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*Guest Editorial*

# Materials and Coatings for Defence Application

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Research activities on materials and coating for defense applications sky the limit. The idea for special issue on 'Materials and Coatings for Defense Application' nucleated quite some time back keeping in mind the direction of future research. However, it took its own time to translate it to actual fact. The purpose of this special issue is to bring out the recent development and progress in research activities in DMRL with regard to defense applications, introduce new comers to this area and foster interdisciplinary research among various communities working in this area. The special issue contains 15 manuscripts composed by various groups in Defence Metallurgical Research Laboratory.

A group of investigators in DMRL in collaboration with National Institute of Technology (Warangle) and National Institute of Technology (Suratkal) explored key aspects of both dynamic (DRX) and Static Recrystallisation (SRX) behaviour of a Cu-bearing HSLA steel developed in house in DMRL for naval application. The high temperature deformation response was examined using 'Gleeble' thermo-mechanical simulator. They established the significant role of Cu in retarding recrystallisation.

Another group developed fused silica radomes for high-speed target seeking missiles employing Cold Isostatic Pressing (CIP) followed by sintering. They also developed First-Wall (FW) of Test Blanket Modules (TBMs) from India Specific Reduced Activation Ferritic Martensitic (INRAFM) steel for International Thermo-nuclear Experimental Reactor (ITER) with the help of Hot Isostatic Pressing (HIP) techniques. The manuscript describes details of innovative processes to overcome the specific technical challenges met for the development of these components.

The first manuscript of armor group deals with development and processing of carbide free high strength nano-structured bainitic armour steels and its ballistic performance. The developed nano-structured bainite showed ballistic performance much superior to ARMOX 500 steel. The other manuscript from the same group evaluated the responses of Ultra High Molecular Weight Polyethylene (UHMWPE) laminates under various test temperature, impact velocity and impact angle. They observed that with increase of temperature, the contact duration increased whereas deceleration was reduced. They also addressed various failure mechanisms involved in energy absorption. The third manuscript of this group in collaboration with others described the effect of aging on microstructure, mechanical properties, texture and ballistic behaviour of AA-7017 aluminum alloy. They observed that the AA-7017 alloy shows the best ballistic performance in the peak aged condition. Distorted material flow lines and adiabatic shear band induced cracking is observed in the post ballistic microstructure of all the target plates. The ballistic response of AA-7017 alloy has been correlated with the variations in the microstructure, texture and mechanical properties with aging.

Titanium group of DMRL elaborated technological issues of indigenous development of titanium alloys such as Titan 29A for compressor sections of an aero-engine and Titan1023 and Titan 44 for aircraft structural applications. His study involves the effect of processing on texture which affects the fatigue and the dwell fatigue life. He also discussed the process of indigenous development of another high strength, deep-hardenable β Titanium alloy, Ti-5Al-5Mo-5V-3Cr for thicker structural sections of an aircraft.

Few researchers from magnetic materials group explored the structural features, glass forming ability and soft magnetic properties of melt spun ribbons of $(Fe_{1-x}Co_x)$ 88-yVyZr7B4Cu1 alloys. They noted that the Ms decreases with increasing V content due to the non-magnetic nature of V, coercivity increases with annealing in all V added alloys due to the low volume fraction formation of bcc α-Fe(Co) phase and $Fe_2Zr$ phase, Curie temperature of amorphous phase decreases with increasing V addition. V addition leads to low volume fraction of bcc α-Fe(Co) phase and promotes $Fe_2Zr$ phase.

Other researchers from the same group, studied surface morphology and exchange bias anisotropy in large area deposited $Co_2FeSi/Ir_{50}Mn_{50}$ multi-layers for spintronic applications. They deposited films over 3-inch size wafers with uniform film composition, thickness, smooth surface, good crystallinity and magnetic properties. The isotropic magnetic properties such as saturation/remanent magnetizations, coercivity were achieved in $Co_2FeSi$ films deposited on 3-inch size $Si(100)/SiO_2$ wafers with 15 nm Cr buffer layer.

Adiraj, *et al.* from the same group reported development of lead free magnetoelectric materials for magnetic field sensor to be used for degaussing as well as sensing the magnetic signatures related to naval applications. They obtained around 80 % higher than the previously published literature on NBT-NFO composites magnetoelectric voltage coefficient. This was attributed to the uniform distribution of grains with each ferroelectric phase surrounded by ferrite phase.

Scientific investigation from powder metallurgy group reveals promising mechanical properties of tungsten heavy alloy rod prepared using tungsten metal powder produced from heavy alloy scrap. Their study highlights the potential of recycled powders in the production of premium quality heavy alloy long rods for stringent applications such as kinetic energy penetrators.

The ETC Center along with die design group discussed the technical/technological details of the various aspects associated with development and manufacturing of High Pressure Turbine Blades (HPTBs) for utilization in an indigenously-developed small turbo-fan engine. They adopted vacuum investment casting process for realization of the above equiaxed components using a Ni-base superalloy.

The manuscript from tribology group concerns with development of tribological coatings for aerospace and missile applications. A cermet coating based on carbide to resist wear, an abradable coating based on cobalt alloy to control clearance between the blade tip and shroud for gas turbine aero-engine application and a low friction coating developed for a missile application are subject matter for their manuscript.

The high temperature coating group provides an outline of brief overview of the advanced oxidation resistant and thermal barrier coatings developed in DMRL. The effectiveness of the TBCs in preventing dimensional degradation of the metallic and composite substrate materials has been evaluated at the laboratory scale. The developed TBCs have the potential for use in aero-engines and propulsion systems of hypervelocity vehicles. Brief description of recent development of various TBC and oxidation resistance coating has also been described.

Methodology for application of damage mechanics approach to model high temperature fatigue damage evolution in a turbine disc super alloy was discussed in the manuscript from mechanical behavior group. A good correlation has been established in the damage mechanics based model's predicted damage and experimentally determined values for Ni base super alloys.

The special melting group investigated microstructural evolution and mechanical properties co-relation of cold-rolled ferritic lightweight steel with increasing carbon content. The addition of carbon to Fe-7wt % Al steel has improved its tensile strength significantly (438 to 828MPa). Tensile elongation, on the other hand, has decreased dramatically (26 % to 12 %) with increasing carbon content. The reduction in ductility with increase in carbon content is mainly ascribed to the increase in volume fraction of κ-carbide precipitates having higher hardness.

Although we are successful to cover several areas of Defence research on materials and coatings, we did miss some areas because of time constraint. We hope that this special issue encourages researcher to take up defence research. We wish it incites collaborative research across various DRDO laboratories and also across India. We also look forward to consider it as a guide for leading researchers.

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