A Gold Thin Film Based Compound Electrode Array Suitable for Electrical Impedance Tomography (EIT)

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Abstract:

Electrical Impedance Tomography (EIT) [1-2] has been researched extensively in medical diagnosis [3] as well as in other fields of science and technology. In medical EIT, electrode contact impedance [1], produced by the skin-electrode interface [1], plays a significant role in the boundary data accuracy which has a great impact on the reconstructed image quality. In EIT, the current is injected and surface potentials are measured on all the electrodes except the current injecting electrodes for contact impedance problem [4]. But for obtaining the greatest sensitivity to the resistivity changes in the domain, measurements on current electrodes are also done [5] though the contact impedance problem produces some error in the EIT systems. A compound electrode [6] array allows us to conduct the current injection and voltage measurement independently by providing two separate sets of electrode geometries (one for current injection and other for voltage measurement). In this paper, a gold thin film based compound electrode array is designed and developed for electrical impedance tomography. As the gold electrodes are found suitable for improved image reconstruction in EIT [7], a flexible compound electrode array (Fig.-1) is developed with gold thin film to eliminate the contact impedance problem in EIT. The thin film based flexible compound electrode is developed by depositing a gold thin film (2 μm) on a flexible FR4 [8] sheet (acting as the substrate) using electro-deposition process [9]. The compound electrode array is found suitable for electrical impedance tomography measurement without contact impedance problem. The compound electrode array (Fig.-2) is put inside a shallow polypropylene tank and the NaCl phantoms [10-12] are developed with nylon cylinders as the inhomogeneities. 1 mA 50 kHz constant sinusoidal current is injected to the phantom boundary using a constant current injector [13]. Boundary potentials are processed with the signal conditioners blocks and then acquired by a USB based high speed data acquisition system controlled by LabVIEW based user interface system. Boundary data are collected with compound electrode array and the results are compared with the data collected for a non compound electrode system. Data are also collected for the phantoms with different inhomogeneity positions and the potential profiles are studied to analyze the contact impedance effects on the boundary data. Resistivity images are reconstructed in Electrical Impedance Tomography and Diffuse Optical Tomography Reconstruction Software (EIDORS). The images obtained for different phantom configurations are studied with compound electrode array and the results are compared with the noncompound electrode array of identical dimensions. It is observed that the design and development of thin film compound electrode array are simple, flexible, biocompatible and low expensive. It is observed that the electronic connections between the wires and electrode connection pads are very easy to make with low contact impedance [7] by soldering of the wires with the gold connecting pads in the electrode array. The

electronic connections of the compound electrode array also reduced the contact impedance problem compared to the other systems especially using stainless steel electrodes [7]. Results also show that the compound electrode array is suitable for boundary data collection and impedance reconstruction avoiding contact impedance problem. As the electrode array is developed on a flexible substrate it would be suitably used for irregular domain geometry in medical imaging. Hence it is concluded that the proposed gold thin film based flexible compound electrode array can be suitably used for improved impedance reconstruction in medical EIT.

Keywords: Electrical Impedance Tomography (EIT), compound electrodes array, flexible electrode array, gold thin film, electrodeposition, resistivity imaging, EIDORS.

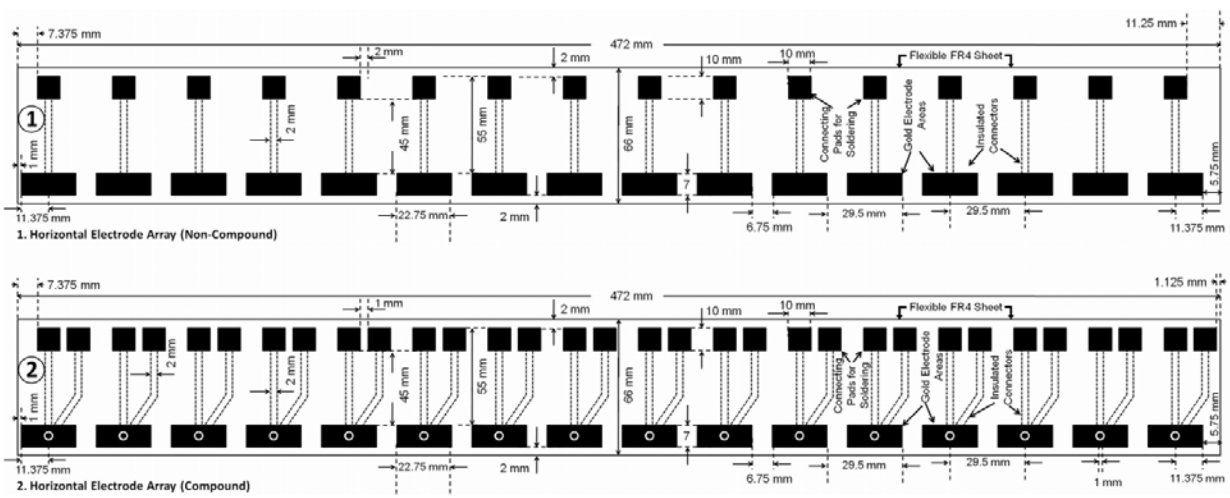

Figure 1: Schematic Design of the gold thinfilm based flexible electrode array (a) Noncompound electrode array, (b) compound electrode array.

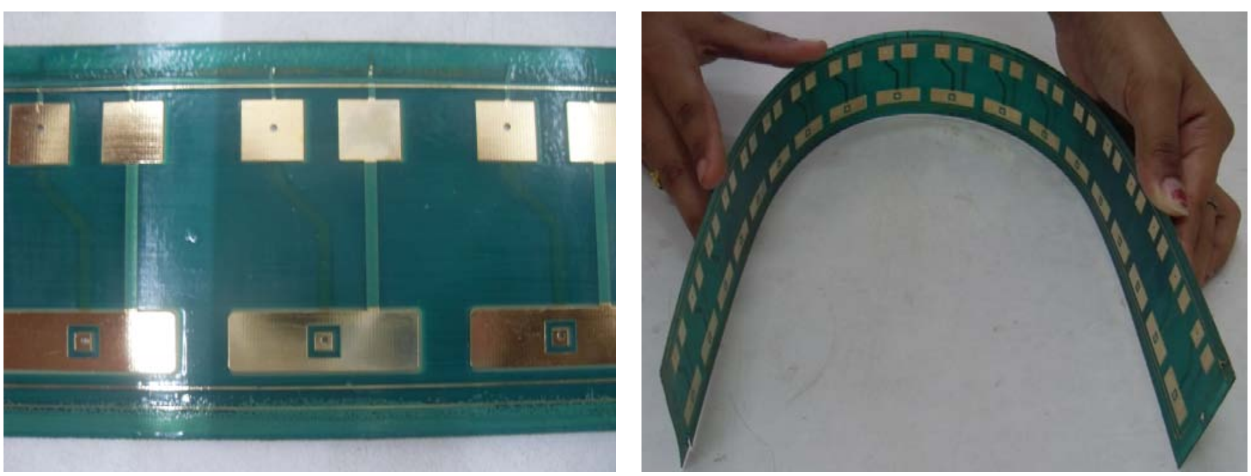

Figure 2: Figure 1: The current electrode (outer larger rectangle) and the voltage electrode (inner smaller square) in the gold thinfilm based flexible electrode array, (b) the fabricated gold thinfilm based flexible electrode array containing eighteen electrodes (two electrodes are made extra for testing and evaluation purpose).

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