A Non-Thermal Soldering Technique to Improve Polymer Based Antenna Performance

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***Abstract*— A non-thermal soldering technique using cold solder or electrically conductive epoxy for connecting SMA connectors to polymer based antennas is proposed in this paper. The proposed technique prevents damage to the polymer due to the solder iron heat and also the loss of efficiency through the use of indirect connections of the coaxial feed via copper pads glued to the antenna. The direct connection of the feed points via SMA connectors on to a transparent antenna designed on AgHT-8 material has been demonstrated. The method can also be applied to solder the coaxial feed points directly to the antenna instead of using copper pads which will introduce additional reflection losses. The technique involves the use of colder soldering instead of hot soldering so as to not damage the polymer based antenna as well as improve the efficiency of the antenna.**

***Index Terms*— Polymer, UWB, Soldering Technique, Transparent Antenna.**

I. Introduction

One of the most serious problems encountered in establishing a strong connection of the coaxial connectors to provide a good electromagnetic feed to flexible polymer based antennas is excessive thermal excursion with the use of lead bearing solders. The excessive heat tends to damage the polymer surface or conductive surface of the antenna leading to a poor connection. When a source of electromagnetic energy varying at a selected frequency or a broad range of frequencies in the case of a broadband is applied to propagate down a coaxial cable, a varying potential difference at that frequency or range of frequencies is established across the antenna feed points. Current varying at these frequencies then flow through the coaxial cable conductors to and fro from the surface of the transparent thin-film conducting material. As a result, electromagnetic waves propagate away from the feed points into the antenna and transmitted. Poor connection of the coaxial cable to the antenna feed points resulting from poor soldering or indirect feed via copper pads [1] glued to the feed points could result in loss of maximum power transfer of these electromagnetic energy besides the usual power transfer loss through poor impedance matching. Alternative methods were to use solder free interconnects [2] but these need special plunger type mechanisms and as such does not give the antenna any degree of freedom.

This paper presents a non-thermal soldering technique to overcome this problem thus eliminating damage to the polymer material of the antenna at the connectors whilst improving the efficiency of the antenna. The use of conductive epoxy to cold solder the connectors to the antenna feed line provides a direct connection in a similar way as thermal soldering the connectors to a feed line on an FR4 antenna. This concept of cold soldering has long been used in the automotive industry and in the last two decades in the surface mount technology to solder heat sensitive electronic components which can be easily damaged through thermal excursions. Finally, a transparent polymer UWB antenna design is presented in this paper to demonstrate the effectiveness of the proposed cold soldering technique.

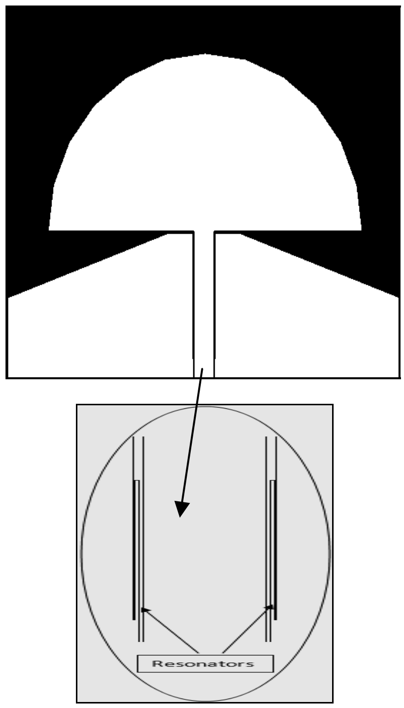


Fig. 1 The AgHT-8 UWB antenna with resonators

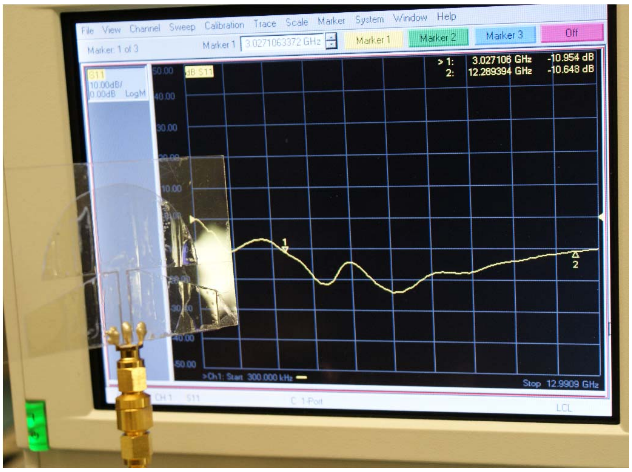


Fig. 2 A cold soldered optically transparent AgHT-8 UWB antenna being measured for return loss on an Agilent Network Analyzer

II. ANTENNA DESIGN

The UWB antenna is designed and fabricated using AgHT-8 for both the monopole and the 50 Ω coplanar waveguide (CPW) feed. The AgHT-8 film is 0.175mm thick and has a surface resistance of 8 Ω-Sq. The AgHT-8 film coating is made up of a transparent silver layer sandwiched between two layers of tin oxide. The antenna is mounted on a 0.175mm thick PET substrate with a relative permittivity of 3.2. The antenna is designed and optimized as a semi-circular disc (mushroom shaped) for size reduction and fed by a 50 Ω CPW. as shown in Fig. 1. The total dimensions of the antenna including the PET substrate are 40 x 60 x 0.350 mm which makes it only 32% of the size of the antenna demonstrated by [3] which has total dimensions of 80 x105 mm for the width and height of the antenna itself. The AgHT-8 antenna is demonstrated to be more compact and totally optically transparent as the CPW feed line is also of AgHT-8 as shown in Fig. 2.

The ground planes are bevelled [4] and have resonators on both walls of the ground planes along the strip gap [5] to improve impedance matching and tune the lower and upper limits of the bandwidth. The coaxial cable is then connected to the feed points by cold soldering a SMA connector using an electrically conductive epoxy. A comparative antenna is similarly designed but is fed via copper pads at the feed points as in [1].

III. EXPERIMENTAL RESULTS

The performance of the proposed approach was verified by fabricating the monopole UWB CPW-fed antenna and measuring the return loss, gain and radiation pattern. The simulated return losses using CST Microwave Studio are as shown in Fig. 3. The measured results for the same are as shown in Fig. 4. The return loss for the antenna without copper pads or cold soldered antenna shows better performance than that with copper pads. The frequency shift between the simulated and measured return losses is attributed to the fabrication accuracy.

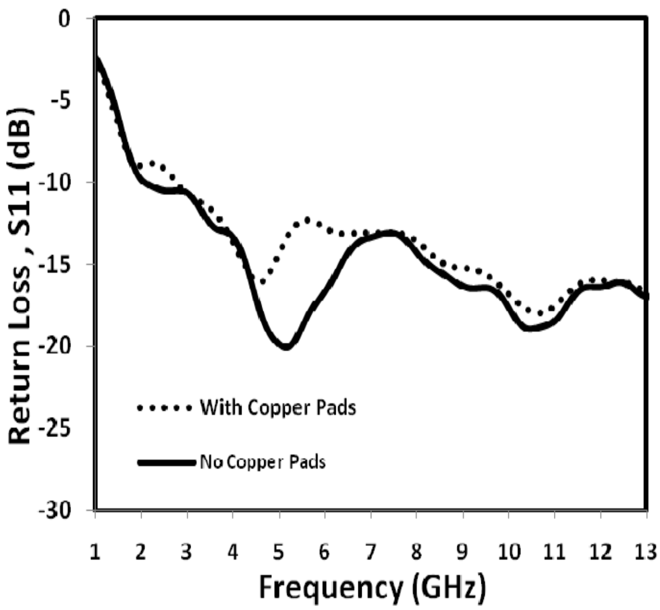


Fig. 3 Simulated return loss, S11 of the transparent antennas with no copper pads and with copper pads.

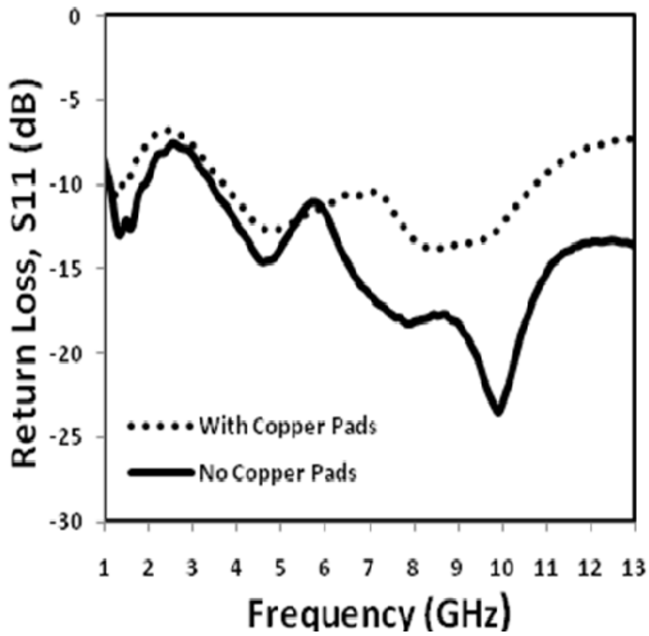


Fig. 4 Measured return loss, S11 of the transparent antennas with no copper pads and with copper pads.

The antenna efficiency and radiation patterns were obtained using SATIMO's StarLab antenna measuring equipment at the University of Hong Kong. The simulated and measured efficiency for the two connection methods are reflected in Fig. 5 & Fig. 6 respectively.

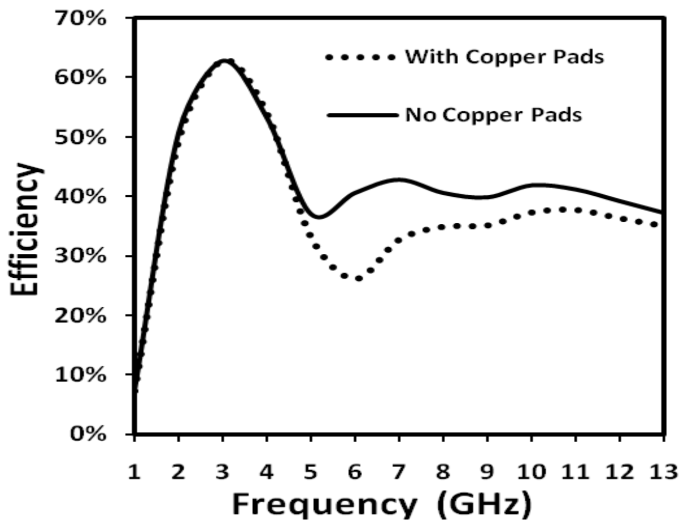


Fig. 5 Simulated efficiency of the two antennas

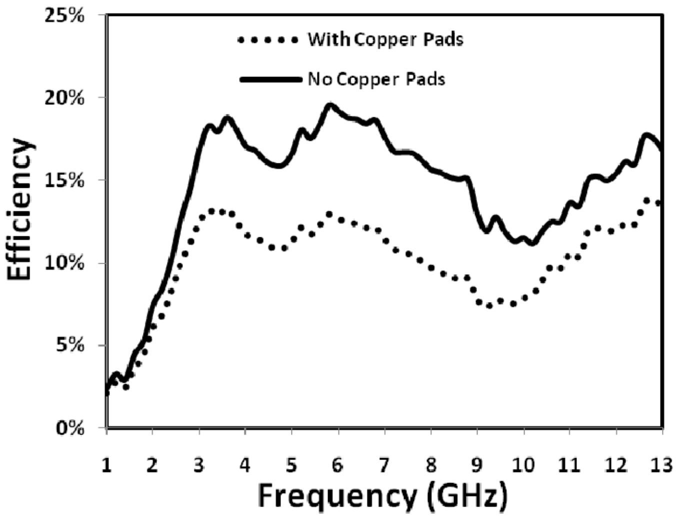
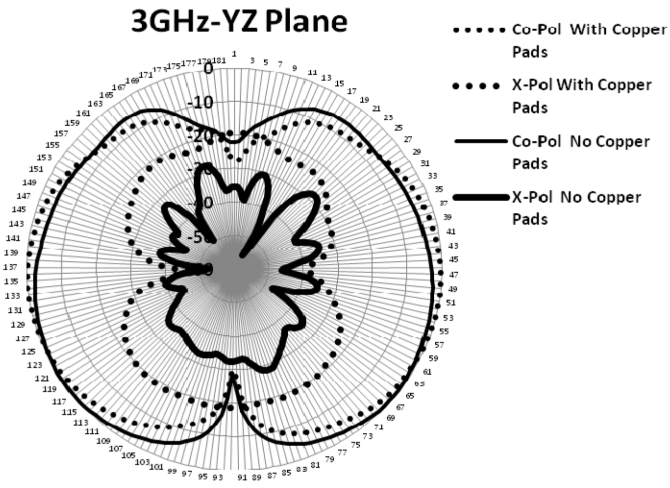
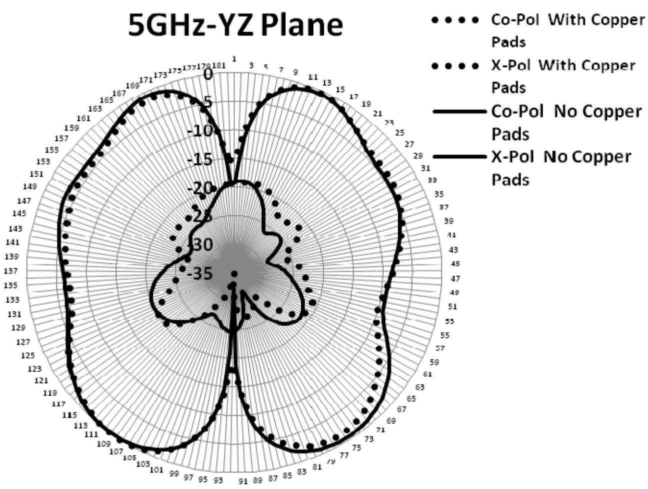


Fig. 6 Measured efficiency of the two antennas using StarLab.

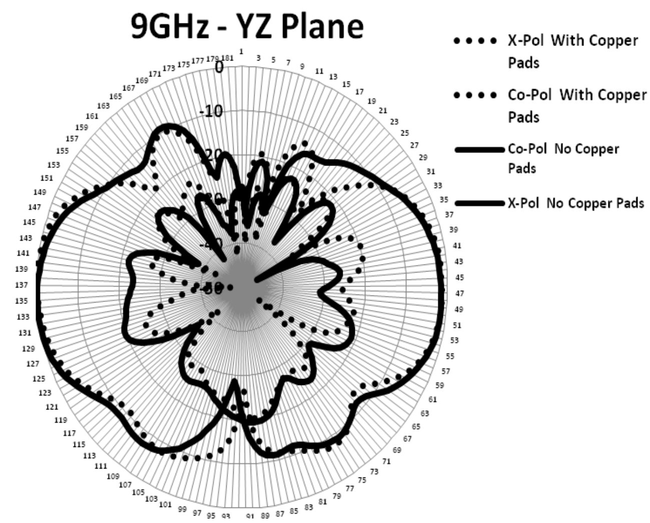
The measured radiation patterns for both the antennas in the Y-Z (vertical) and XY (horizontal) planes at 3 GHz , 5Hz and 9GHz are as shown below in Fig. 7 (a) – (c) and Fig. 8 (a) – (c) respectively. The antennas demonstrate a near omni-directional radiation pattern.



(a)

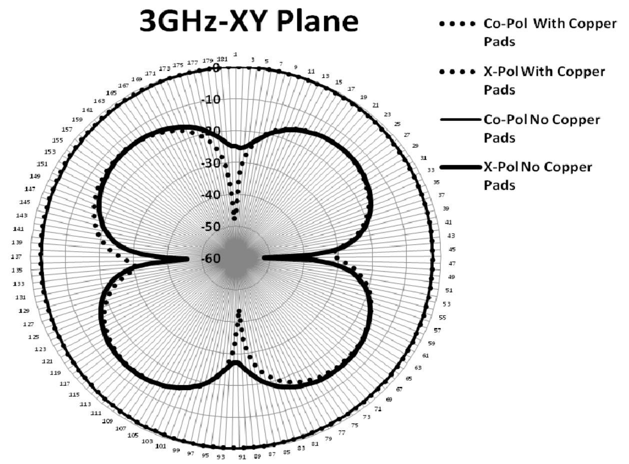


(b)

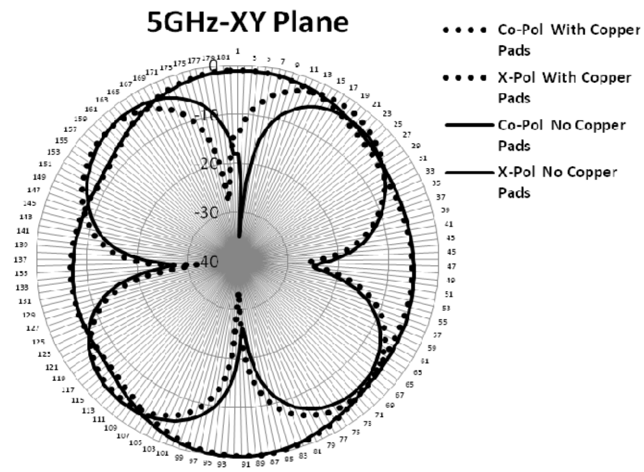


(c)

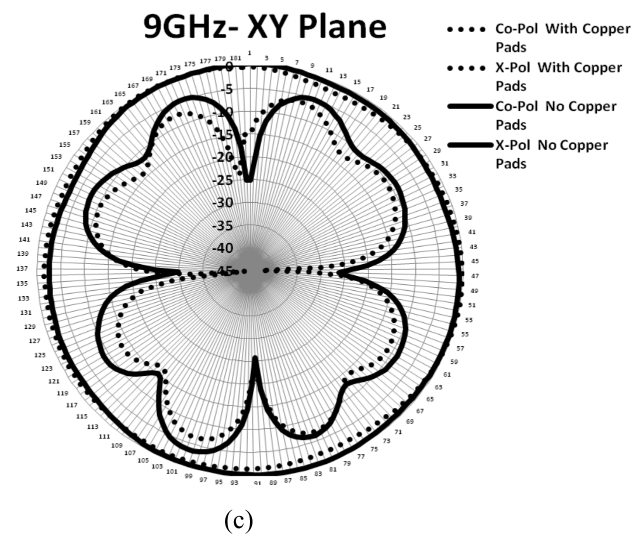
Fig. 7 Measured radiation patterns in the Y-Z (vertical plane)



(a)



(b)



(c)

Fig. 8 Measured radiation patterns in the X-Y (horizontal plane)

IV. Conclusions

A non-thermal soldering technique was proposed to improve the efficiency of polymer based antennas made of transparent conductive materials by applying conductive epoxy to solder the SMA connectors to the CPW feed instead of indirectly connecting them through copper pads to avoid thermal excursion. The effectiveness of the proposed technique was shown through S-parameter simulations and measurements of a monopole AgHT-8 UWB antenna with the feed connected using cold solder and a comparative antenna using copper pads. The measured return loss and efficiency for the cold soldered antenna shows better results over that of the copper pad antenna as demonstrated in Fig. 4 and Fig 6 respectively.

The proposed technique can be widely employed in the design and fabrication of other types of conductive polymer antennas which are sensitive to thermal excursion.

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