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Using Additive Processing to Harness and Implement Graphene Technology for Wear and Corrosion Protection

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USING ADDITIVE PROCESSING TO HARNESS AND IMPLEMENT GRAPHENE TECHNOLOGY FOR WEAR AND CORROSION PROTECTION

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BACKGROUND AND MOTIVATION

Since its discovery in 2006, scientists and engineers have attempted to find applications of graphene. As of 2022, nearly 20 different products have come to market taking advantage of one or more of graphene's amazing properties, e.g., use as a flexible touch screen for smartphones because of the high electrical conductivity, stiffness, and optimal optical properties of graphene. In much the same way, this study focused on using graphene in materials of naval interest like Al-6061.

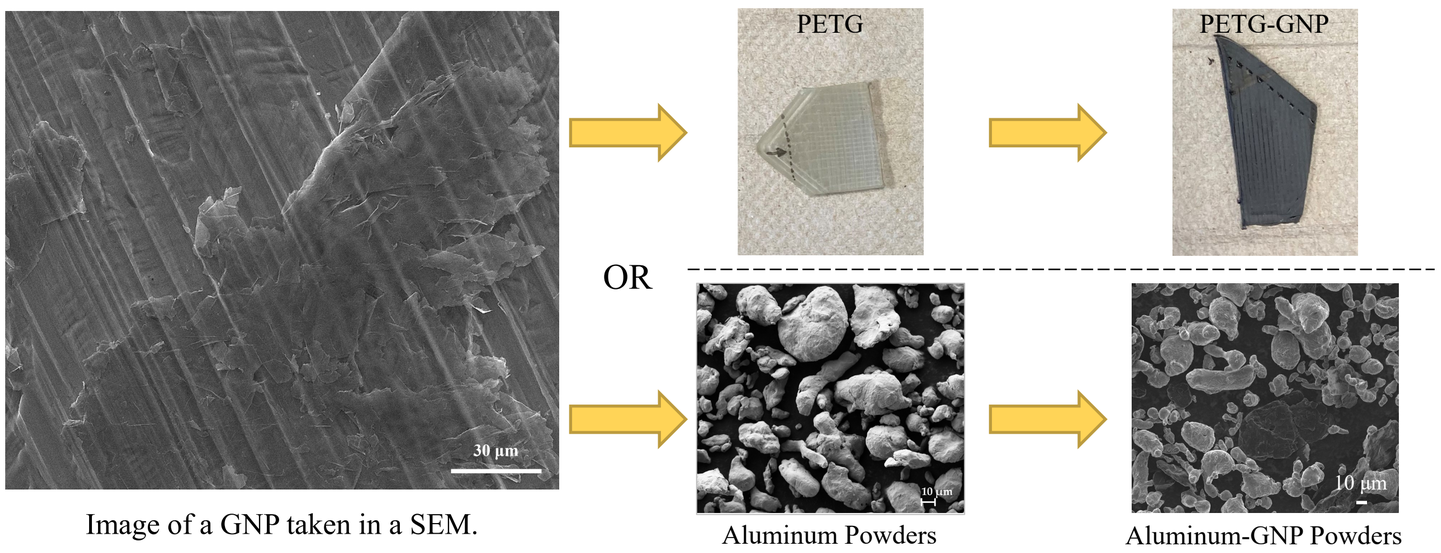


Image of a GNP taken in a SEM.

Aluminum Powders

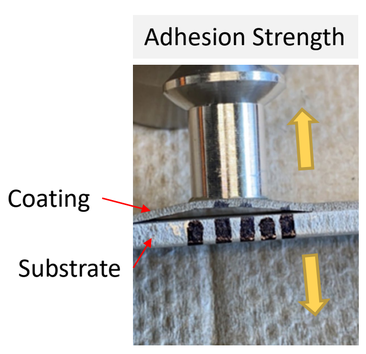
Aluminum-GNP Powders

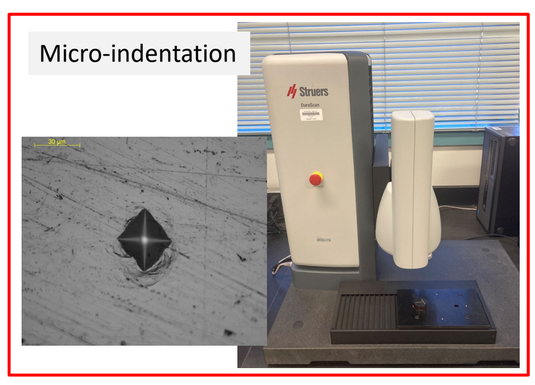
Graphene nanoplatelets (GNPs) were combined with either polyethylene terephthalate glycol (PETG) polymer composite or aluminum (Al) metal composite. The motivation for adding GNPs to a polymer or metal was, in both cases, to increase the wear and corrosion resistance of the part.

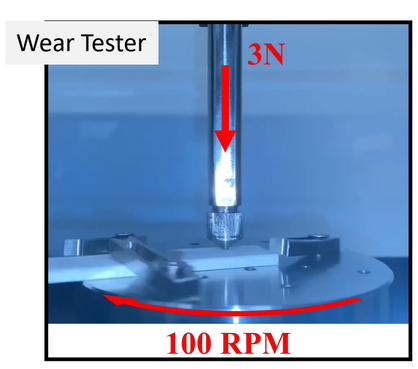
Another part of this investigation was to study any possible harmful effects of introducing graphene to the environment. This included our own bodies.

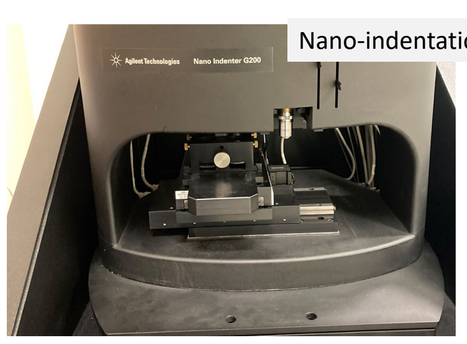
METHODS

- GNP mixed with PETG in a filament extruder and extruded as a printable polymer filament. This was printed in a Lulzbot Mini 2 into 5 cm square plates with 3 mm thickness.
  - Some of the polymer samples were exposed to UV, higher temperature, and higher humidity to accelerate aging and study its effects on wear.
- High energy ball milling was used to mix GNPs with Al powders specifically fabricated for cold spraying. Composite powders were sprayed onto Al-6061 substrate.
- Once printed or sprayed, several mechanical tests (shown on the right) were conducted on samples.



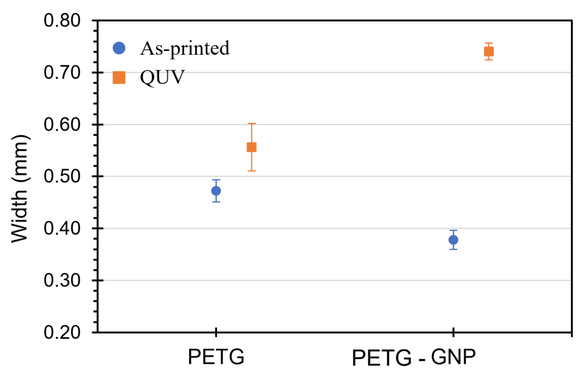


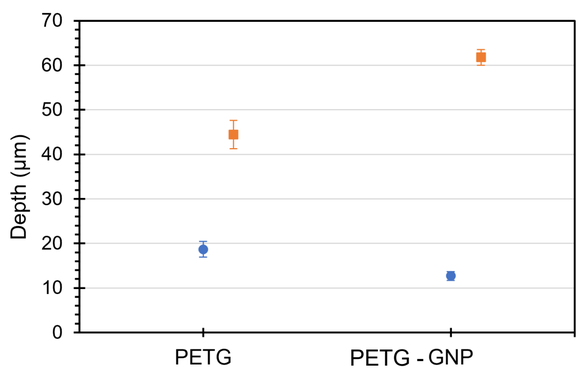


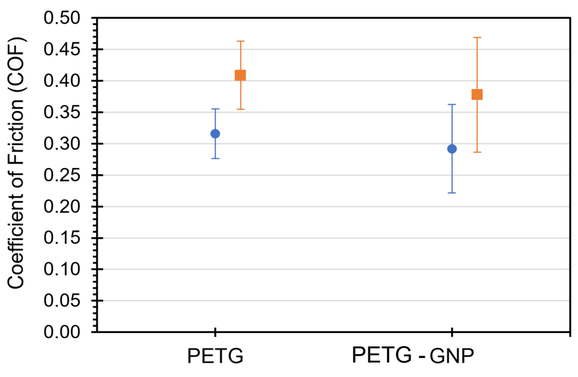


RESULTS

PETG-GNP

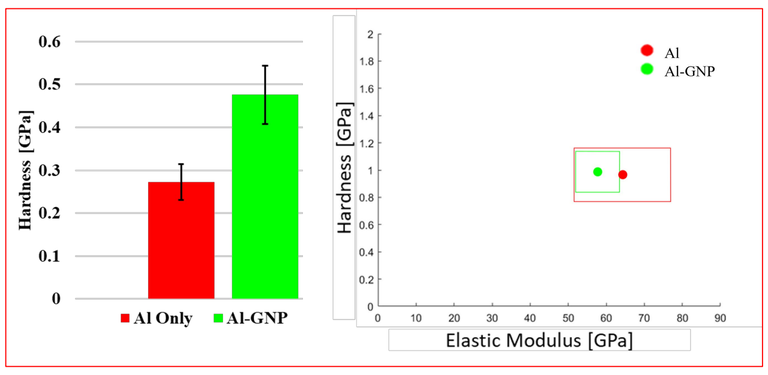




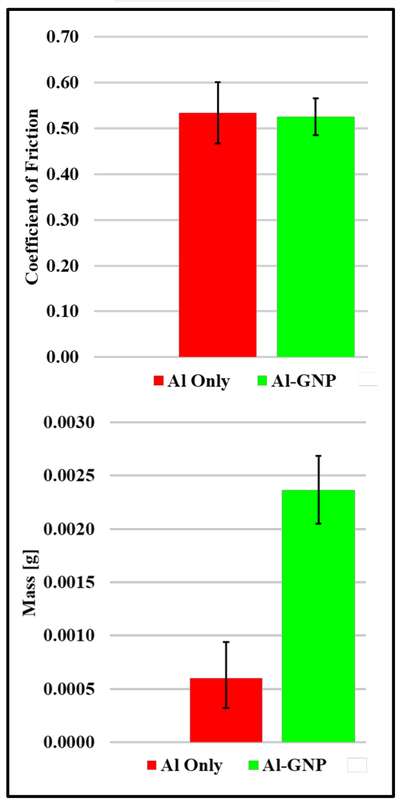


- Part distortion minimal in PETG-GNP after UV/heat exposure.
- Wear resistance higher for PETG-GNP samples that were unexposed.
- Wear resistance lower, however, for the exposed samples.
- GNPs likely contributing to wear in exposed samples.

Al-GNP



- Porosity was reduced by 45% with GNP addition. Thickness, however, reduced by 50%.
- Micro-indentation hardness increased by 75% with GNP addition. Nano-indentation showed no changes.
- Adhesion strength increased by 4%. The failure mode was delamination like in pure Al.
- Same coefficient of friction (COF) coupled with an increase in mass loss with GNPs indicate lower wear resistance of composite coating.



CONCLUSIONS

- GNP addition to PETG increased wear resistance when polymer composite not exposed to UV-B. UV/heat exposure reversed this.
- GNP addition to Al cold spray coating improved coating density and hardness. Adhesion strength was essentially the same and wear resistance was reduced with GNPs.
- In both cases, no more than 1 vol% GNPs were added. Future work should include examination of any trends in these properties with 2 or more vol% GNP added.
- Some literature suggests negative effects of graphene in the environment. Careful use and disposal of graphene products maybe needed but this requires further investigation.

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