Stress cycle on a ZnO nanowire-based nanogenerator: a phenomenological study
E. Dumons, Guylaine Poulin-Vittrant, Louis-Pascal Tran-Huu-Hue

To cite this version:
E. Dumons, Guylaine Poulin-Vittrant, Louis-Pascal Tran-Huu-Hue. Stress cycle on a ZnO nanowire-based nanogenerator: a phenomenological study. JNRSE, Jul 2022, Bordeaux (France), France. hal-04049179

HAL Id: hal-04049179
https://univ-tours.hal.science/hal-04049179
Submitted on 28 Mar 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Stress cycle on a ZnO nanowire-based nanogenerator: a phenomenological study

Emmanuel Dumons, Guylaine Poulin-Vitrant, Louis-Pascal Tran-Huu-Hué
GREMAN, UMR 7347, CNRS, University of Tours, INSA CVL, 3 Rue de la Chocolaterie, 41000 Blois, France

Introduction: The aim of this work is to search influential parameters on the energy conversion in a ZnO nanowire-based nanogenerator and transfer to the external load during a quasi-static stress cycle. The studied parameters are: mechanical excitation characteristic times, ZnO doping level, polymer dielectric permittivity and external load resistance.

Context: Mechanical energy harvesters are promising devices to make integrated sensors or actuators autonomous, by scavenging free energy from the environment. Piezo-nanogenerators use direct piezoelectric effect to harvest an external mechanical energy and convert it into electrical one. For this purpose, ZnO nanostructures are used as piezoelectric material and are embedded within a polymer matrix.

System description

Design of a nanogenerator with ZnO NWs [1]

Evolution of electrical energies during a quasi-static stress

Electrical energy transfer to an external circuit with \( \tau_e = R e_{\text{unit cell}} \)

FEM Simulation: A unit cell with a single monocrystalline ZnO NW with piezoelectric and semiconducting coupled properties and a polymer capacitive layer above.

Electrical cycle

\( \omega_{el} = \frac{1}{2} D_3 d E_3 \)

The larger the cycle, the higher the electrical energy transferred to the external circuit.

Influence of ZnO doping level

The higher the doping level, the thinner the cycle.

Influence of the polymer dielectric permittivity

The higher the polymer dielectric permittivity, the larger the cycle.

Influence of the external load

There is a match between mechanical \( \tau_m \) and electrical \( \tau_e \) characteristic times.

Conclusion and perspectives: This transient analysis shows the influencing parameters that have a real impact on the amount of converted and transferred energy to an external resistor. This work opens perspectives to take into account even more realistic mechanical cycles in specific applications, by considering losses in the different materials, ZnO surface traps [2] and other external loads.

References