Engineering 2D Nanomaterial Coatings on Flexible Polymer Substrates

A. Longo[1]*, M. Palomba[1], G. Carotenuto[1], F. Giubileo[2], A. Di Bartolomeo[2,3], D. De Felicis[4], D. Duranti[4], S. Rashid[4], E. Rossi[4], M. Sebastiani[4], E. Bemporad[1] mail: angela.longo@cnr.it

[1]Institute for Polymers, Composites and Biomaterials, National Research Council (IPCB-CNR), SS Napoli/Portici, Piazzale Enrico Fermi n. 1, 80055 Portici, Italy;
[2] Institute for SuPerconductors, INnovative Materials, and Devices, National Research Council (SPIN-CNR), SS Salerno, Via Giovanni Paolo II, 84084 Fisciano, Italy;
[3]Department of Physics 'E.R. Caianiello', University of Salerno, Via Giovanni Paolo II 132, 84084 Fisciano, Italy
[4]Department of Civil, Computer and Aeronautical Engineering, Roma Tre University, Via della Vasca Navale 79 - 00146 Rome, Italy

1 BACKGROUND AND MOTIVATION

Flexible polymer substrates offer unique opportunities for lightweight and multifunctional devices. However, exploiting the potential of 2D nanomaterials requires understanding how colloidal behavior and substrate characteristics interact during coating formation and dictate the final functional response.

2 SCALABLE AND SUSTAINABLE PROCESS

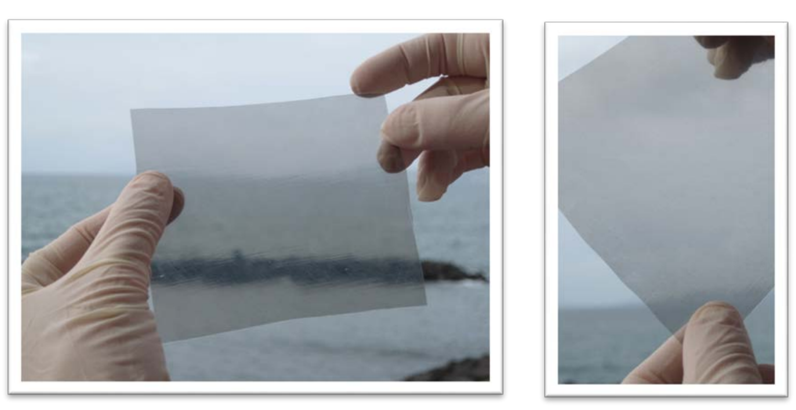
ENGINEERING CONCEPT

Functional performance arises from the coupling between the stable colloidal dispersion of 2D nanomaterials and the properties of the polymer substrate. During deposition, this interaction governs coating formation, determines the resulting architecture, and ultimately dictates the final functionality.

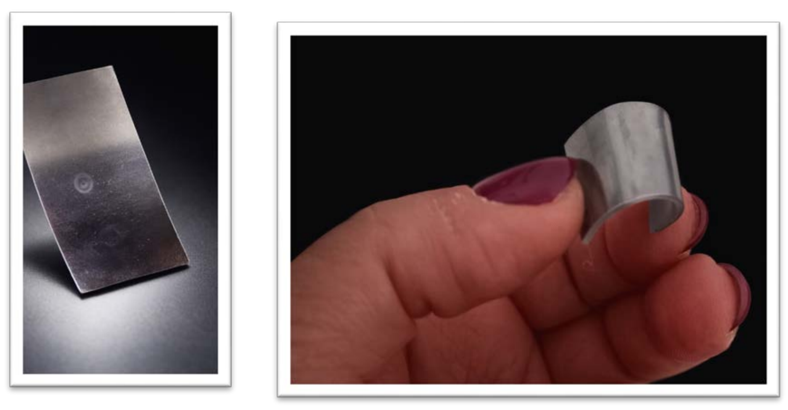
STABLE COLLOIDAL DISPERSION → SUBSTRATE PROPERTIES → DEPOSITION → COATING ARCHITECTURE → FUNCTIONAL PERFORMANCE

3 STRUCTURE-FUNCTION OUTCOMES FROM THE SAME DEPOSITION STRATEGY

CASE 1: GNP on LDPE



CASE 2: GNP on Silicon Rubber

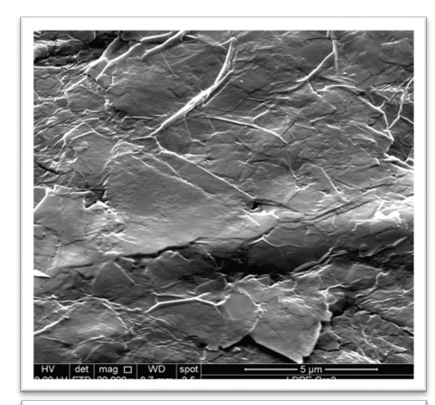


CASE 3: MoS_2 on LDPE

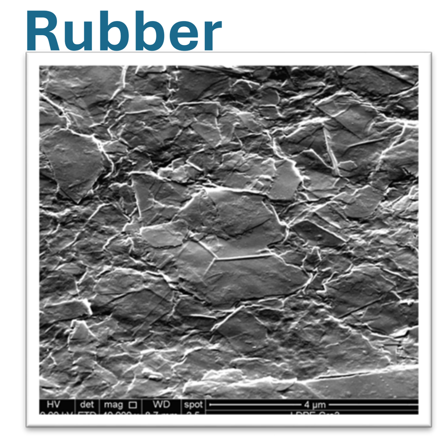
Colloidal/Substrate	Coating Architecture	Function
GNP + LDPE	Semi-transparent percolative network	Thermoresistive sensing
GNP + Silicon Rubber	Compliant conductive network	Field emission
MoS_2 + LDPE	Compact lubricating layer	Tribological protection

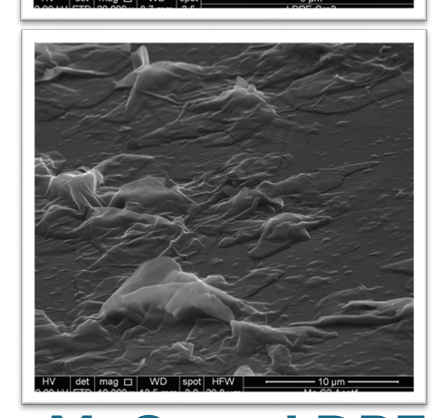
4 SEM ANALYSIS

GNP on LDPE



GNP on Silicone Rubber





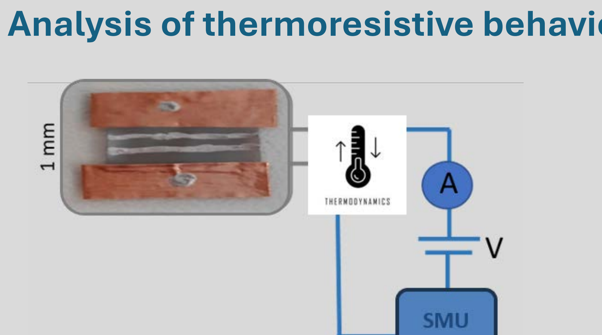
MoS_2 on LDPE

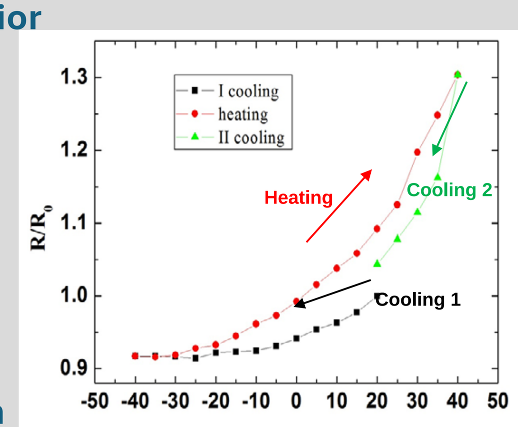
Tilted SEM imaging reveals coating continuity and flake arrangement.

5 FUNCTIONAL PERFORMANCE CHARACTERIZATION

CASE 1: GNP on LDPE

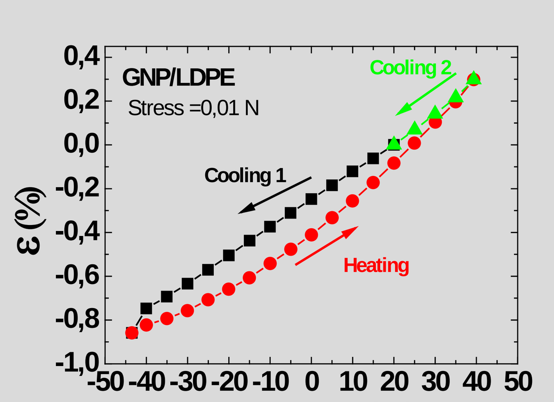
Analysis of thermoresistive behavior





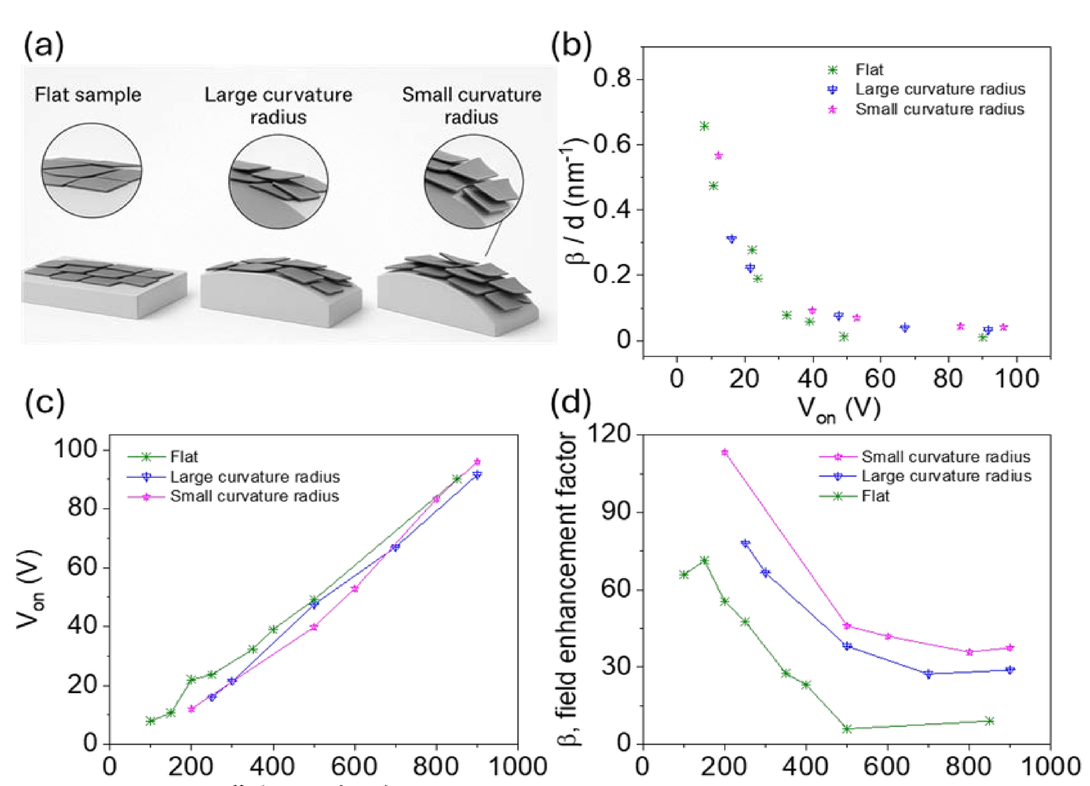
Measurement setup
- Two-probe coplanar configuration
- In vacuum (1 mbar)

Dynamic Mechanical Analysis (DMA):



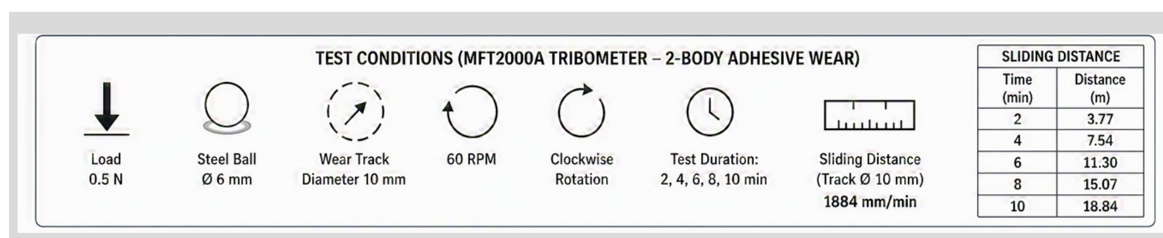
The GNP coating enables thermoresistive sensing, with the electrical response governed by conductive network evolution and substrate mechanics.

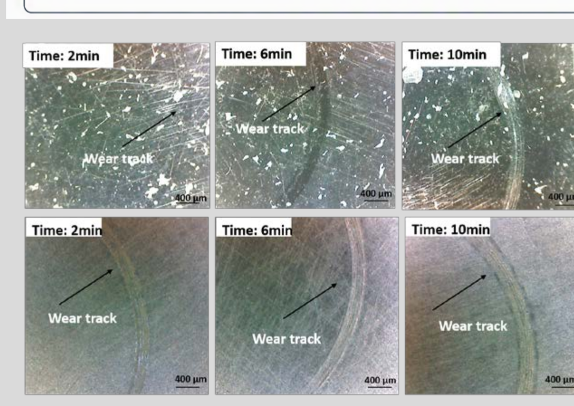
CASE 2: GNP on Silicone Rubber



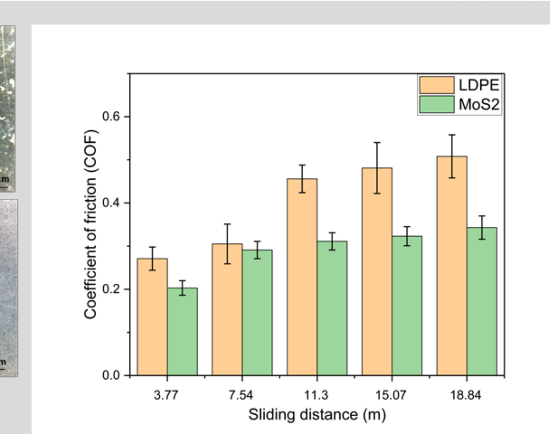
The GNP coating on Silicon Rubber enhances field emission performance, increasing the field-enhancement factor and lowering the emission threshold compared to bare LDPE.

CASE 3: MoS_2 on LDPE





Optical microscopy of the wear tracks



The MoS_2 coating provides effective lubrication, reducing the coefficient of friction (COF) by 25-33%, enhancing wear resistance, and ensuring more stable tribological performance over time compared to bare LDPE.

6 TAKE-HOME MESSAGE

By engineering the coupling between stable colloidal dispersion and substrate properties, a single scalable deposition strategy can generate distinct coating architectures and functionalities, ranging from sensing to field emission and tribology.

Nano Innovation 2026 Rome, 14-18 September Conference & Exhibition

References

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3) Coscia, U., Longo, A., Palomba, M., Sorrentino, A., Barucca, G., Di Bartolomeo, A., ... & Carotenuto, G. (2021). Influence of the thermomechanical characteristics of low-density polyethylene substrates on the thermoresistive properties of graphite nanoplatelet coatings. *Coatings*, *11*(3), 332.