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A Flexible Piezoelectric - Polymer Composite for Non-Invasive Detection of Multiple Vital Signs of Human

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Abstract : Vital sign monitoring is crucial for both everyday health and medical diagnosis. A significant factor in assessing a human's health is their vital signs, which include heart rate, breathing rate, blood pressure, and electrocardiogram (ECG) readings. Vital sign monitoring has been the focus of many system and method innovations recently. Piezoelectrics are materials that convert mechanical energy into electrical energy and can be used for vital sign monitoring. Piezoelectric energy harvesters that are stretchable and flexible can detect very low frequencies like airflow, heartbeat, etc. Current advancements in piezoelectric materials and flexible sensors have made it possible to create wearable and implantable medical devices that can continuously monitor physiological signals in humans. But because of their non-biocompatible nature, they also produce a large amount of e-waste and require another surgery to remove the implant. This paper presents a biocompatible and flexible piezoelectric composite material for wearable and implantable devices that offers a high-performance platform for seamless and continuous monitoring of human physiological signals and tactile stimuli. It also addresses the issue of e-waste and secondary surgery. A Lead-free piezoelectric, SrBi4Ti4O15, is found to be suitable for this application because the properties can be tailored by suitable substitutions and also by varying the synthesis temperature protocols. In the present work, SrBi4Ti4O15 modified by rare-earth has been synthesized and studied. Coupling factors are calculated from resonant (fr) and anti-resonant frequencies (fa). It is observed that Samarium substitution in SBT has increased the Curie temperature, dielectric and piezoelectric properties. From impedance spectroscopy studies, relaxation, and non-Debye type behaviour are observed. The composite of bioresorbable poly(l-lactide) and Lead-free rare earth modified Bismuth Layered Ferroelectrics leads to a flexible piezoelectric device for non-invasive measurement of vital signs, such as heart rate, breathing rate, blood pressure, and electrocardiogram (ECG) readings and also artery pulse signals in near-surface arteries. These composites are suitable to detect slight movement of the muscles and joints. This Lead-free rare earth modified Bismuth Layered Ferroelectrics – polymer composite is synthesized using a ball mill and the solid-state double sintering method. XRD studies indicated the two phases in the composite. SEM studies revealed the grain size to be uniform and in the range of 100 nm. The electromechanical coupling factor is improved. The elastic constants are calculated and the mechanical flexibility is found to be improved as compared to the single-phase rare earth modified Bismuth Latered piezoelectric. The results indicate that this composite is suitable for the non-invasive detection of multiple vital signs of humans.

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