TU/11-1/Pur/Physics/2018-2019/4176 Dated 25.01.2019	02/05/19	15,95,480.00 (INR) (Including taxes)		Good
14	Anritsu Vector network analyzer	Empower Technology Kolkata	Vector network analyzer	TU/11-24/Pur/Qtn(ET)/2018-19/2752 Dated 04/10/2018	26/02/20	27,30,000.00 (INR) (Including taxes)		Good

EQUIPMENT (INDIGENOUS) PROCEDURE FOR THE PROJECT

Sl.No.	Description	Manufacturer/ Supplier	Brief Specifications	Purchase Order No. & date	Date of Receipt	Total Cost	Duty * Paid	Conditions G – Good B – Bad
1.	Lab Tables and partitions	S. M. Enterprise, Tezpur, Assam	Acid resistance tables, partitions	--	12/02/17	2,89,460.00 (INR) (Including taxes)		Good
2.	Online UPS System	D.S. System	10 KVA online UPS system with inbuilt isolation transformer and 60 minutes backup capacity	TU/11-1/Pur/Physics/2016-17/5131-A Dated 28.02.2017	08/03/17	1,85,725.00 (INR) (Including taxes)		Good
3.	BlueStar AC	PD TRADE AGENCIES, Tezpur, Assam	2 Ton 5 Star AC	TU/11-1/Pur/Physics/2017-18/5525-A Dated 01.03.2018	24/03/18	72,300.00 (INR) (Including taxes)		Good
4.	10 KVA Online UPS	D.S. SYSTEM, Guwahati, Assam	10 KVA Online UPS with 60 min backup	TU/11-1/Pur/Physics/2017-18/5869-A Dated 20.03.2018	24/03/18	1,53,383.00 (INR) (Including taxes)		Good
5.	UPS Battery	CLARIANT ELECTRIC, Guwahati, Assam	14 no. UPS Battery	TU/11-1/Pur/Physics/2017-18/5866-A Dated 20.03.2018	24/03/18	35,074.00 (INR) (Including taxes)		Good
6.	File Cabinet	FARM MACHINERY, Tezpur, Assam	Four door file cabinet	TU/11-1/Pur/Physics/2017-18/5870-A Dated 20.03.2018	26/03/18	36,370.00 (INR) (Including taxes)		Good
7.	Laptop	Data Computers, Tezpur, Assam	Laptop	TU/11-1/Pur/Physics/2018-19/4834-A Dated 28.02.2019	18/03/19	94,600.00 (INR) (Including taxes)		Good
8.	Free Space Measurement System Parts:	AROHAN ENTERPRISE	Free Space Field and Absorption Testing System and	TU/11-1/Pur/Physics/2018-19/4327 Dated	22/01/20	19,12,680.00 (INR) (Including taxes)		Good

	ESCAN – 40 EMP Studio 10 RCU – 10 R – Arm – 8		Machining Cost	18.12.2019				
9.	Workstation	NAKSH SCIENTIFIC SOLUTION	Workstation	TU/11-1/Pur/Physics/2018-19/4280 Dated 16.12.2019	09/01/20	2,48,000.00 (INR) (Including taxes)		Good

Annexure IV

MANPOWER ASSOCIATED WITH THE PROJECT

S. No.	Name	Designation	Qualification	% of time devoted to this project	Salary drawn (Amount)	Date of Joining	Date of Leaving	Total
(a)								
1.	Prof. Nidhi S. Bhattacharyya (Project PI)	Professor	Ph.D	60%	--	--	--	
2.	Prof. Satyajib Bhattacharyya (Project Co-PI)	Professor	Ph.D	30%	--	--	--	
(b)								
1	Dipangkar Borah (Technical Part and procu-rement of capital equipment)	JRF (Resigned)	M.Sc	80%	25,000.00	22.04.16	01.02.18	
2	Rocktotpal Baruah (Technical and fund utilization Part)	JRF	M.Sc.	90%	16,000.00	22.04.16	31.03.17	
3	Rocktotpal Baruah (Technical and fund utilization	JRF	M.Sc.	90%	18,000.00	01.04.17	31.07.19	

	Part)							
4	Rocktotpal Baruah (Technical and fund utilization Part)	RA	Ph. D.	90%	47,000.00 +HRA	01.08.19	29.09.20	
5	Sanghamitra Saikia (Technical Part)	JRF	M.Sc	80%	14,000.00	03.09.18	29.09.20	
(c)								
1	Arunav Phukan	Research Scholar	M.Sc	20%	--	--	--	
2	Rajon Bhuyan	JRF	M.Sc.	30%	--	01.12.19	--	

- (a) Institute Faculty and Staff
- (b) Staff recruited for the project
- (c) Students

FROM G.F.R. 19
(See Government of India's Decision 7(b) under Rule 148 (3)

GENERAL FINANCIAL RULES 2017
Ministry of Finance
Department of Expenditure

GFR 12 – A

[(See Rule 238 (1)]

FORM OF UTILIZATION CERTIFICATE FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR **2016 - 2020** in respect of
recurring/non-recurring
GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme: **Design and realization of light weight shields to reduce electromagnetic interference (EMI) at microwave ranges (C and X band) with different geometries for customized applications like anechoic chamber, as terminations and stealth for strategic device camouflaging**
2. Whether recurring or non-recurring grants.....
3. Grants position at the beginning of the Financial year
   (i) Cash in Hand/Bank: 0
   (ii) Unadjusted advances 0
   (iii) Total: 0
4. Details of grants received, expenditure incurred and closing balances: (Actuals)

Unspent Balances of Grants received years [figure as at Sl. No. 3 (iii)]	Interest Earned hereon	Interest deposited back to the Government	Grant received during the year			Total Available funds (1+2-3+4)	Expenditure incurred *	Closing Balances (5 - 6)
1	2	3	4			5	6	7
			Sanction No. (i)	Date (ii)	Amount (iii)			
0.00	4,40,741.00	4,40,741.00	1(2)/2016 - EMCD	30th March ,2016	1,29,44,000.00	2,14,32,000.00	2,14,32,000.00	0.00
				28th June, 2018	71,88,000.00			
				11th, May, 2020	13,00,000.00			

Component wise utilization of grants:

Grant-in-aid– General	Grant-in-aid– Salary	Grant-in-aid–creation of capital assets	Total
29,05,502.00	20,80,408.00	1,64,46,090.00	2,14,32,000.00

Details of grants position at the end of the year
(i) Cash in Hand/Bank: 0
(ii) * Unadjusted Advances: 0
(iii) Total: 0

Principal Investigator
DeitY Project
Title "Design and realization of light ..... device camouflaging"
DEPARTMENT OF PHYSICS
TEZPUR UNIVERSITY

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.: 305054

GENERAL FINANCIAL RULES 2017

Ministry of Finance
Department of Expenditure

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under..... (name of the scheme has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure – I duly enclosed.

(viii) The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date:

Place:

Signature 27.1.21

Name.....

Chief Finance Officer Finance Officer
(Head of the Finance) Tezpur University

Signature 27/1/21

Name.....

Head of the Organisation Registrar
Tezpur University

(Strike out inapplicable terms)

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 305054

GENERAL FINANCIAL RULES 2017
Ministry of Finance
Department of Expenditure

GFR 12 – B

[See Rule 256 (2)]

FORM OF UTILIZATION CERTIFICATE

(1) Certified that out of the Loan of **Rs. 2,14,32,000.00 (Two Crore Fourteen Lakhs and Thirty Two Thousand Only)** SANCTIONED under **1(2)/2016 - EMCD**, dated **30th March 2016, 28th June 2018 and 11th May 2020** in favour of **Tezpur University** during the year **2016-2020** an amount of **Rs. 2,14,32,000.00 00 (Two Crore Fourteen Lakhs and Thirty Two Thousand Only)** has been utilized for the purpose for which it was sanctioned, and that the balance of **Rs. 0.00 (zero)** remaining unutilized at the end of the year **2020**.

(2) Certified that I have satisfied myself that the conditions on which the loan was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually spent for the purpose for which the loan was made.

Kinds of checks exercised

1. Stock checking for procured equipment and other expenditure
2. Physically verified equipment installed
3. All the vouchers related to expenditure in the project checked and deposited

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS

CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 305054

Signature.....
Designation ..... Registrar, Tezpur University
Date .....