The 6th International Conference on Nanogenerators and Piezotronics

NGPT 2022 20 – 23 June

hosted by FSCN reseach centre Mid Sweden University Sundsvall

Peeled-off polydimethylsiloxane film-based triboelectric nanogenerator for understanding the mechanism of triboelectrification

Huidrom Hemojit Singh, Da Woon Jin, Jong Hoon Jung

Department of Physics, Inha University, Incheon 22212, Republic of Korea

*Email: hmjt003@gmail.com(**H.H.S.**) and jhjung@inha.ac.kr (**J.H.J.**)*

❖ Introduction

Motivation

❖The triboelectric nanogenerator (TENG) operates based on the triboelectrification and electrostatic induction principles. Although electrostatic induction is a well-known phenomenon in the scientific community, the triboelectric effect is still poorly understood. Understanding this physical phenomenon is critical for proposing a correct mechanism and improving TENG's performance.

Abstract

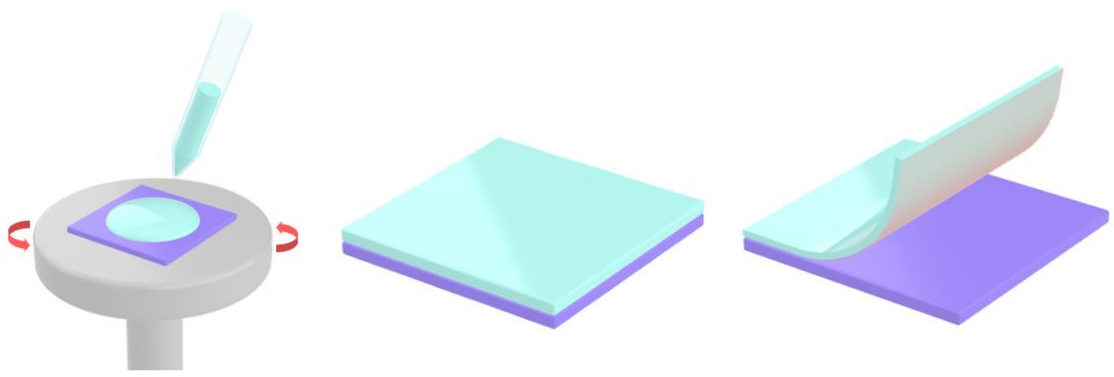
➢ In the present work, we have fabricated single electrode TENG out of peeled-off polydimethylsiloxane (PDMS) films to better understand the phenomenon of triboelectrification. PDMS films were prepared on ITO-Glass and ITO-PET substrates.

➢Despite the fact that the two surfaces have similar surface roughness and surface energy (32-40 mN/m), the PDMS film peeled-off from the ITO-Glass substrate produces more TENG output than the one removed from the ITO-PET substrate.

➢The XPS result shows more materials being transferred in the case of PDMS peeled off from ITO-glass substrate. It has been concluded that the enhancement in material transfer is dependent on the substrate's surface energy and the difference in Young's modulus between the two contacting materials.

➢The current work not only validates the material transfer phenomenon that control triboelectrification, but it also proposes a novel strategy for increasing TENG's output.

❖ Experiment



➢*PDMS films were prepared by spin-coating technique in different substrates ITO-Glass, ITO-PET, PTFE, and Glass. The films were then cured on the hot plate for 2 hours. The films were peeled off from the substrates.*

➢*To cancel out the effects of the environment specially the relative humidity on the performance of the TENG, the removal of the films and the whole TENG measurements were carried out inside a glove box, in which relative humidity was maintained at 15% and chamber pressure at 76 mTorr.*

❖ Summary

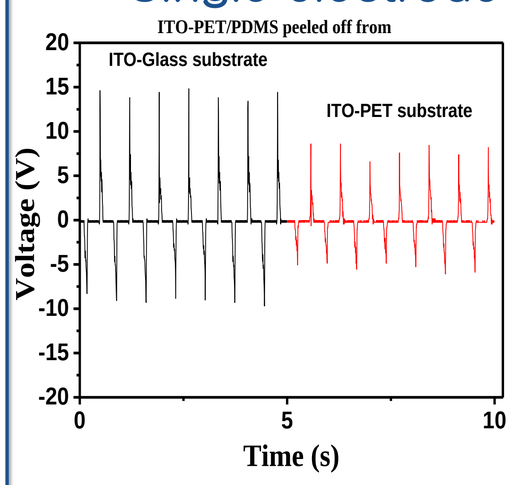
➢We fabricated peeled off PDMS based triboelectric nanogenerator and its output was found to be dependent on the mechanical strength of the substrate on which PDMS film was prepared.

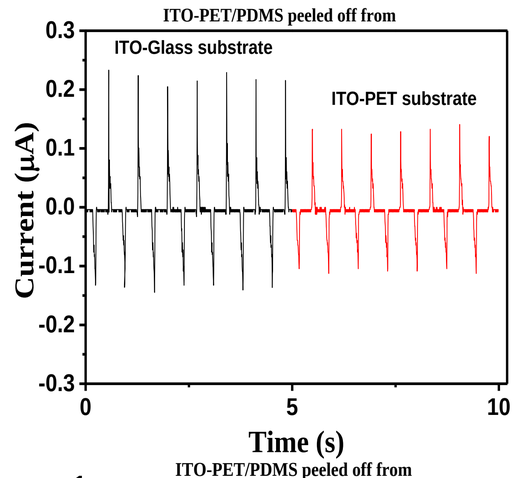
➢As we change the substrate, different in mechanical strength, more material transfer is observed when PDMS was deposited on the substrate with more mechanical strength.

➢The above conclusion can be applied to understanding the mechanism of triboelectric nanogenerator, in which we are proposing that when two materials having large difference in mechanical strength comes into contact, more output will be observed as compared to two materials having lesser difference in mechanical strength.

❖ Results

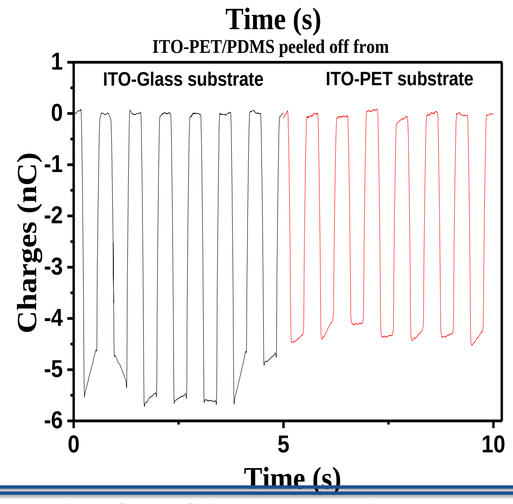
Single electrode TENG measurement



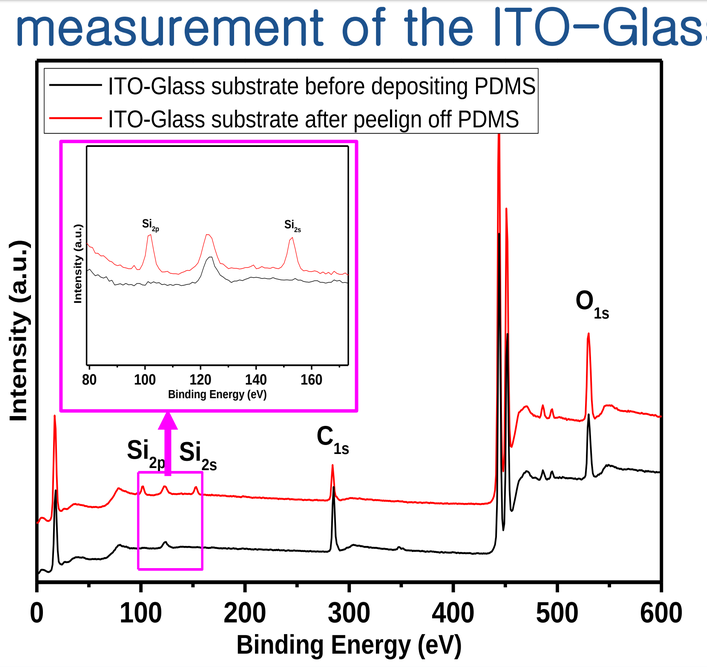


➢ Single electrode TENG fabricated with ITO-PET as the contacting electrode and the peeled off PDMS as the single dielectric material.

➢ The peeled off PDMS from ITO-Glass substrate gives more output as compared to the PDMS removed from the ITO-PET substrate.



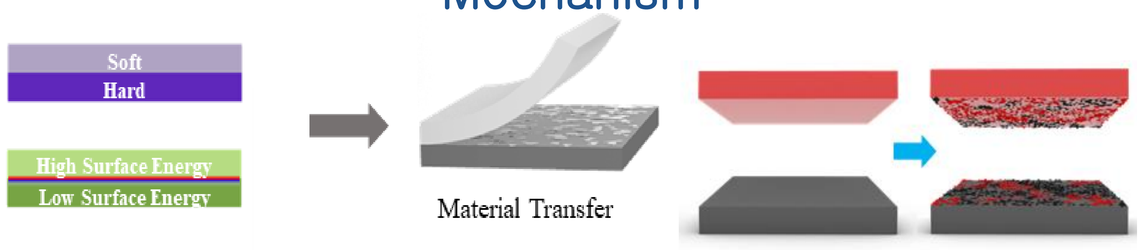
XPS measurement of the ITO–Glass substrate



➢ XPS measurement of the ITO-Glass substrate before depositing the PDMS and after removing the PDMS confirmed that material is being transferred from PDMS to the ITO-Glass.

➢ As we peeled off PDMS from the ITO-glass substrate, PDMS were transferred from PDMS film to ITO-glass. It is evident with the emergence of two Si peaks shown in the inset of the XPS plot.

Mechanism



➢ As observed from the XPS graph, material transfer from the PDMS to ITO-glass substrate is taken place. More material transfer is expected to the substrate which are mechanically stronger and to the surface having higher surface energy.

➢As the PDMS film was peeled off from the substrate, material mostly from the surface of PDMS transferred to the substrate thereby creating voids on the surface of the PDMS films. This results in generating unbalanced extra charges on the surface of PDMS. That's why more triboelectrification is observed with PDMS removed from the ITO-glass substrate.

➢The observation can be extended to explaining the origin of triboelectrification in triboelectric nanogenerators.

➢Similarly, in TENG if we take the two contacting material as very soft material and another material mechanically very hard material, then more enhanced output will be observed due to the increase in material transfer between the two contacting materials.