Large-scale and Flexible Energy Harvester based on ZnO Conical Nanostructures by Nano-imprint Lithography and Atomic Layer Deposition

D. Spirito[1,2,*], E.Defay[1], K.Menguelti[1], J.Kreisel[1,2], and D.Lenoble[1]
[1]MRT Department, Luxembourg Institute of Science and Technology (LIST)
5 Avenue des Hauts-Fourneaux, L-4362 Esch-sur-Alzette, Luxembourg
[2]University of Luxembourg
2 Avenue de l ?université, L-4365 Esch-sur-Alzette, Luxembourg
*David Spirito: David.Spirito@list.lu

Mechanical energy harvesting still remains an emerging technology since the late 90's. The development of lead-free piezoelectric materials during the past few years and their now reliable and high properties make them a natural choice for the design of environmentally friendly energy sources

In this work, we report both the processing of conical shape ZnO nanostructures as well as their characterizations under low electric field and large mechanical field stimuli. The large scale fabrication of an efficient piezoelectric nanogenerator is hence demonstrated.

We propose here an original top-down approach while bottom-up processes are usually favoured for the growth of ZnO nanowires. The fabrication combines Nano-Imprint Lithography (NIL) and low-temperature (<80°C) Atomic Layer Deposition (ALD). The NIL process leads to a PMMA regular array of truncated conical holes of 2 μm in depth. The conical shape of the stamp allows for reaching a high aspect ratio of 10. These holes are then filled with 150 nm-thick polycrystalline ZnO film by low-temperature ALD. A p-n junction is created by adding 100 nm-thick PEDOT by plasma radicals assisted polymerization via chemical vapour deposition[1].

Using this method, we demonstrate the possibility to grow functional device on a flexible substrate with an active surface from $5x5mm^2$ to $50x50mm^2$. Voltage output, effective transverse piezoelectric coefficient, generated power were measured using electrical and mechanical stimuli. We measured an output voltage of 200 mV corresponding to an effective transverse piezoelectric coefficient e_{31eff} of $-0.45C/m^2$.

[1] Pistillo et al., J. Mater. Chem. C, 2016