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### Review of Additive Manufacturing 3D Printed Microwave Components for Rapid Prototyping

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**Abstract:** With current development in 3D printing technology the additive manufacturing techniques are getting popular as it results in rapid prototype development by achieving low cost. Many complex designs that would be unmanufacturable or costly are realizable on a 3D printing machine. The ability to create 3D designs of virtually any configuration makes it possible to build RF structures that can form fit to any space. This paper describes review of waveguide structure fabrication in RF and microwave frequency ranges using 3D printing technology with the help of additive manufacturing methods.

**Keywords:** Additive, Manufacturing, Microwave, Printing, Waveguide, 3D.

#### 1. INTRODUCTION

3D printing has achieved significant consideration for developing prototypes with a low cost solution. The ability to print high resolution 3-dimensional geometries using a range of materials makes it ideal for the fabrication of complex microwave passive components, especially antenna elements. This is attractive as there is a significant demand for compact wireless systems which in turn require components that fit in small lattice space.[1] The ability to print high resolution 3D using a range of materials makes it ideal for the fabrication of complex microwave passive components, especially antenna elements. This is attractive as there is a heavy demand for compact wireless systems which in turn require components that fit in small lattice space.[1][5] The advancement in 3D printing which is also called as additive manufacturing technology, the manufacturing of custom-built 3D designs becomes possible at local level along with diminished fabrication cost. Since the lattice space size of 3D structure varies from small to medium sized structure applicable to various markets. One such design is a rectangular waveguide for satellite communication as the quantity required for same is limited.[4].

#### 2. 3D PRINTED MICROWAVE WAVEGUIDE

As compared to planar transmission lines the waveguides provide the outstanding performance at microwave frequency. Standard process to fabricate waveguide involves micro-matching processes such as milling, drilling,

lathing, shaping, brazing. There has been more research done on 3-D Printed Metal-Pipe Rectangular Waveguides (MPRWG) for different microwave frequency bands X band (8-12 GHz), W band (75-110 GHz). 3D printing offers lightweight rapid prototyping with similar performance compared to micromachining techniques. As per Mario D Auria, author of [1] 3-D Printed Metal-Pipe Rectangular Waveguides in case of commercially available MPRWG the metal pipes are reshaped through rectangular dies or with the help of CNC milling. The split block WR-10 aluminium line waveguide (75-110 GHz) series manufactured using CNC has same level of attenuation compared to 3D printed structure. [2] [4]



Figure 1: 3D printed and copper plated WR-10 side view and end view

### 3. ADDITIVE MANUFACTURED MICROWAVE ANTENNAS

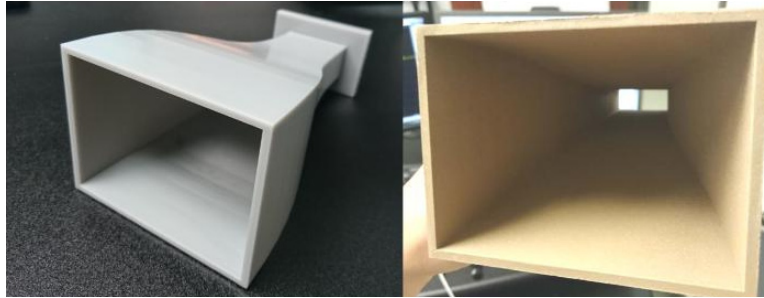
The research by M.M.Ghazali [2] focused on multi band and narrow band 3D patch antennas which are lightweight and low profile design. This antenna which operates at 5.45 GHz has a structure consisting of a dielectric substrate called as “Vero White” is sandwiched between a metalized ground plane at the bottom and a metalized radiating patch at the top. The complete patch is fabricated in 3D printed structure and Cu metallization on one side. Figure 2 shows 3D patch antenna.



Figure 2: 3D printed patch antenna

The advanced version where complex shapes need to fabricate over the same antenna which discussed above. Thus logo of the manufacturer can be printed over the antenna using 3D printing. The author [2] also discusses the Spartan logo of Michigan state university 3D printed over the patch antenna which is metallized after printing. In case of multiband antennas where multiple current paths are required can be achieved through a notch structure which is readily printed in 3D printing. [1][6]

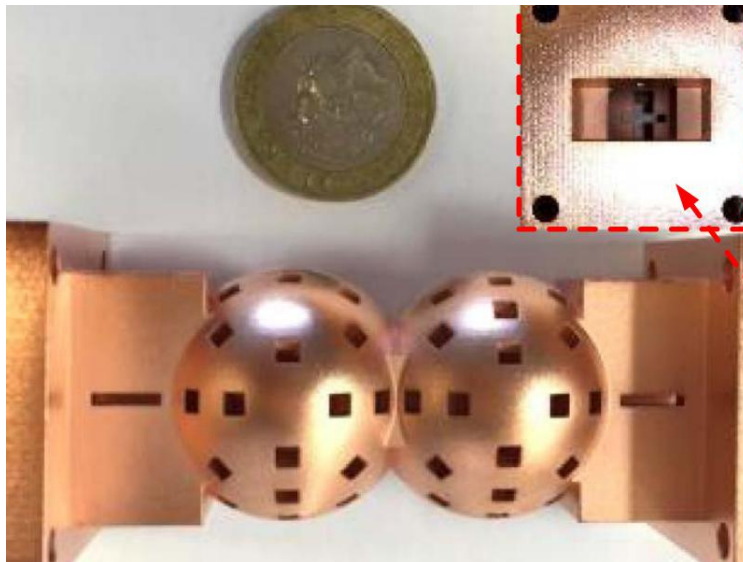
The horn antenna is an antenna that consists of an aring metal waveguide shaped like a horn to direct radio waves into a beam. The copper mountain technology [4] has designed 3D printed horn antenna resonant at 5.97 GHz. Figure 3 shows 3D printed horn antenna with a rapid prototyping. For calibration and testing the waveguide adapter used was WR-137 (5.85 GHz to 8.2 GHz). The antenna gives reflection coefficient less -16 dB. [6]



**Figure 3: 3D printed Horn antenna**

#### **4. MICROWAVE BANDPASS FILTER**

Cheng Guo, author[3] have designed 3D printed fourth order X-band bandpass filter with a centre frequency of 10 GHz. The design consideration of band pass filter two high-Q spherical dual-mode cavity resonators, and was fabricated using a stereo lithography-based 3-D printing technique. As shown in figure 4 the fabricated X-band band pass filter after copper plating, the inset shows the cross-iris and a rectangular waveguide angle. The filter was printed using an SLA printer with a 10- $\mu$ m thick copper layer [2][3]. This thickness increment was taken into consideration during design but compensated prior to plating by lengthening inner air space of the cavity. Thus this additive manufacturing technique resulted in low weight X bandpass filter. [3] [5]



**Figure 4: Fabricated X-band dual-mode BPF post copper plating**

#### **5. CONCLUSION**

The additive manufacturing technique in microwave components has evolved the rapid prototyping techniques which help the low cost design and fabrication that otherwise is complex process using traditional methods. The microwave waveguides operating in X band and W band frequency region become commercially available with help of 3D printing methods at affordable price. Also 3D printing has developed low profile microwave antennas that has unique pattern to sandwich the metalized part and radiating patch along with a printed logo. The horn antenna which is flaring metal waveguide when fabricated using additive manufacturing methods offers similar radiation pattern and gain compared to the designed with traditional ones.

The microwave filter operating in X band had been fabricated using stereo lithography based 3-D printing technique which results in low weight prototype.

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