TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Nano 2023 Innovation
Rome, 18-22 September
Conference & Exhibition

Functionalized Nickel-Graphene Coatings for Tribological Applications

Daniele Almonti (1), Gabriele Baiocco (1), Daniel Salvi (1), Nadia Ucciardello (1)
(1) Dipartimento di Ingegneria dell'Impresa "Mario Lucertini", Università degli Studi di Roma "Tor Vergata"

1. Aim

Obtain a self-lubricating coating well adhesive to the substrate that can obtain a low coefficient of friction under wear conditions, obtaining an improvement over a nickel-only coating.

2. Introduction

Wear represents one of the most significant and costly challenges in the industrial sector, directly impacting the reliability, efficiency, and lifespan of critical components and machinery. In this context, the application of protective coatings emerges as an advanced and scientifically supported strategy to mitigate wear and extend the service life of industrial components. Protective coatings, often produced using advanced techniques such as Chemical Vapor Deposition (CVD) and Physical Vapor Deposition (PVD), cover material surfaces with thin layers of highly wear-resistant materials. These layers, also known as thin films, provide an effective barrier against wear mechanisms, significantly reducing adhesive and abrasive wear.

3. Materials and Methods

The electrodeposition process allows for the fabrication of coatings with precise thickness control, offering significant economic advantages compared to other techniques. The key reaction underlying this process is the redox reaction regulated by Faraday's law.

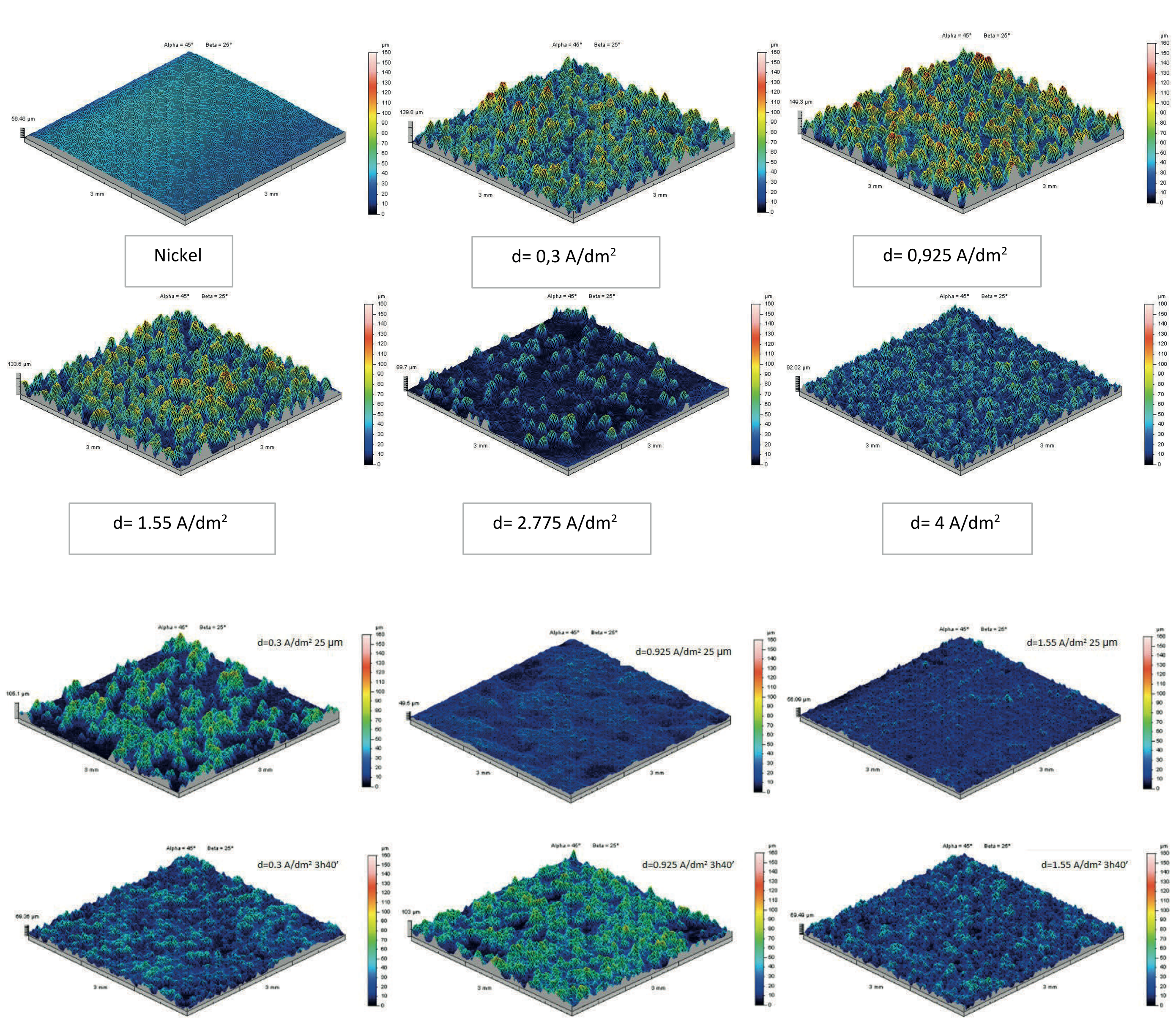
Graphene oxide (GO) is considered a precursor to graphene. It consists of a single atomic layer of carbon containing oxygen functional groups attached to the lattice atoms. Coatings were produced by varying the current density and using both simple graphene oxide (GO) and graphene oxide functionalized with amino- benzene (frGO). Subsequently, a morphological characterization of the coating roughness was conducted.

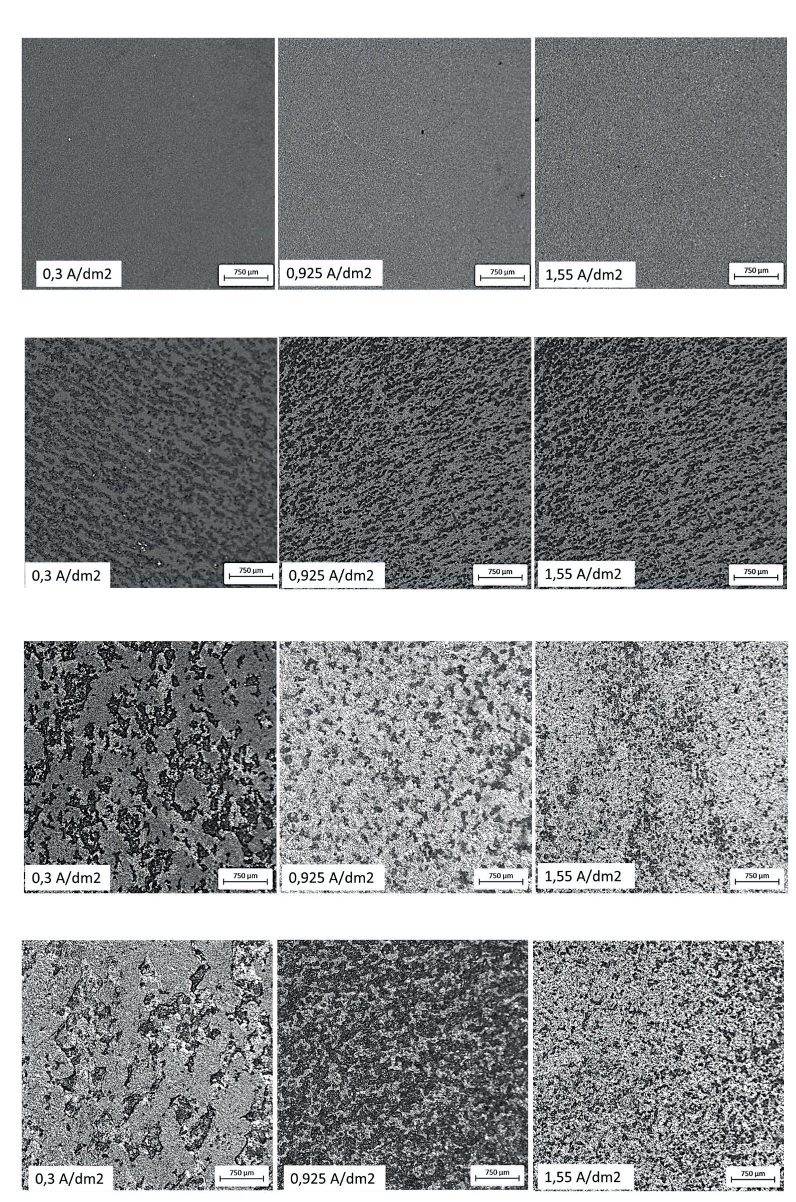
Lastly, the wear resistance characteristics were evaluated using a tribometer with reciprocating linear motion with a 5 mm amplitude and a velocity of 5 cm/s. A 6 mm diameter 100Cr6 steel sphere was used as the counterpart in the tests. The test length was set at 100 m with a constant normal load of 3 N.

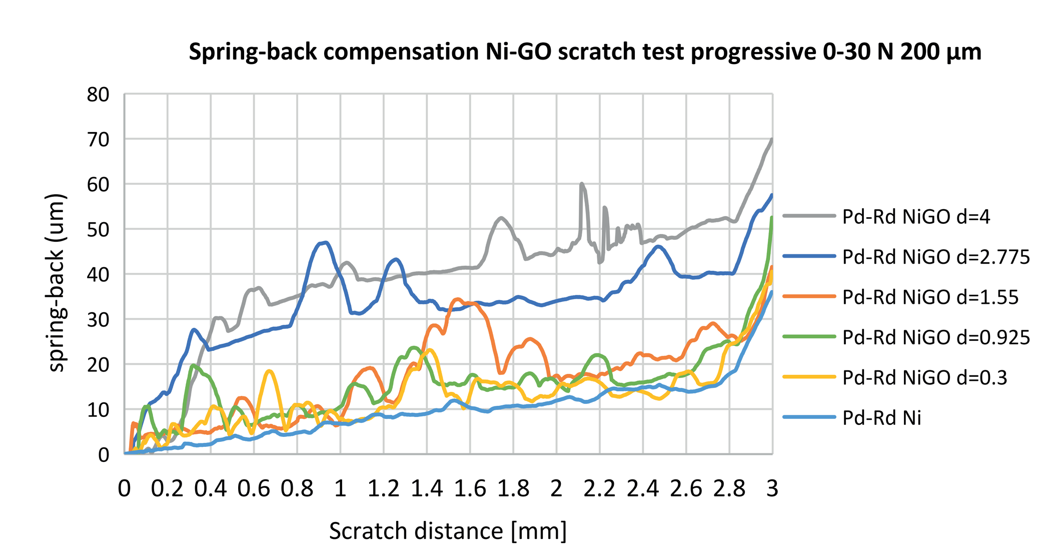
To assess coating adhesion, scratch tests were performed using a Rockwell tip with a diameter of 200 µm. The scratch length was fixed at 3 mm with a gradual load ranging from 0.033 to 30 N.

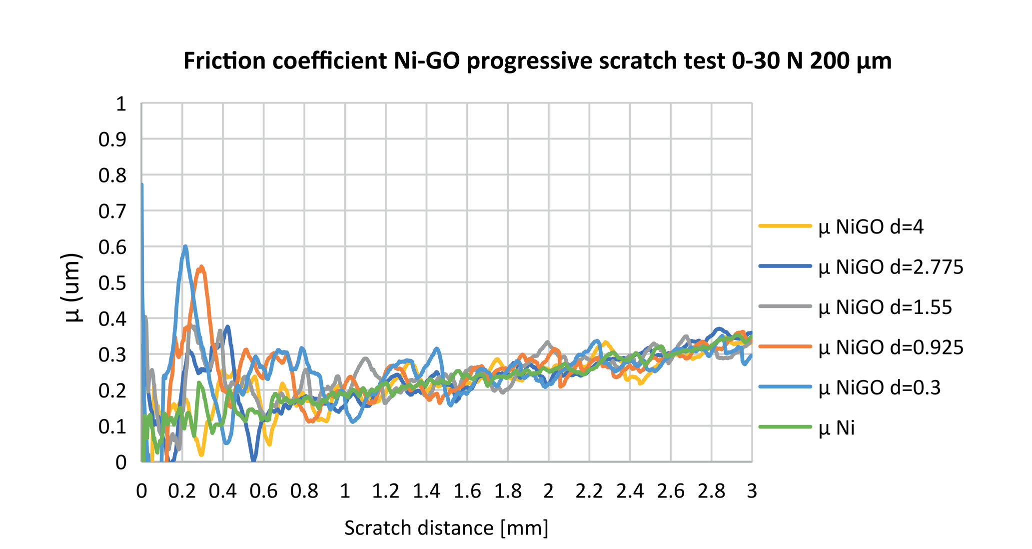
4. Results

Regarding Nickel coatings; the nickel coatings exhibit very low roughness values across all tested current densities, with a maximum roughness value of 1.06 microns. The roughness tends to increase at very low and very high current densities but remains relatively lower at intermediate values.
Regarding the Ni-GO coatings; the Ni-GO coatings show consistent improvement in quality across all tested current densities. At a current density of 0.3 A/dm2, there is a notable improvement of over 20% compared to pure nickel coatings. Elastic recovery increases with higher current densities. Ni-GO coatings exhibit a less stiff and compact structure compared to pure nickel coatings. All Ni-GO coatings demonstrate good adhesion.









5. Conclusions

Ni-GO and Ni-frGO coatings exhibit different wear mechanisms. Both Ni-GO and Ni-frGO coatings show varying roughness values, both higher than that of nickel. Ni-GO has Ra values ranging from 6 to 16 microns, while frGO exhibits values ranging from 1 to 14 µm. With both Ni-GO and Ni-frGO, an improvement in the coefficient of friction compared to nickel is achieved at every current density. In particular, at a density of 0.3 A/dm2, Ni-GO demonstrates a 20.93% improvement.
The elastic recovery of Ni-GO samples is higher than that of pure nickel, with the coating becoming stiffer at lower current densities. In all cases, good coating adhesion is observed.
An improvement in the coefficient of friction is evident as the concentration of frGO increases.