Direct Measurements of the Electrocaloric Effect in Solid Ferroelectric Materials Via Thermoreflectance.

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***Abstract*—**Electrocaloric (EC) effect refers to the isothermal entropy or adiabatic temperature changes of a dielectric material induced by an external electric field. This phenomenon has been largely ignored for application because only modest EC effects (2.6 K) have been detected in bulk ceramics materials such as $Pb_{0.99}Nb_{0.02}(Zr_{0.75}Sn_{0.20}Ti_{0.05})_{0.98}O_3$ **[1]**. The discovery of a giant electrocaloric effect by Mischenko et al. **[2]** in thin films (up to 12 °C with E=480 $kV.cm^{-1}$) renewed interest in electrocaloric materials.

Several methods have been developed to characterize EC effect. "Direct methods" measure the EC temperature change or released heat in the material on application or withdrawal of the electric field. ''Indirect method'' employs Maxwell equations to calculate the EC effect.

In fact, ferroelectric thin films exhibit significant dielectric losses ($tan\delta$>0.1). Furthermore, EC thin layer being deposited on a solid substrate, the thermal capacity of the assembly is very high compared to that of the thin layer alone. Thus, even if the change in specific entropy following the application of an electric field is very large, the change in total entropy is almost undetectable because of the very low volume of the thin films. Due to these limitations, till now it has been difficult to present experimental values of electrocaloric properties in thin films from direct measurements, and the use of indirect methods is privileged **[3]**. It is therefore imperative to study these materials using instruments offering high resolution and dynamic.

To overcome these difficulties, we propose a novel characterization method based on thermoreflectance for measuring directly the electrocaloric effect. This method allows the study of systems such as thin films, multilayers, and nanoparticle. It is a non-contact and non-destructive measurement method with a very large temporal dynamic **[4], [5]**. It exploits the temperature-dependent reflectivity of a surface which is probed using the intensity variation of a reflected laser beam. We report laser-based direct measurements of ECE in various solid ferroelectric materials in the form of multilayered capacitor and thin films as a function of the applied electric field. Using appropriate model, the signal can be used to retrieve electrocaloric properties of embedded or stacked electrocaloric layers.

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Biography

Layla FARHAT is a Ph.D candidate in Material science with great interest in thermal characterization of electrocaloric thin films and their applications in the field of refrigeration. Currently in my Ph.D research I am conducting a systematic study of the thermal properties of nanoscale electrocaloric layers, via ThermoReflectance, as a function of the thickness of the material.

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