Biodegradable Materials for Short Term Wireless Implants

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The development of efficient and low cost biodegradable devices represent a major challenge for researchers in terms of not only characterization and manufacturing of suitable materials, but also the design of corresponding passive and active electronics. A wide range of applications can be targeted from healthcare to environmental sensing and recyclable electronics. In the case of medical scenarios, surgeons use a broad range of biocompatible materials, which range from natural and synthetic polymers (e.g., silicon for breasts and prosthetic facial characteristics) to metallic and ceramic materials (e.g., titanium for orthopaedic prosthesis and phosphate tricalcium for bone defect reconstruction, respectively). Medical implants using bio-absorbable materials are designed to overcome the disadvantages of permanent metal or synthetic polymer-based devices that produce corrosion, tissue infection and imaging and radiotherapy interference (H.J. Agins, N.W. Alcock, et al., JBJS, 70, 47-56, 1988). The results of recent studies showed the clinical treatment of ankle fractures and osteotomies using bio-absorbable synthetic polylactide (PLA) polymeric devices (P.U. Rokkanen, O. Bostman, et al., Biomaterials, 21, 2607-2613, 2000). Although bio-absorbable fixation devices have been in clinical use for 15 years, the presence of biodegradable wireless implants are still nonexistent.

Some bio-resolvable RF circuits were designed using magnesium oxide (MgO) or silicon dioxide (SiO2) for the interlayer dielectrics and magnesium for the conductive parts; in some cases, magnesium conductors with 99.9% purity and a mixture of alloys made of Zink (Zn), Magnesium (Mg) and iron (Fe) were applied (S. Hwang , X. Huang, et al., Advanced Materials, 25.26, 3526-3531, 2013). The empirical results showed the response of wideband quasi-log-periodic dipole antennas (8x4 cm) for 2.4 GHz and 950 MHz. It is evident that those antenna designs and dimensions are impractical for implantable scenarios. On the other hand, the electromagnetic properties (i.e., μ_r, ε_r) and the behavior of such materials within tissue mimicking phantoms and animal testing remain unexplored.

In this work, we will explore applications of biodegradable materials in the design of implantable antennas for radio frequency (RF) operation. In order to reduce the size of the antenna and achieve compact designs, various biocompatible substrate and superstrate dielectric materials are required (A. Sani, et al., Proceedings of the IEEE 98, 9, 1648-1655, 2010). We have created biodegradable PLA laminates of 1.92 mm thickness using Collin single screw extruder. The dielectric properties over a broad frequency range were measured using the PNA-L Network Analyser (N5230C) from Agilent technologies together with the 85070E Dielectric Probe kit. The mean values for the isotropic PLA material at 2.45 GHz are ε'=2.70 with standard deviation of 0.18 and ε''=0.07 with standard deviation of 0.02. The material was employed as a substrate base for a microstrip patch antenna with resonance frequency at 2.45 GHz. The empirical results of the degradation process of both material and radio communication will be presented at the conference.