Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supplementary Information

NiO-Ti nanocomposites for contact electrification and energy harvesting: Experimental and DFT+U studies

[1]Aneeta Manjari Padhan, [1]Sugato Hajra, [2]Jagadish Kumar, [1]Manisha Sahu, [3]Sanjib Nayak, [4]Hamideh Khanbaerh, [1,5*]Hoe Joon Kim, [6*]Perumal Alagarsamy

[1]Department of Robotics and Mechatronics Engineering, Daegu Gyeongbuk Institute of Science and Technology (DGIST), Daegu-42988, Republic of Korea

[2]Department of Physics, Utkal University, Vani Vihar, Bhubaneswar-751004, India

[3]Department of Physics, Indian Institute of Technology-Madras, Tamilnadu-600036, India

[4]Department of Mechanical Engineering, University of Bath, Bath BA2 7AY, UK

[5]Robotics and Mechatronics Research Center, Daegu Gyeongbuk Institute of Science and Technology (DGIST), Daegu-42988, South Korea

[6]Department of Physics, Indian Institute of Technology-Guwahati, Assam-781039, India

#Corresponding Authors: Dr. Hoe Joon Kim: joonkim@dgist.ac.kr

Prof. Perumal Alagarsamy: perumal@iitg.ac.in

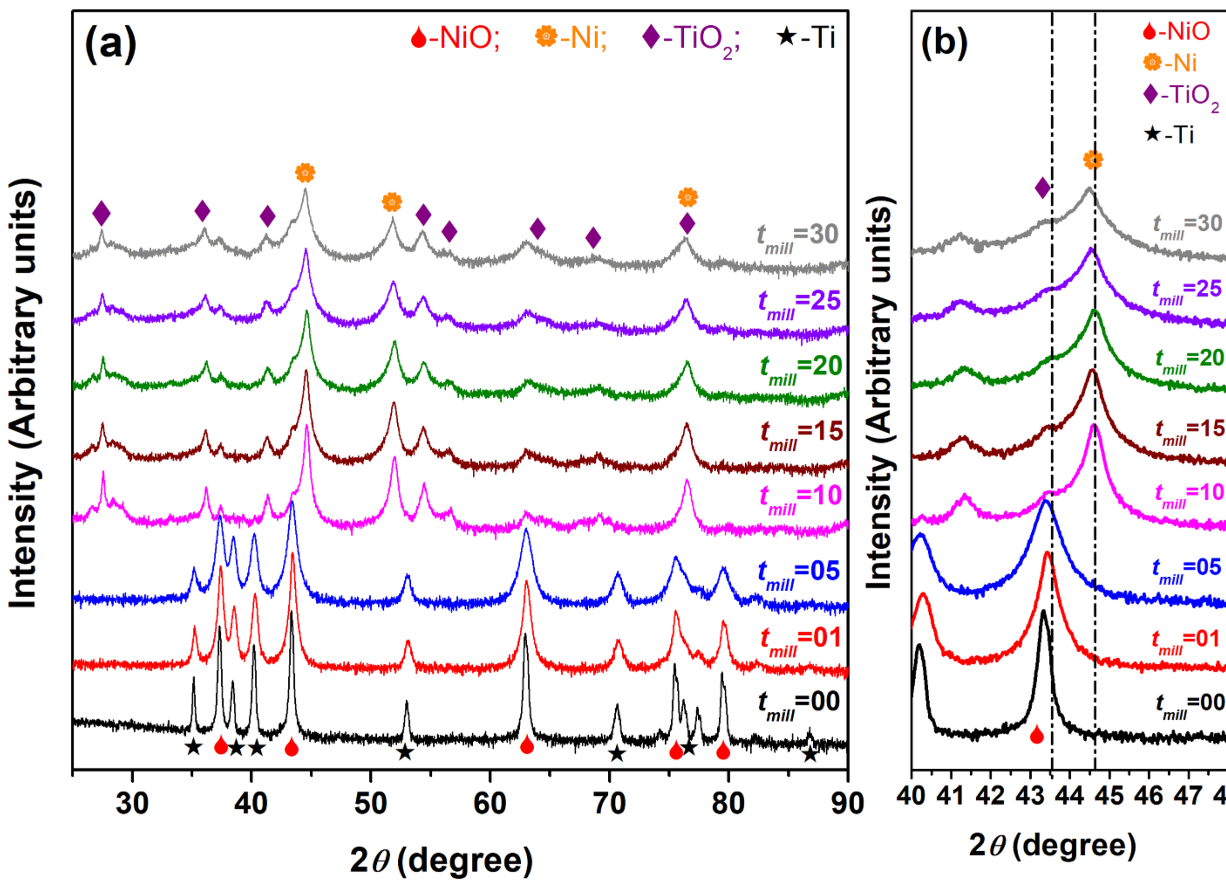

Figure S1: Milling time-dependent mechanochemical reduction of NiO by a reactive Ti to form an *in-situ* NiO-Ni-TiO_2 nanocomposite (a); The enlarged version of the peaks within 2θ = 40-48° showing the formation of Ni at the critical activation time of 10 h.

Supplementary Information

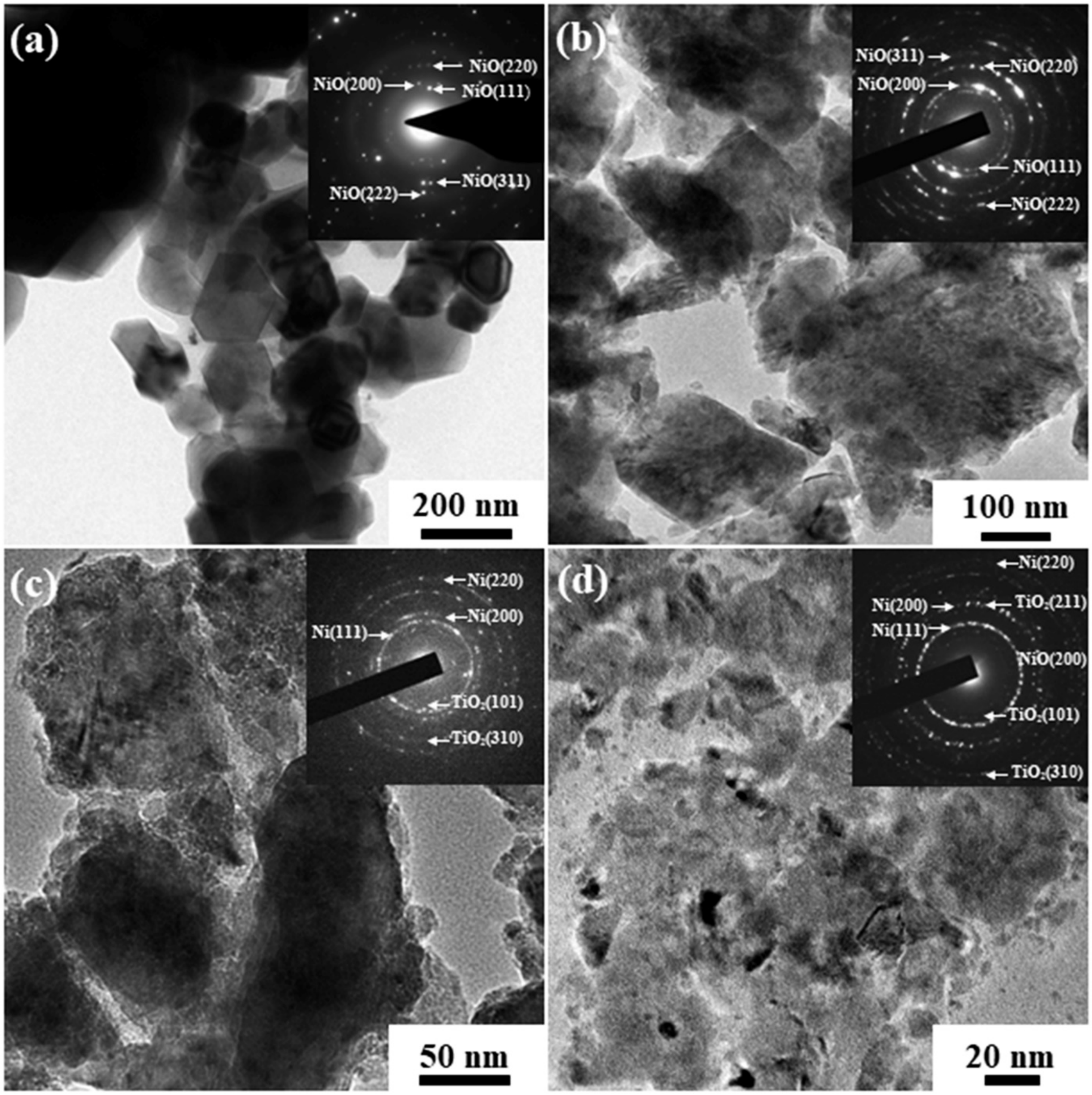

Figure S2: Bright-field TEM images and selected area electron diffraction patterns of NiO-Ti powders prepared at different milling periods with (a) Bulk NiO; (b) t_{mill} = 5 h; (c) t_{mill} = 10 h; (d) t_{mill} = 30 h.

Supplementary Information

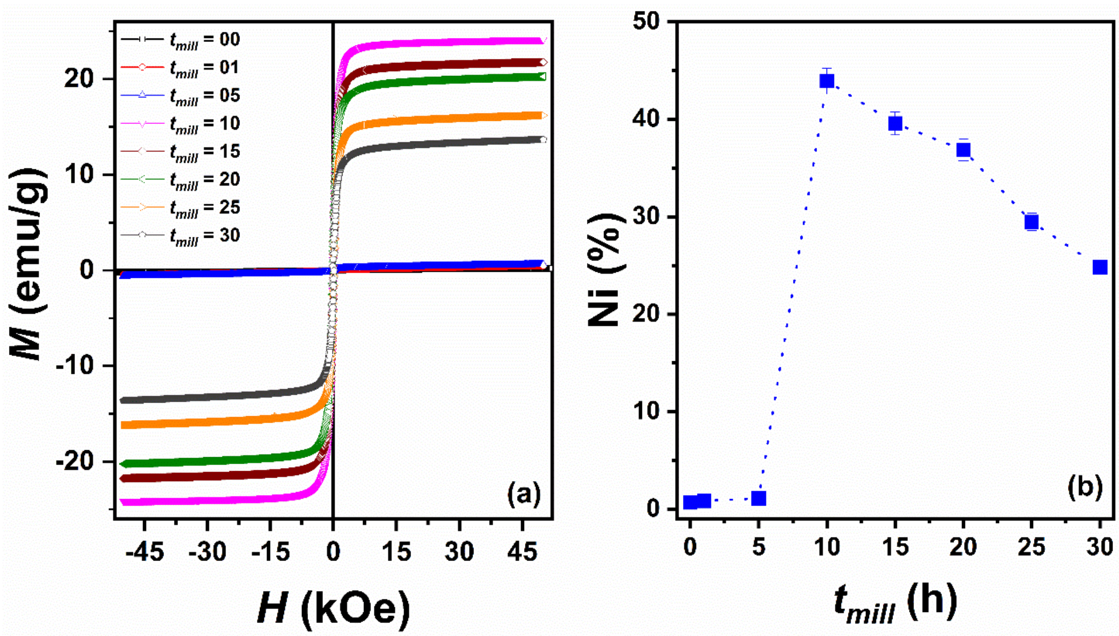

Figure S3: (a) Milling time-dependent magnetic hysteresis (*M-H*) loops measured at room temperature; (b) Percentage of Ni estimated for the NiO-Ti powders at different milling periods.

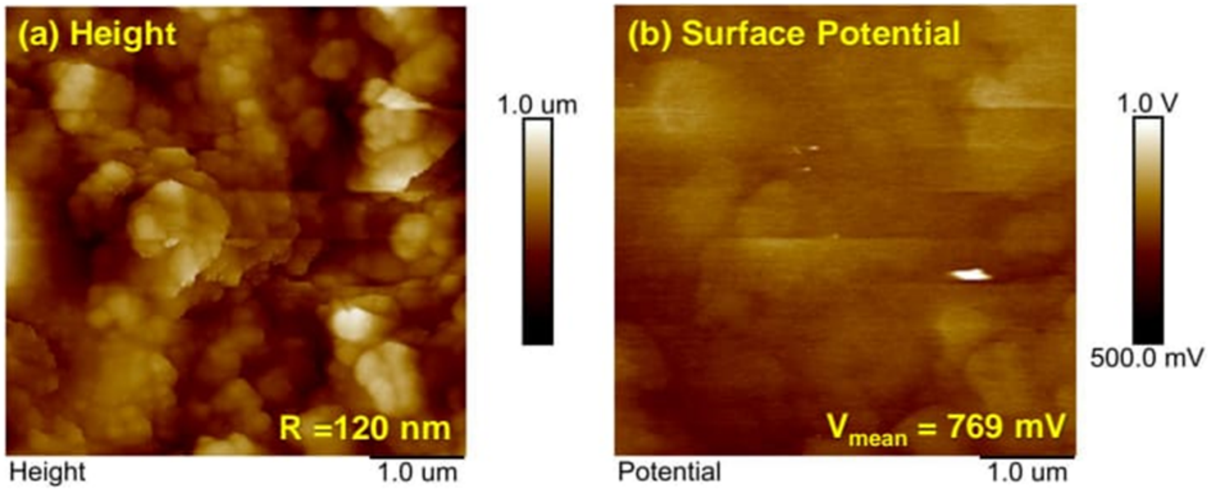

Figure S4: AFM (surface roughness) and KPFM (surface potential) features of the NiO-Ni-TiO_2 nanocomposite.

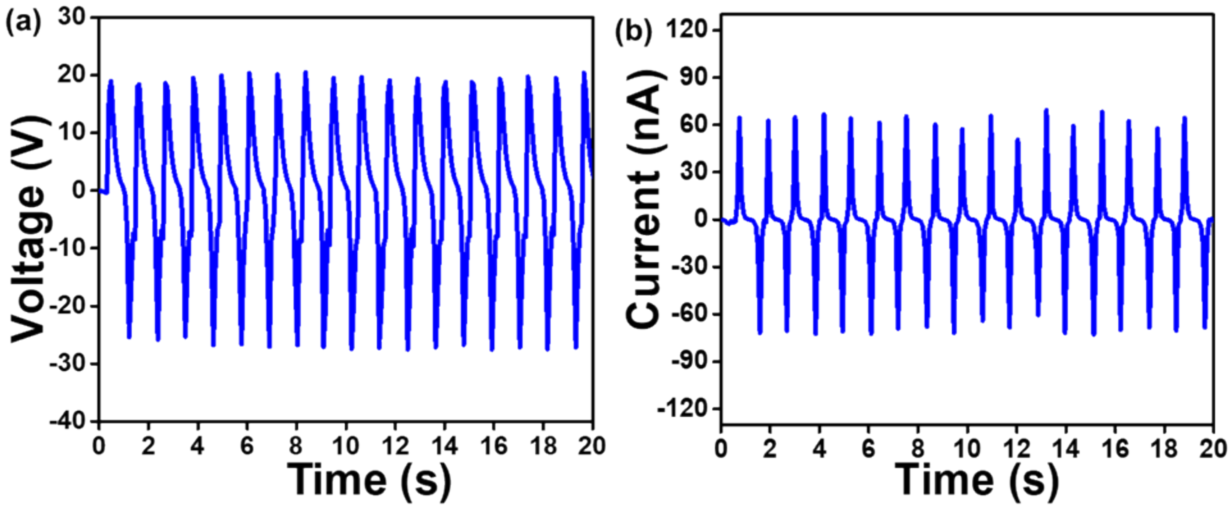

Figure S5: Voltage and current of the TENG based on NiO and Kapton triboelectric layers.

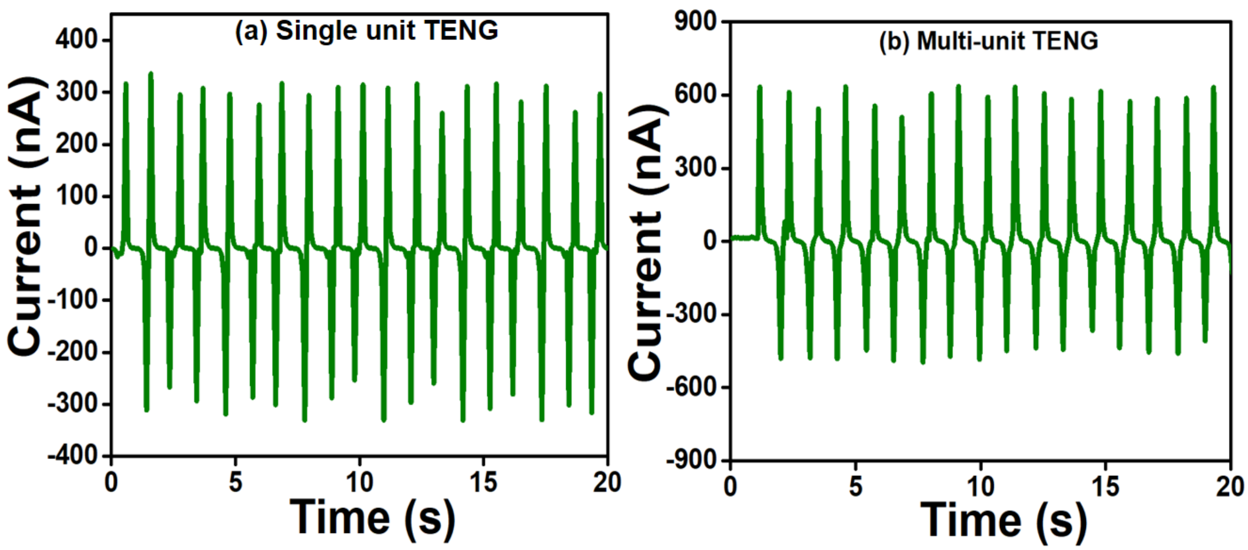

Figure S6: Electrical current output for single unit TENG and two units of TENG (multi) connected in parallel connection.

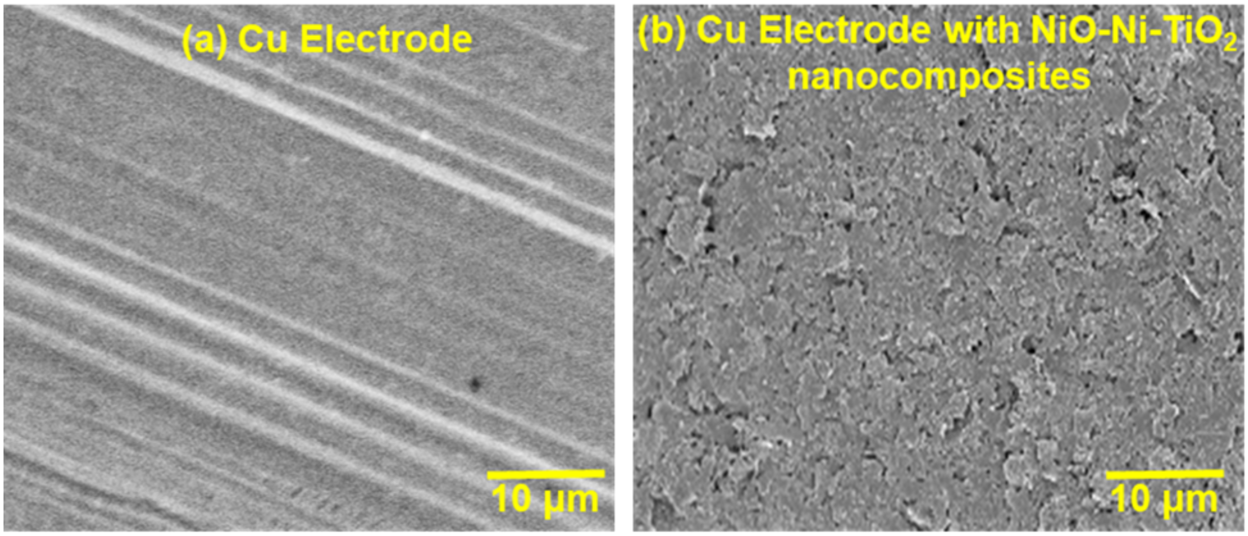

Figure S7: Surface micrographs of bare copper and NiO-Ni-TiO_2 particles attached to copper electrode.

Table S1: Comparison of different metal-oxide based TENG with present work.

Sl.	Device structure	Working Mode	Active Materials	Voltage (V)	Current (μA)	Ref.
1	Spring Type Contact Separation	TENG	Kapton/ZnO	57	1.21	1
2	Spring Type Contact Separation	TENG-PENG hybrid	$Ti_{0.8}O_2$-Ag co-doped $BaTiO_3$/ PDMS	150	0.32	2
3	Flapper type single electrode mode	TENG	ZnO nanorods/PDMS	5.34	0.181	3
4	Vertical contact mode	TENG	$Ba_3Fe_2TeO_9$/ Kapton	88	2.69	4
5	Square shape vertical contact separation	TENG	Al_2O_3-PDMS	34	1.77	5
6	Square shape vertical contact separation	TENG	SiO_2-TiO_2	0.2	-	6
7	Square shape vertical contact separation	TENG	TiO_2-HfO_2	0.2	-	
8	Square shape vertical contact separation	TENG	Al_2O_3-HfO_2	0.25	-	
9	Vertical contact separation	TENG	TiO_2-Natural rubber	45-78	4.5-7.0	7
10	Spring Type contact separation (2 cm × 2 cm)	TENG	NiO-Mg/ Kapton	35	0.13	8
11	Spring Type contact separation (2 cm × 2 cm) two units in parallel	TENG	NiO-Mg/ Kapton	35	0.49	
12	Spring Type contact separation (3.5 cm × 3.5 cm)	TENG	NiO-Mg/ Kapton	80	1.0	
13	Eye-shaped vertical contact separation	TENG	NiO-Ni-TiO_2/ Kapton	60	0.6	This work

Supplementary Information

References:

1. M. Sahu, S. Šafranko, S. Hajra, A.M. Padhan, P. Živković, S. Jokić, H.J. Kim, Materials Letters 301 (2021) 130290
2. S. Sriphan, T. Charoonsuk, T. Maluangnont, N. Vittayakorn, ACS Appl. Energy Mater. 2, 5 (2019) 3840-3850
3. Y.H. Ko, G. Nagaraju, S.H. Lee, J.S. Yu, ACS Applied Mater. Interfaces 6 (2014) 6631-6637
4. J. Kojčinović, M. Sahu, S. Hajra, D. Tatar, T. Klaser, Ž. Skoko, Z. Jagličić, E. Sadrollahi, F. Jochen Litterst, H.J. Kim, I. Djerdj, Mater. Chem. Front. (2022); DOI: 10.1039/D1QM01565F
5. H.J. Hwang, Y. Lee, C. Lee, Y. Nam, J. Park, D. Choi, D. Kim, Micromachines 9 (2018) 656
6. Y.J. Kim, J. Lee, S. Park, C. Park, C. Park, H.-J. Choi, RSC Adv. 7 (2017) 49368
7. W. Bunriw, V. Harnchana, C. Chanthad, V. Ngoc Huynh, Polymers 13 (2021) 2213.
8. A.M. Padhan, S. Hajra, S. Nayak, J. Kumar, M. Sahu, H.J. Kim, P. Alagarsamy, Nano Energy 91 (2022) 106662.