

# System and method for the measurement of the static dielectric permittivity

## KEYWORDS

- ❑ STATIC DIELECTRIC CONSTANT
  - ❑ ROTATIONAL RHEOMETER
  - ❑ POLARIZATION CURVE
  - ❑ HYSTERESIS LOOP, DIRECT CURRENT
  - ❑ MEASUREMENT METHOD
- ## AREA
- ❑ ELETTRICAL ELECTRONIC & ICT ENGINEERING

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## Patent Type

Patent for invention.

## Ownership

Sapienza Università di Roma 100%.

## Inventors

Giovanni De Bellis.

## Industrial & Commercial Reference

Energy storage, Capacitors, Ferroelectric Memories, substrates for electronics, Rotational Rheometers.

## Time to Market

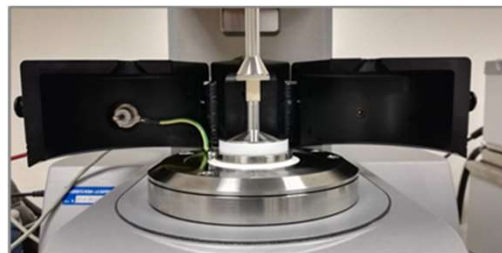
The method has been thoroughly validated through laboratory characterization. Since the method is based on commercial instrumentation, already available on the market, it is possible to estimate a Technology Readiness Level of 8 out of 9.

## Availability

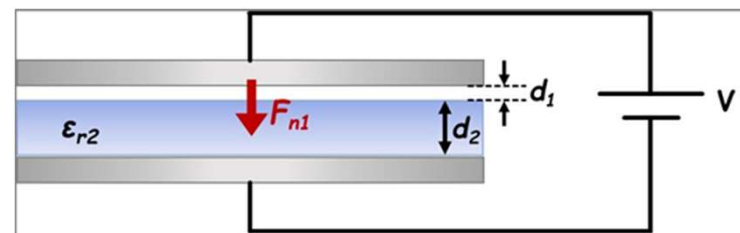
Cession, Licensing, Research, Development, Experimentation, Collaboration and Spin-Off.



**Fig. 1** Measurement setup, including, from left to right, the DC voltage supply, the rotational rheometer and the thermostat required to cool down the Peltier cell integrated underneath the lower plate.



**Fig. 2** Detail of the measuring fixture with open insulating hood. Upon closure of the hood the spring electrode on the left side contacts the upper plate, thus enabling the possibility to apply an electric field.



**Fig. 3** Schematic of the test configuration employed on solid specimens.

## Abstract

the inventive proposal deals with a novel method for the measurement of the static dielectric constant of materials, regardless of their aggregation state. The technique is based on the employment of a commercially available rotational rheometer, equipped with a DC voltage supply with current feedback control. The system also features a Peltier cell, allowing the operator to monitor the variation of the DC permittivity as a function of temperature. Furthermore, the same system can allow the estimation of the polarization curve (for a dielectric material) or hysteresis loop (for a ferroelectric material), again within the temperature range covered by the Peltier system.



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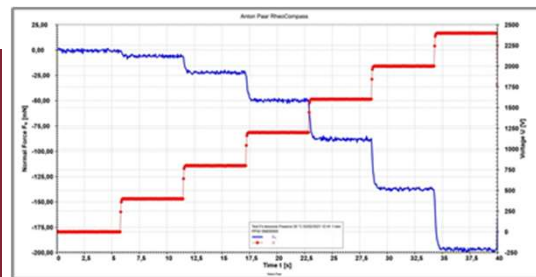
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## Technical Description

The employment of a rotational rheometer, having disc-shaped parallel electrodes, between which a DC voltage is applied and the corresponding electrostatic force acting on the upper plate is measured, with a resolution of 0.1/0.5 mN (depending on the specific model of rheometer used) allows, given the voltage and geometrical parameters of the system, to evaluate the relative DC permittivity of virtually any material placed between the electrodes. Moreover, the same system allows the evaluation of the hysteresis polarization curve of the material, particularly useful for ferroelectrics. Furthermore, the use of a Peltier cell, conveniently placed underneath the lower electrode, allows the evaluation of both the dielectric constant and polarization curve as a function of temperature.



**Fig. 4** Electrostatic force (blue curve) measured on the upper electrode as a function of the applied voltage ramp (in red), applied at 20 ° C on silicone oil, with 1 mm gap between the electrodes.

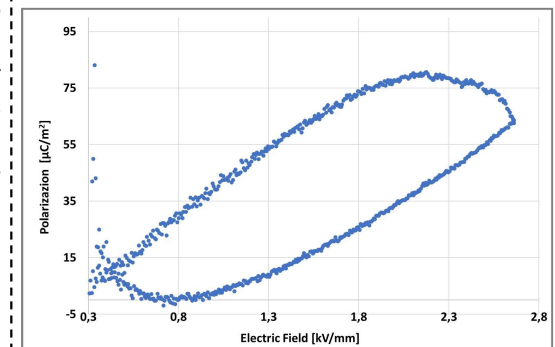
## Technologies & Advantages

The main advantages of the developed measuring method can be listed as follows:

- 1) Capability of performing extremely fast measurements (few seconds or tens of seconds, as compared to tens of minutes of traditional methods);
- 2) The exact same setup can be employed for the measurement of the DC permittivity of materials in every aggregation state (instruments currently available on the market have dedicated fixtures for each state of aggregation);
- 3) The same setup can be employed for temperature-controlled measurements;
- 4) The same setup can also be employed for the evaluation of both polarization curve (for dielectrics) or hysteresis loop (for ferroelectrics);
- 5) The ferroelectric Curie temperature can be easily detected by using the same setup, provided it falls within the range controlled by the employed Peltier cell;
- 6) The equipment can be even utilized for the measurement of the volumetric conductivity/resistivity of the sample;
- 7) The measurement technique is non-destructive, not even requiring contacting of the test specimen with electrodes.

## Applications

Possible applications of the proposed measurement method span from the field of electrical energy storage and capacitors to ferroelectric RAMs, from substrates for electronics to high voltage technologies, including all those applications involving an estimation of the interaction between an electric field (not necessarily a static field) and a given material. Great Interest can be also drawn on companies dealing with piezoelectrics and refrigeration through the electro-caloric effect. Furthermore, being the method based on the employment of a commercial rotational rheometer, already available on the market, immediate interest can be shown by companies currently commercializing instruments of such type.



**Fig. 5** Partial hysteresis loop, evaluated through application of a triangular voltage ramp (up to 4 kV) on a PVDF sample.

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