Temasek Defence Systems Institute

Effect of Dual Nanoparticles Reinforcement and Heat Treatment on the Mechanical and Tribological Properties of Cold Sprayed Aluminium Coatings

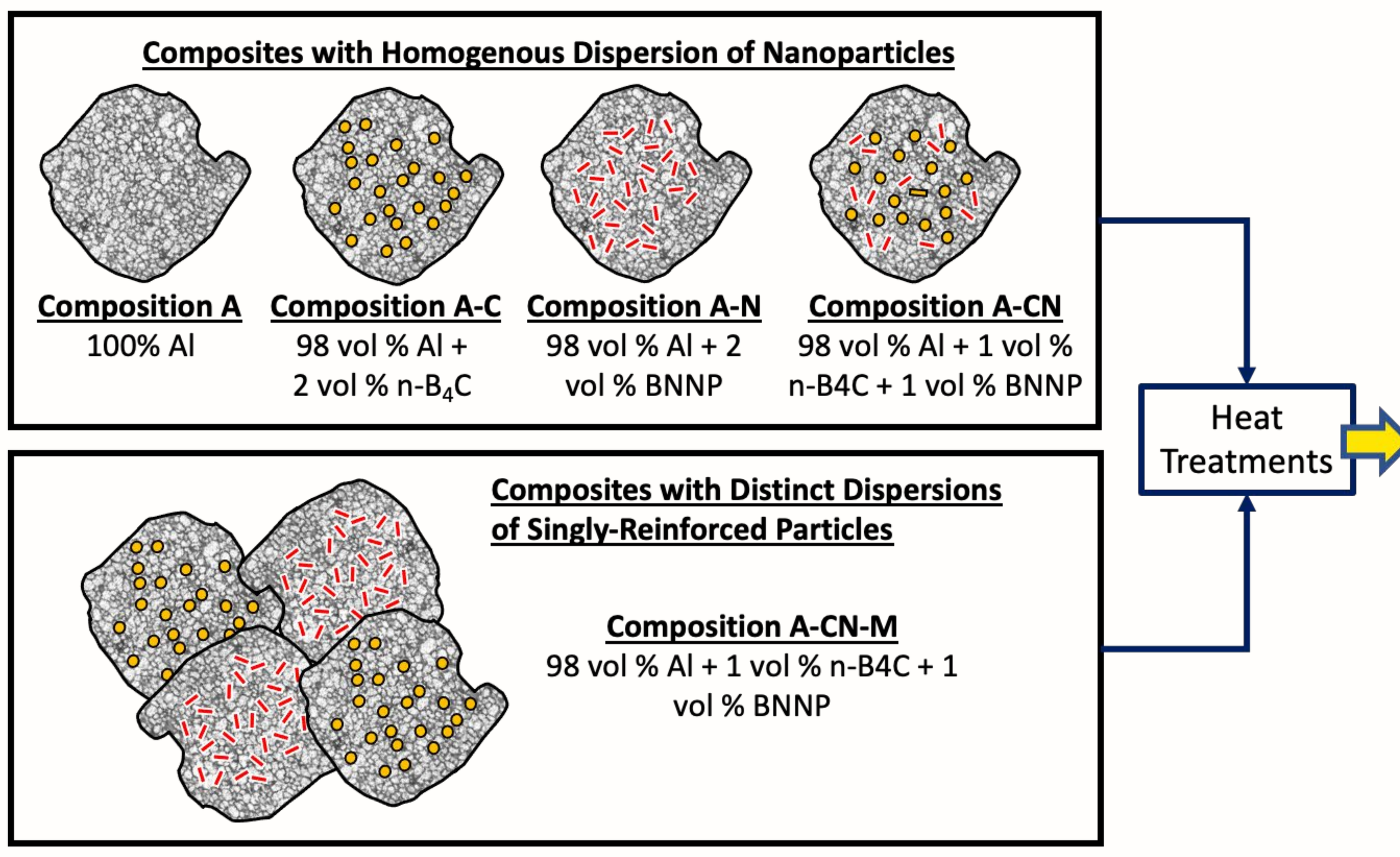
Author: ME5 Phua Kia Min

Advisors: Dr. Troy Ansell and Dr. Erick S. Alley

Motivation

- Over-utilization of military equipment results in degradation of its components and leads to failure being more commonplace.
- Militaries have adopted additively manufacturing (AM) to manufacture obsolete parts to replace damaged components
- Cold spray (CS) can be exploited by a military repair crew to repair any mechanical damages due to its portability and ease of setup.
- The control of its mechanical and tribological properties of the aluminium metal matrix composite formed by CS becomes critical.

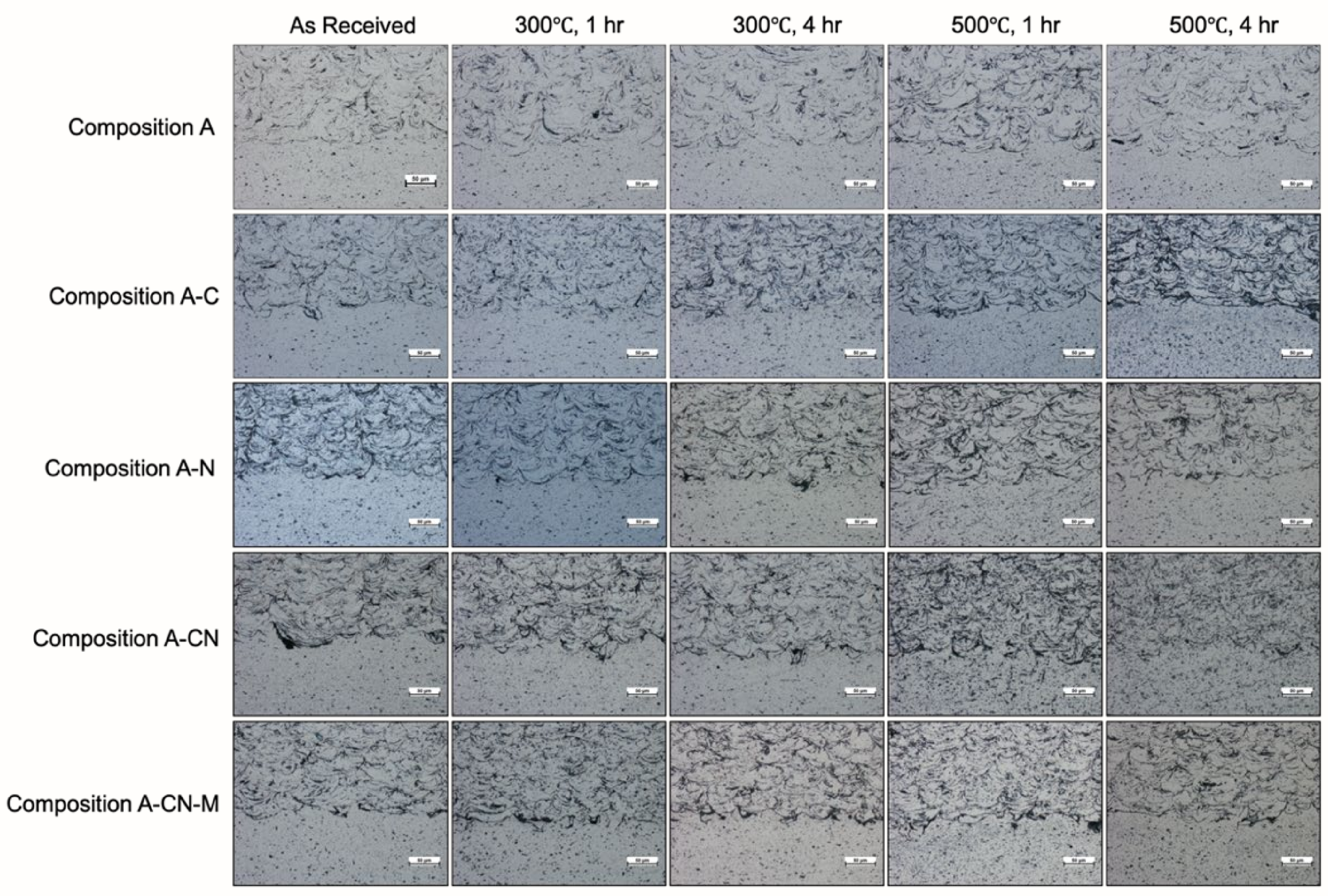
Objectives



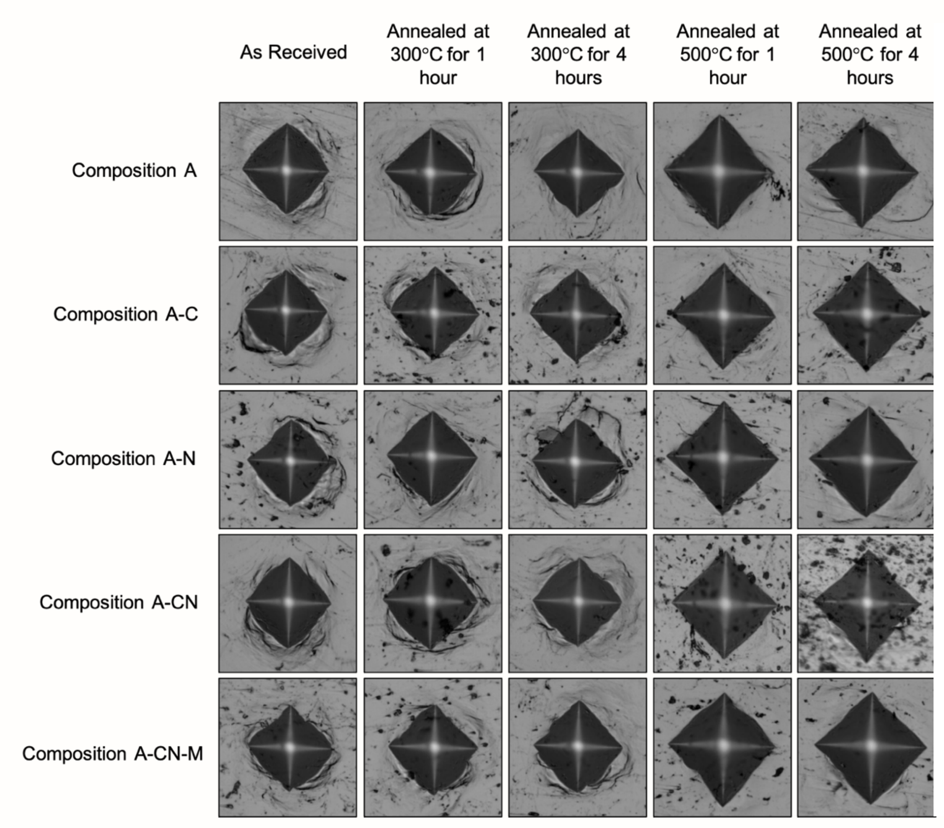
This study aims to provide a way for military engineers to control the desired **properties** of aluminum CS composites

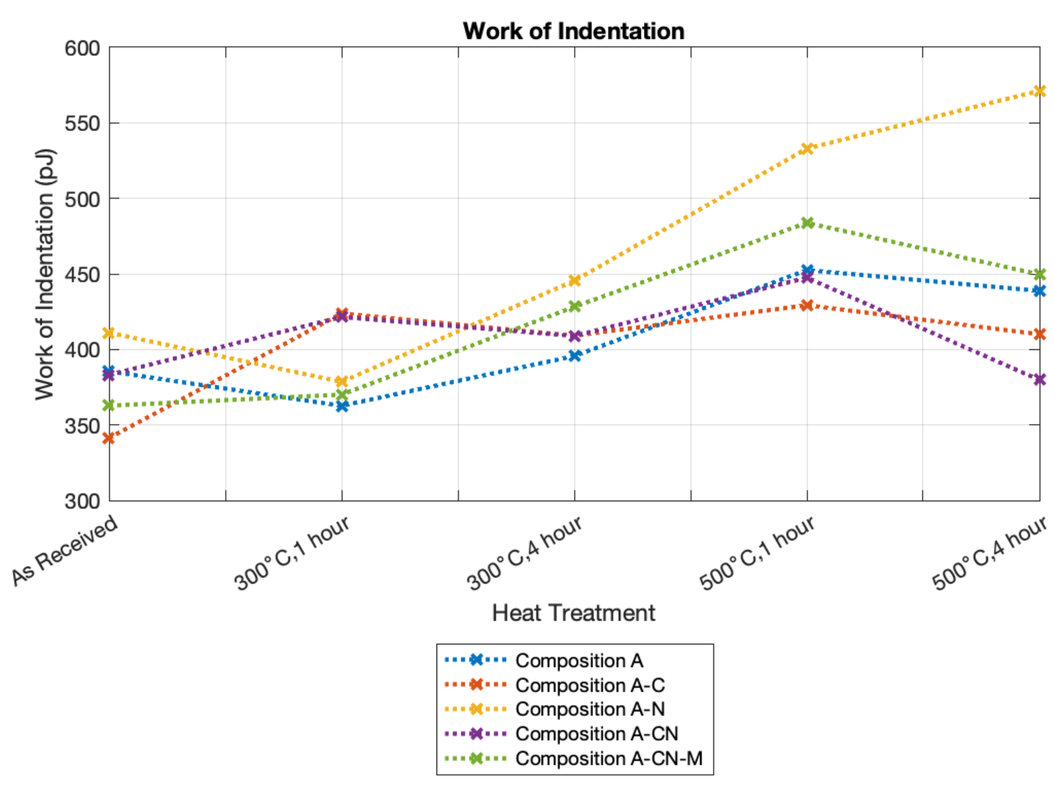
- Mechanical
- Tribological
- Microstructure

Metallographic Analysis



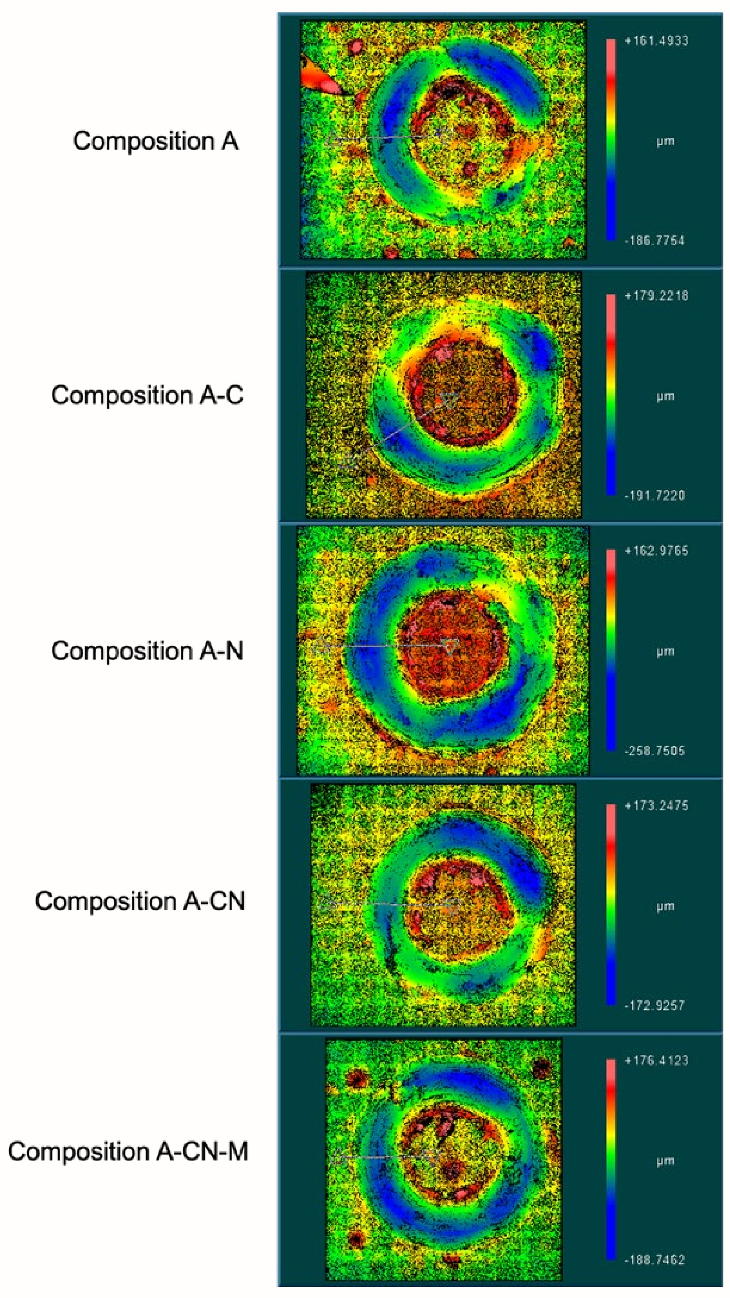
Nanoindentation & Microhardness Tests

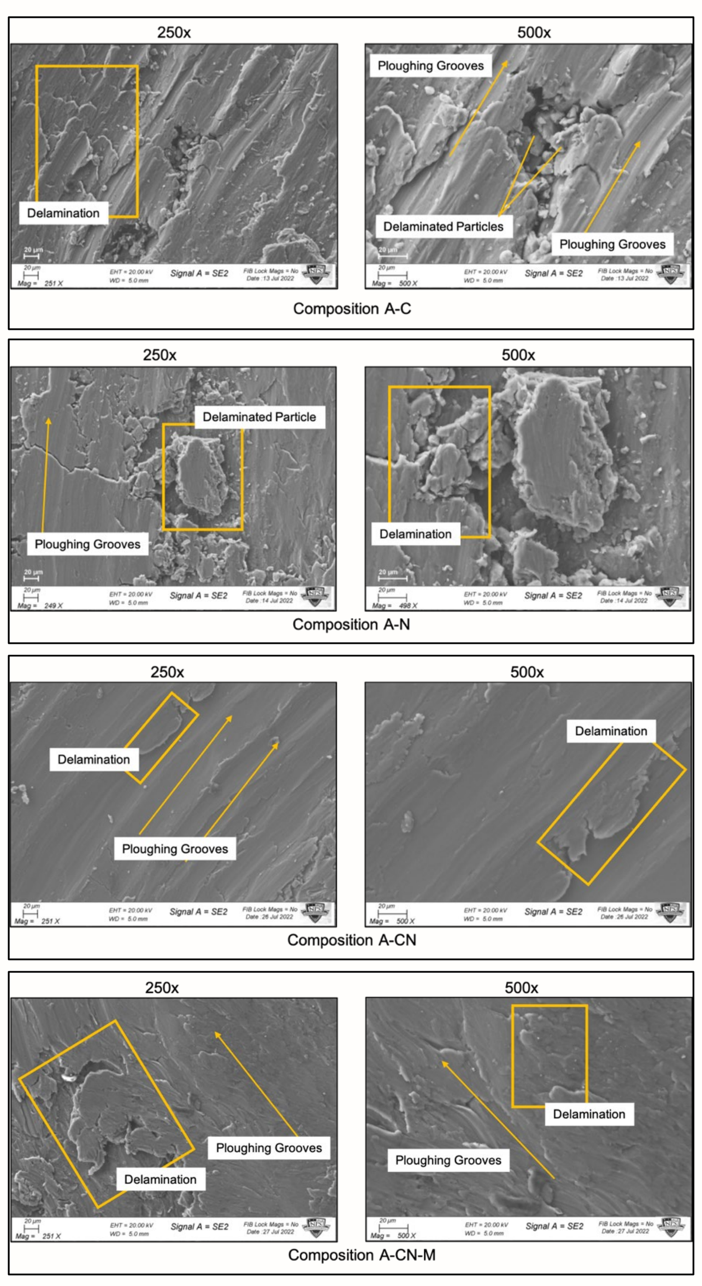




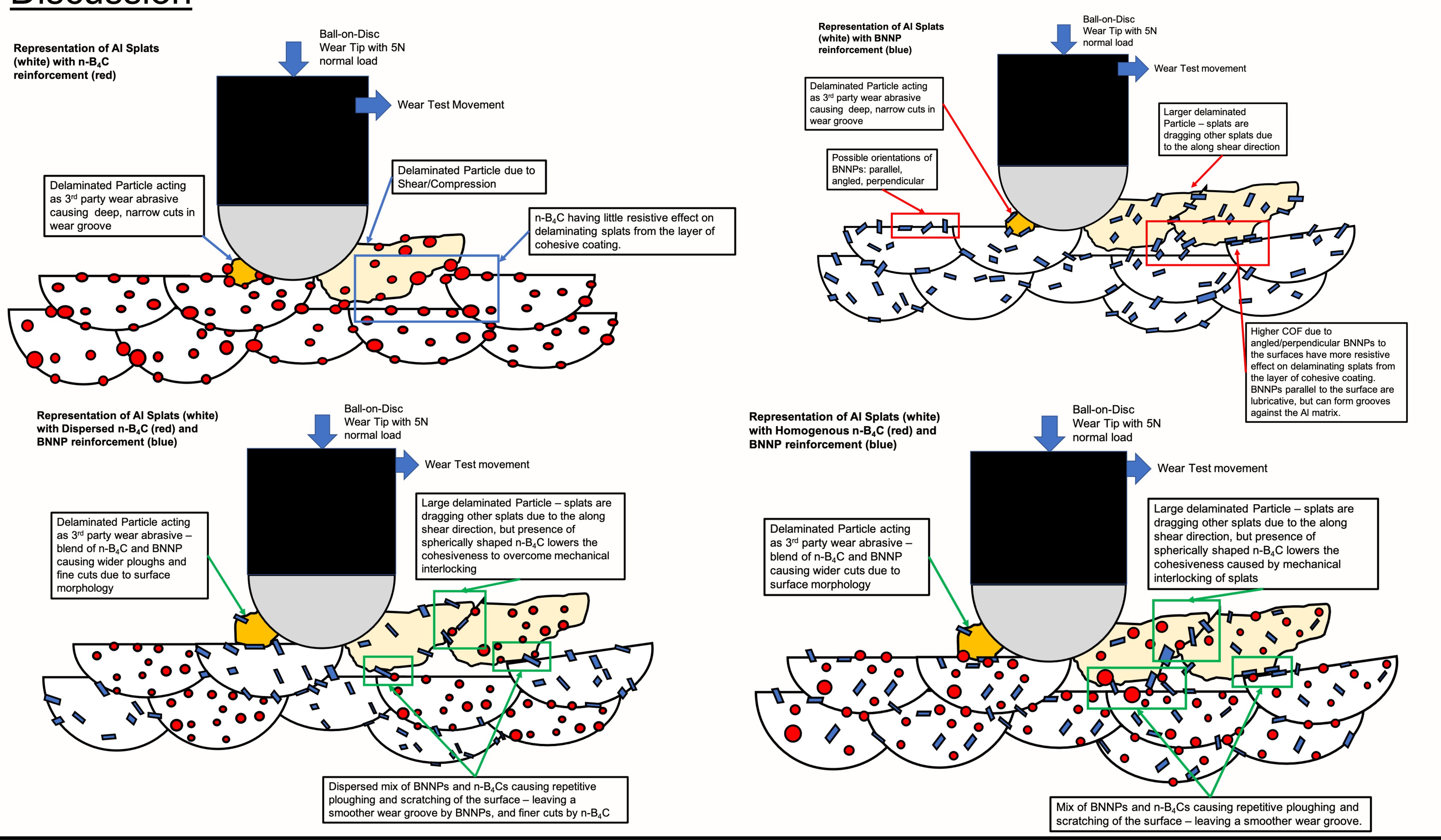
Tribological Tests and Specific Wear Rates

Composition	Average Width (mm)	Average Depth (µm)	Volume (nm³)	Specific Wear Rate[1] (m³/Nm)
A	0.9794	78.9640	0.5725	4.0519×10^{-10}
A-C	1.0888	101.5922	0.8188	5.7951×10^{-10}
A-N	1.0989	103.5406	0.8422	5.9608×10^{-10}
A-CN	0.9767	76.4467	0.5527	3.9118×10^{-10}
A-CN-M	0.9484	83.9462	0.5893	4.1708×10^{-10}





Discussion



Heat treatments saw almost no changes in the inter splat porosity and did not result in diffusion across splat boundaries.

At 500°C heat treatments, the bonding between the phases improved and saw that the contributive effects of n-B_4C and BNNPs on hardness of the composite.

Adding BNNPs to heat treated Al-MMCs reduced the stiffness while adding n-B_4Cs to heat treated Al-MMCs had a stabilizing effect on stiffness and as a consequence saw smaller improvements to WOI.

Adding both randomly oriented BNNPs with n-B_4Cs resulted in
- Large wear debris – BNNPs and n-B_4Cs as "spikes" that drag delaminated material along
- Low COF with low Specific Wear Rate – Homogenous mixture of BNNPs acting as ploughs and n-B_4Cs as small wear balls that cause a smooth appearance on the wear surfaces, but also interacts with other reinforcements to limit wear rate.

NUS National University of Singapore