A Short Review of Mechanics for Skin Modulus Measurement via Conformal Piezoelectric Systems

Precise measurements of the elastic modulus of the human skin under various conditions can facilitate the assessment of a variety of pathophysiologic conditions, may predict reactions to exogenous substances and environmental factors, can help in gauging the effectiveness of cosmetic products and further establish mechanisms associated with growth, repair and ageing. The piezoelectric systems consisting of conformal modulus sensors (CMS)[1] achieve conformal contact with the underlying complex topography and texture of the targeted skin, as well as other organ surfaces, under both quasi-static and dynamic conditions. Studies on human subjects establish the clinical significance of these devices for rapid and non-invasive characterization of skin mechanical properties.

Young's modulus, a key parameter for human skin is of great interests to dermatology, cutaneous pathology, and cosmetic industry. Currently, the Young's modulus of human skin has been obtained from the linear elastic part of the stress-strain curve[2]. The stress-strain curve is measured by one of the following three techniques, 1) twist of the skin[2]; 2) indentation[3], and 3) method of suction[4]. These tests, however, all involve relatively complex set up in the laboratory, which prevent simple and portable applications outside the lab. In addition, such tests involve relatively large deformation of the skin, and therefore are difficult to repeat quickly because it takes hours for the skin distortion to disappear upon unloading[2].

Dagdeviren and Shi et al.[1] developed a wearable, ultrathin, and stretchable modulus measurement device that is much more robust than the existing techniques. The device consists of a series of micro flexible PZT (lead zirconate titanate) actuators and

sensors laminated on a thin elastomeric matrix. It provides a non-invasive approach to measure the Young's modulus of human skin at any location, normal conditions and upon administration of pharmacological and moisturizing agents, and in a way that is mechanically invisible to the subject. As shown in the analytic model in Shi et al.'s work[5], the Young's modulus of human skin is linearly proportional to the sensor's output voltage (for each given actuating voltage). Therefore, the measured output voltage, together with the analytic model, gives the Young's modulus of human skin.

A brief review will be given in this paper to reveal the mechanism of the conformal skin modulus measurement systems and the expectable applications from this kind of soft piezoelectric composite actuator/sensors.

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