医学と生物学 (Medicine and Biology)
[原著論文]
Vol. 158 (1): i1_oe01

An Apparatus to Measure Surface Electric Potential of Electrets

Tetsuo HIYAMA[1,2,3]

[1]Saitama University
[2]Tokyo Medical and Dental University
[3]Supporting Association for Biotechnology Standardization (SABS)

Summary

A simple and low-cost apparatus to nondestructively measure the surface electric potential of electrets was built and tested. The apparatus consisted of a vibrating electrode connected to an oscilloscope and a fixed electrode on which a sample ceramic pellet was placed. The fixed electrode was connected to a variable voltage supply. Measurement is achieved by adjusting the bias voltage so that output sinusoidal AC wave observed on the oscilloscope becomes null.

Keywords: surface potential, Kelvin probe, hydroxyapatite, electrets, ceramics

Introduction

Kelvin probe, so named after famous English physicist Lord Kelvin who first proposed this method back in 19th century, is for measuring surface charge, mostly electrostatic, and has undergone tremendous improvement during the past century(1). Numerous devices have been reported and some of them have been commercially available, although quite expensive. The method itself is basically rather simple and quick to operate, and best of all, *non-destructive*.

The principle of Kelvin probe is based on the theory of electric capacitance represented by a simple equation, $C = \varepsilon A/d$, where C is capacitance; ε, dielectric constant; A, the area of the electrode; d, distance between the electrodes. As the vibrating electrode vibrates against the surface of the sample placed on a fixed electrode, C changes accordingly, ε and A being constants. Following another classic equation, $Q = CV$, the changes in C are reflected as changes in electric current flowing through a load resistor connected between the two electrodes. With the electrode vibrating at frequency, *f*, the final equation to represent electric current I is as follows:
$I = -V_0 \varepsilon A(d_w \cdot 2\pi f \cdot \cos 2\pi f t)/(d_0 + d_w \cdot \sin 2\pi f t)^2$,
where d_0 is distance; d_w, vibration width; *f*, frequency; A, area; I, current; V_0, surface voltage.

Corresponding Author:
E-mail: thiyama@athena.ocn.ne.jp
[3] Nakashuku 44-2, Itabashu-ku, Tokyo 173-0005, Japan

Received: Mar. 26, 2018
Accepted: Aug. 30, 2018

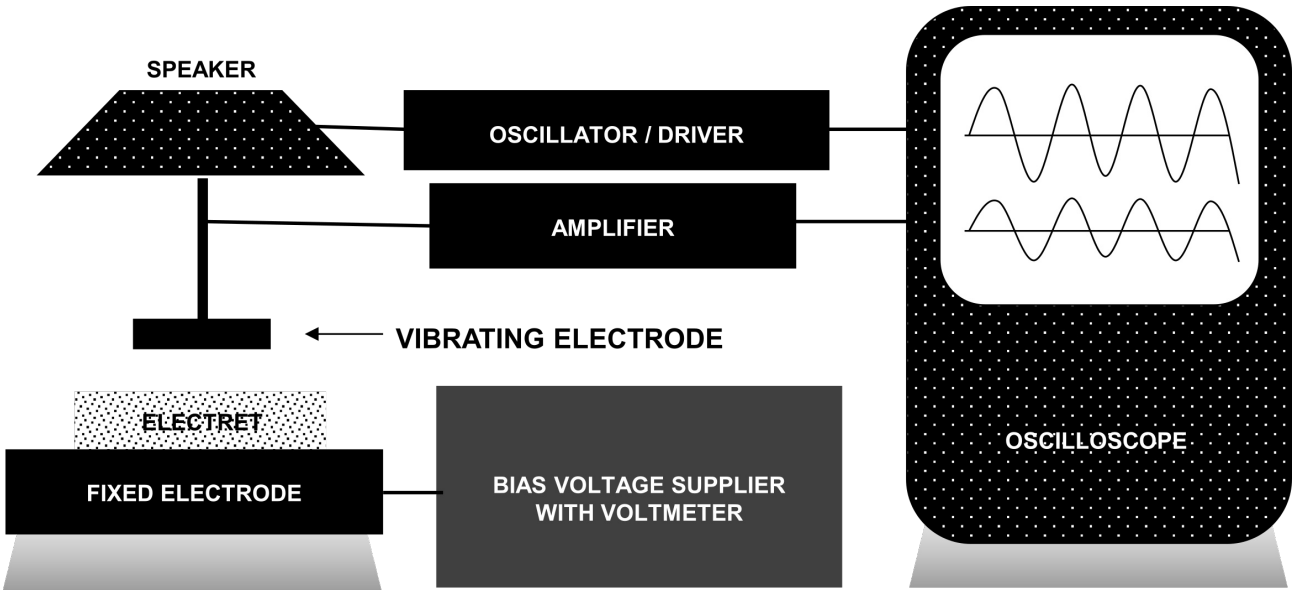

Fig 1. Outline of a surface potential measuring set-up.

Results and Discussion

Several different types of electrodes and amplifier circuits have been constructed and tested. The latest version consists of a vibrating electrode driven by a small audio speaker, a fixed electrode, and current-to-voltage converter circuit connected to an oscilloscope. The fixed electrode, on which a pellet of electrets is placed, is connected to a variable DC bias circuit. Measurement is achieved by adjusting the bias voltage so that output sinusoidal AC wave observed on the oscilloscope becomes null. This particular bias is supposed to be surface voltage of the test sample. The validity of the measurement has been confirmed by using button-type batteries of 1.5-volt and 3.0-volt types. Since then, the instrument has been in use routinely. Most of polarized hydroxyapatite (HA) pellets(2), calcite and HA-coated titanium alloys have been successfully measured so far. Since then, the instrument has been in use routinely(3).

References

1) Reedyk, CW, Perlman, MM: The Measurement of Surface Charge J. Electrochem. Soc. 115 49-51 (1968).
2) Yamashita, K, Oikawa, T, Umegaki, N Acceleration and deceleration of bone-like crystal growth on ceramic hydroxyapatite by electric poling: Chem. Mater., 8 2697-2700 (1996).
3) Nakamura, S., Takeda, H, Yamashita, K, Proton transport polarization and depolarization of hydroxyapatite ceramics: J.Appl. Phys. 89 5386 (2001)

エレクトレット表面電位測定装置

檜山哲夫 [1,2,3]

[1] 埼玉大学、[2] 東京医科歯科大学、[3]バイオテクノロジー標準化支援協会

要旨

エレクトレットなどの表面電位を非破壊的に測定する装置を試作して、分極したセラミックスエレクトレットの表面電位を測定した。

キーワード：表面電位、ケルビンプローブ、ヒドロキシアパタイト、エレクトレット ,セラミックス

著者連絡先：thiyama@athena.ocn.ne.jp