Impact of Different Inorganic and Organic Biocompatible Substrates on the Performance of In-Body Implantable Antennas for Biomedical Telemetry: A Comparative Study

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A strong link between Medical Science and Communication engineering in terms of Wireless Implanted Medical Devices (WIMDs) has become focal point of Body-centric wireless communications systems (BWCS). A biocompatible micro implant system to be used for biomedical telemetry is shown in Fig.1, comprising an encapsulated WIMD, a Wireless Power Transfer system, a high frequency rectifier attached to the encapsulated implant antenna and its associated bio electronics circuitry. The entire system can be used for obtaining both real time and stored physiological data in biomedical telemetry for the ISM (2.4-2.5 GHz) band, thereby monitoring the health conditions in deep tissue environment. The challenges to be faced in the WIMD design include miniaturization, biocompatibility, and variation of dielectric properties of tissues, Specific Absorption Rate (SAR) and maximum permissible Effective Isotropic Radiated Power (EIRP) for safety concerns.

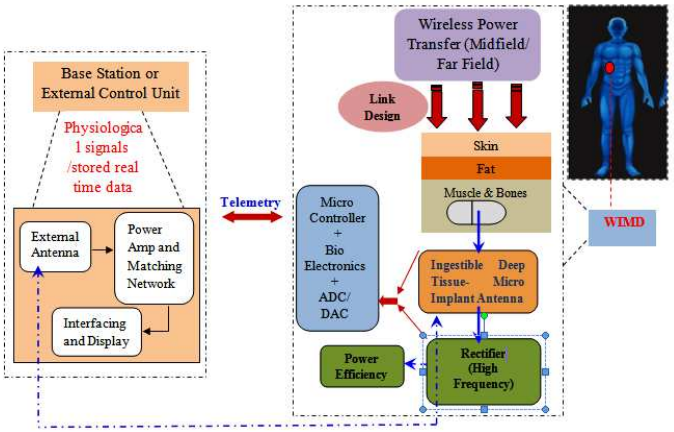

Fig.1. An encapsulated micro implant antenna with its associated circuitry and its work setup for Biomedical Telemetry

In this work, the authors propose to present a detailed overview of the effect of different commercially available inorganic and organic substrates which can be used for in-body wireless medical devices (WIMDs). Keeping in pace with the ushering in of state of the art on chip integrated WIMDs, substrate selection plays an important role since implant antennas are generally immersed in a highly lossy tissue environment. So using substrates with low permittivity can cause tissue erosion while substrates with very high permittivity can lead to design complexity of the WIMDs. Although to prevent tissue erosion having a superstrate with high permittivity seems to be a good choice that again can make the WIMD bulky. Therefore, it is to be investigated what happens in an in-body scenario if a wide range of the biocompatible inorganic/ organic polymer and ceramic substrates having high permittivity varying widely from as low as ε_r =2.7 (PDMS) to Alumina Al_2O_3 (ε_r ~9.6) and BST (Barium Strontium Titanate) with epoxy resin having ε_r = 36, almost close to/comparable with that of human tissue (ε_r > 30) are used.

Figures of merit such as Radiation efficiency of implantable antennas which degrade due to reflection losses of in-body tissue environment, detuning issues due to high lossy environment and SAR need to be investigated for different substrates. Also, one needs to explore the Power transfer efficiency (PTE) of WIMD device, Path Loss estimation for heterogeneous body tissue along with the Link Budget calculation for biomedical telemetry.

References

[1] S.G. Kirtania *et.al*," Flexible Antennas: A Review", *Micromachines, MDPI*, 847, November 2020, pp.1-43.

[2] A.J.T. Teo, A. Mishra, I. Park, Y. Kim, W. Park, and Y-Jin Yoon, "Polymeric Biomaterials for Medical Implants and Devices" *ACS Biomater. Sci. Eng.* 2, 2016, pp.454−472. doi: http://dx.doi.org/10.1021/acsbiomaterials.5b00429.