Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

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91120 Palaiseau
Amphithéâtre

«Switchable photovoltaic properties in ferroelectric PZT thin films»

Komalika RANI

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Jury members :

Houssny BOUYANFIF, Rapporteur, Maître de conférences-HDR, Université de Picardie (LPMC)
Bohdan KUNDYS, Rapporteur, Chargé de recherche, HDR, Université de Strasbourg, CNRS
Laurent DANIEL, Examinateur, Professeur des universités, Université Paris-Saclay
Maryline GUILLOUX-VIRY, Examinatrice, Professeur des universités, Université de Rennes 1
Hélène MAGNAN, Examinatrice, Ingénieure de recherche CEA
Philippe LECOEUR, Directeur de thèse, Professeur, Université Paris-Saclay (C2N)
Sylvia MATZEN, Encadrante, Maître de conférences, Université Paris-Saclay (C2N)
Thomas MAROUTIAN, Invite, Chargé de recherche, Université Paris-Saclay-CNRS

Abstract :
Ferroelectric (FE) thin films are being explored for their possible use in photovoltaic (PV) applications. This is due to their high open-circuit voltage and switchable photovoltaic effect, which make them attractive for PV applications. Theoretically, 100% switching of the photocurrent can be achieved by varying the direction of the ferroelectric pola-rization through the ferroelectric layer. This is particularly intriguing for applications such as photo-ferroelectric me-mory. The presence of switchability in integrated ferroelectric films between electrodes, however, is not always achieved due to extrinsic parameters such as the nature of the electrode-ferroelectric interface (Schottky contact) or the presence of non-mobile charged defects in the ferroelectric film. In addition, the movement of charged defects, such as oxygen vacancies, under the influence of applied electric fields can have an effect on switchable photocur-rent as well. It is not an easy process to disentangle all these contributions (polarization, interfaces, defects) to the photovoltaic properties of ferroelectric devices, and little is known about the quantitative link between photocurrent and ferroelectric polarization.
In this work, a thorough investigation of the switchability of the PV properties of epitaxial lead zirconate titanate Pb(Zr,Ti)O3 (PZT) thin films has been carried out in order to study quantitatively the role of ferroelectric polarization. 100 nm thick PZT films were grown using pulsed laser deposition (PLD) and integrated into a capacitor geometry between bottom and top electrodes. The photoinduced current in the PZT devices was investigated under UV illumi-nation (above the PZT band gap) and in different polarization states by poling the devices under increasing electric fields in order to achieve distinct electrical states while simultaneously monitoring their polarization value.
A comparison study of different interfaces was also carried out, including Pt and ITO as top electrodes, SrRuO3 (SRO) and LaSrMnO3 as bottom electrodes, as well as the insertion of SrTiO3 dielectric layer at the PZT/electrode interface. This work has provided a quantitative determination of the switchable vs unswitchable parts of photocurrent. More precisely, the study of the dependence of the photocurrent as function of electrically controlled remanent polariza-tion has shown that (1) the photocurrent depends linearly on the switchable part of the ferroelectric polarization and that (2) the analysis of this dependence allows extracting quantitatively the pinned polarization value in the FE layer. Such pinned polarization strongly affects the switchability of the PV properties in FEs and is otherwise rather difficult to probe by classical FE characterizations. In addition, the comparison study of different interfaces also revealed the contribution from the electrode-ferroelectric interface on the PV properties, which can induce really different swit-chability and amplitude of photocurrents.
In conclusion, these results are thus particularly relevant for the optimization of FE thin films to achieve switchable PV properties which could have far-reaching implications for future photo-ferroelectric memory applications. In addi-tion, the developed method of investigation of photocurrents switchability provides important insights on the fer-roelectric behavior in all types of ferroelectric layers, in which pinned polarization could be significant but difficult to investigate otherwise.