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# Development of Solid-Liquid Triboelectric Nanogenerators Based on Metallic Glass Nanotube Arrays for Sensing and Energy Harvesting Applications

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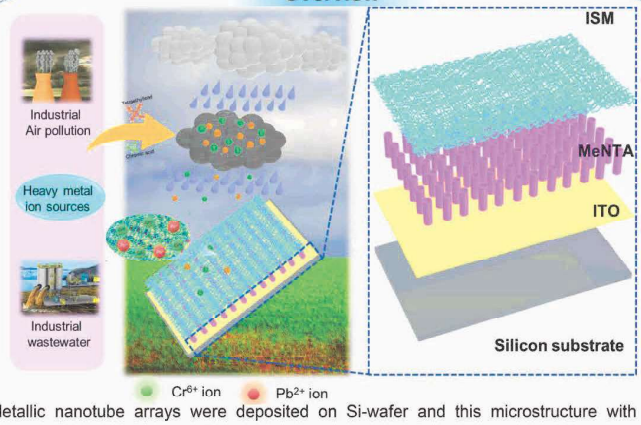
## Abstract

Arrays of metallic nanotubes are fabricated on Si-wafer to fabricate a stable hydrophobic surface for a longer life span. The selected compositions of metallic nanotube arrays (MeNTAs) have shown contact angles in a range of 120° - 144° due to the air trapped in these nanotubes. The switching nature of water droplets has been utilized when it impacts on a hydrophobic surface and employment of top electrode also helps in enhancement of voltage output. Ion selective membrane has been coated on high surface area of MeNTA to functionalize the sensitivity and selectivity of heavy-metal ions ($Cr^{6+}$, $Pb^{2+}$, and $Hg^{2+}$).

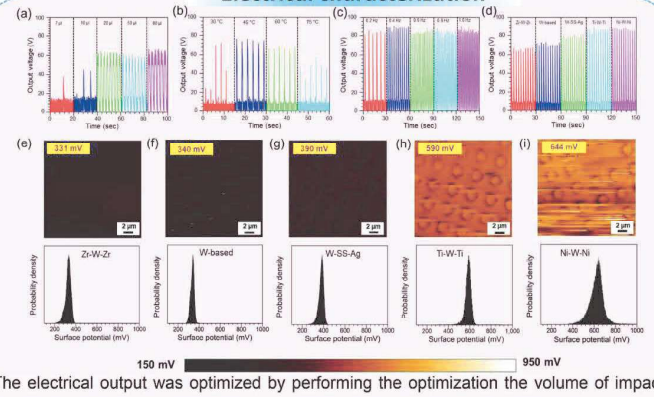
## Research focus

### Overview



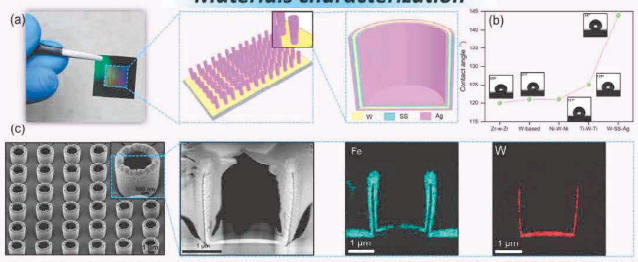

Metallic nanotube arrays were deposited on Si-wafer and this microstructure with high-surface area was modified with ion selective membrane (ISM) to functionalize the heavy-metal ion sensing in natural water resources and man made water resources.

### Electrical characterization



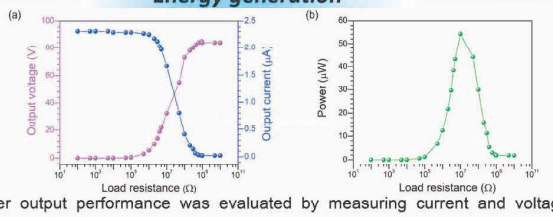

The electrical output was optimized by performing the optimization the volume of impacting water droplet, inclination angle of sliding surface, dripping frequency, and composition of MeNTA. To validate the output voltage of various material compositions, surface potential was measured by Kelvin probe force microscopy (KPFM).

### Materials characterization



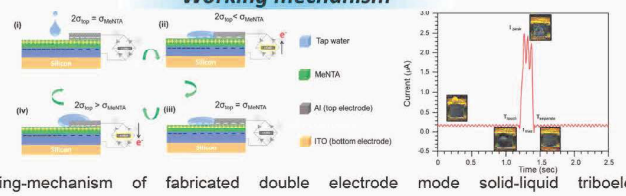

The insights of materials properties were investigated by performing field emission-scanning electron microscopy (FE-SEM) and transmission electron microscopy (TEM). The above FE-SEM image is showing morphology of MeNTA and TEM images are showing cross-section of single nanotube. Moreover, hydrophobicity is measured by water contact-angle.

### Energy generation



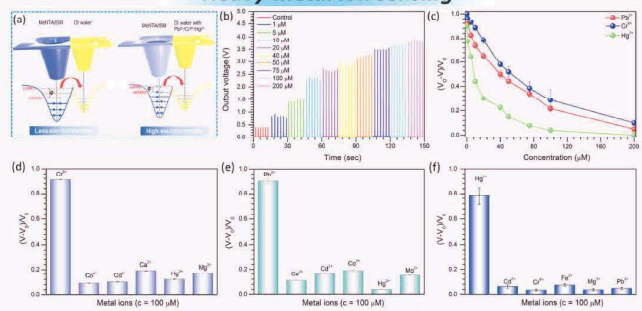

The power output performance was evaluated by measuring current and voltage under variation of load resistance with the optimized MeNTAs (Ni/W/Ni).

### Working mechanism




Working-mechanism of fabricated double electrode mode solid-liquid triboelectric nanogenerator (SL-TENG) is based on switching nature of water droplet on hydrophobic surface. The figure is showing working-mechanism along with current waveform.

### Heavy-metal ion sensing




The heavy-metal ion sensing is based on binding of specific ions on ISM coated MeNTAs (Ni/W/Ni) which changes the surface charge density and resulted in change in voltage output.

**Selected Journal Publication** 1. *npj Biosensing* **1**, 13 (2024) 2. *Chemical Engineering Journal* **490**, 151586 (2024) 3. *Biosensors and Bioelectronics* **219**, 114783 (2023)