

MILITARY NANOTECHNOLOGY

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Abstract

Nanotechnology (NT) is the study of manipulating matter on atomic and molecular scale. Nanotechnology deals with structures sized between 1 to 100 nanometer, and in at least one dimension (Quantum Dots are of zero dimensions). Dominance of electromagnetic force, the presence of quantum mechanical phenomena, the large surface area to volume ratio and the importance of random kinetic motion cause nano-scale sized particles to often have very different properties than their macro-scale (bulk matter) counterparts. NT enable military technologies will ensure high speed and high capacity systems for command, control, communication, surveillance; automation and robotics for minimizing exposure war fighters, first responders; superior platforms, weapons with miniaturisation.. The military use of nanotechnology should lead to higher protection, more lethality, longer endurance and better self-supporting capacities of future soldiers. Nanotechnology could greatly improve some of the existing technologies that will be fitted on military platforms and thus create new operational opportunities or, at least, help the engineers to deal with some shortcomings The paper is a review of NT applications in military technology and proposes few applications for Air force in particular. Still very little is known about NT and its side effects. Old systems can replace subsystem with NT enable sub-system for enhance operation capability like survival kit modernization in fighter aircraft ,quantum dots enable display system of aircraft and Aircraft canopy can be coated with CNT. NT enable combat suit is need of the hour for Armed Forces. It is unknown if producing items this small could be dangerous to the manufacturers or the soldiers using them for protection, as it is not known if the nanoscale devices could penetrate cell membranes and skin on the human body. Research will continue to be done, and hopefully the possibilities can do more protecting and helping than damaging as we enter in new “nano age”.

Index Terms: Personal Digital Assistant (PDA), Nanobots, Carbon Nano Tubes (CNT), NAVs, MAVs, Nanoscale energetic materials (nEMs), and RCS.

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1. INTRODUCTION

Nanotechnology, originally coined by *Norio Taniguchi* in 1974. One nanometer (nm) is one billionth, or 10^{-9} , of a meter. NT is the engineering of functional systems at the molecular scale. There are four basic forces in nature, gravity, electromagnetism, strong nuclear force, and weak nuclear force. There are four main things that change from macro-scale objects. First, due to the small mass of the particles, gravitational forces are negligible. Instead electromagnetic forces are dominant in determining the behaviour of atoms and molecules. Second, at nano-scale sizes; we need to use quantum mechanical descriptions of particle motion and energy transfer instead of the classical mechanical descriptions. Third, nanosized particles have a very large surface area to volume ratio. Fourth, at this size, the influences of random molecular motion play a much greater role than they do at the macro-scale. Dominance of electromagnetic force, the presence of quantum mechanical phenomena, the large surface area to volume ratio and the importance of random kinetic motion cause nano-scale sized particles to often have very different properties than their macro-scale

(bulk matter) counterparts. The discovery that the properties of a substance can change with size (made possible by the new generation of scanning probe microscopes) has helped us to expand our understanding of the nature of matter and to develop new products that take advantage of the novel properties of materials at the nanoscale.

1.1. Military Potential Applications

Armies throughout world are looking for a 21st century battle suit. The clothing must stop bullets, detect chemical, biological agents, monitor a wounded soldier's vital signs, administer basic first aid, and communicate with Headquarters. NT produces stronger, less weight material which is ideal for military applications [1], [2]. Nano-materials (CNT) enable the following material functionalities in uniforms and equipment to make them stronger and lighter could lead to nanofiber-like materials that break off from uniforms and equipment and enter the body and environment.

1.2 Light weight

High strength nano-composite plastics are expected to replace metal and thus reduce weight and Radar signature (RCS) of military weapon platforms. Smart components, with built-in condition and load monitoring sensors improve monitoring of important parameters. Self-repairing or self-healing materials, Shape memory alloys which memorise shape are also possible with NT. Shape memory alloys are used in sleeves of fighter aircraft.

1.3 Adaptive Structure

Active structures that adapt to changing conditions such as adaptive camouflage, suspension, flexible/rigid, nanofluids, and shape memory alloys as example of adaptive materials.

1.4 Reduce Vibrations

Composites in aircraft also reduce vibrations. In aircrafts particularly in rotator wing suppression of vibration is a great design challenge. NT composite reduces vibrations.

1.5 Stealth Nanotechnology

Radar absorption coatings, camouflage and composites reduces RCS. NT is used for developing these materials antiballistic structures, reactive nanoparticle armour, and shock absorbing nanotubes. Nanoparticles are used as surface coverings to make it harder, smoother, and/or stealthier. IR image also reduces with composites.

1.6 Filter

Nanomaterials used in filters to remove selected impurities from fluids could become very low in cost and hence ubiquitous, and result in many small but discrete concentrations of possibly toxic impurities. "Argonide Nanomaterials" filters can be used in war where water contamination is biggest threat.

2. APPLICATIONS UNDER DEVELOPMENT

Body Armor made of CNT is 117 times stronger than steel, these can be used for bullet proof, helmets and safety device bullet-proof vests are basically made from high stiffness and toughness, woven or laminated, polymeric fibers stacked in a number of layers. Upon impact of the striking bullet, the fabric material absorbs the energy by stretching of the fibers and the stiff fibers ensure that the load is dispersed over a large area throughout the material. CNT is an ideal candidate material for bulletproof vests due to its unique combination of exceptionally high elastic modulus and high yield strain. If one compares these values with those for other fibers suitable for

ballistic applications, the enormous potential of CNTs as a candidate material for bullet-proof armor system is quite evident. *Abalone shell* can be used as body armour.

2.1 Armour Vehicle

Armour Vehicles uses Al₂O₃, which is standard high performance form a grain size of 2-10 micro-meter; Vickers hardness of 1,750 (HV 10); a binding strength of 385 MPa and elastic modulus of 410 GPa. Nano crystalline version of Al₂O₃, Silicon carbide (SiC), with grain size of 50 nm and 20 nm respectively. This offer hardeners value 3,000 with 70/840 MPa and elastic moduli of 680/900 GPa. "Nanodyne" makes a tungsten-carbide-cobalt composite powder (grain size less than 15nm) that is used to make a sintered alloy as hard as diamond, which is in turn used to make cutting tools, drill bits, armour plate, and jet engine parts.

2.2 Nano Fibre

Primitive NBC suit reduces soldier capability because it can't pass air. NT in cloths nonwoven composite fabrics can be made 25% lighter and stronger than current woven military uniform fabrics. In addition, they can be made to exhibit over three times the air permeability or breathability of the current woven military uniform fabrics. Uniform fabric will offer enhanced abrasion resistance, develop a fire and chemical/biological resistant fabric and offer combination water repellent/moisture absorbent composite fabric.

Nano-silver socks/undergarments will remain hygienic for days in war scenario, where it is impossible to change undergarments.

2.3 Nano Food

NT enable food will last more without getting rotten, these foods are ideal for war where supply of food is difficult. Nano-Silver packed food withstand days together without damage. These foods can be used in disaster recovery teams, in war and hash areas like very high altitude areas where fresh food is a difficulty.

2.4 Nano Machines

Nanosopic machines, called *assemblers*, can be programmed to manipulate atoms and molecules at will. It would take thousands of years for a single assembler to produce any kind of material one atom at a time. Trillions of assemblers will be needed to develop products in a viable time frame.

In order to create enough assemblers to build consumer goods, some nanomachines, called replicators, will be programmed to build more assemblers.

Trillions of assemblers and replicators will fill an area smaller than a cubic millimetre, and will still be too small for us to see with the naked eye. Assemblers and replicators will work together like hands to automatically construct products, and will eventually replace all traditional labour methods. This will vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger.

2.5 Nano Energetic Materials (nEMs)

Nanoscale energetic materials (*nEMs*) offers much higher energy densities, faster rate of energy release, greater stability, and more security. Batteries used for combat gadgets with *nEMs* definitely have much less weight and a relief to soldiers. Nano-inspired batteries will provide reliable power to military weaponry while requiring less volume themselves. Shrinking batteries will enable devices to shrink in size. *nEMs* reduce battery weight by 20% to 30% which mean soldiers to carry less weight in war.

3. FUTURE APPLICATIONS

The military use of NT should lead to higher protection, more lethality, longer endurance and better self-supporting capacities of future soldiers [4]. Water purifier kit, which will be the part of survival kit in jungle operation to clean water to drink.

3.1. Electro Chromic Camouflage

With NT electro chromic camouflage can be achieved, by which soldiers can disappear to, seen by naked eye. Fabric made of Electro-chromic camouflage, which changes colours instantly to blend in with the surroundings. Nano enabled paint currently developing a special paint that makes drones, missiles, or aircraft simply disappear, or to be more precise, they become very difficult to detect. NT developed envelopes the object, absorbs the radio waves emitted by the radar, and releases them as heat energy scattered in space. In doing so, the material disguises the object, making it difficult to identify by Radar.

3.2 Fabrics

Dust repellent /strain resistance/ fire resistance cloths for warfare. Nanopolymers developed for soldier act as fabric to breakdown bio/chemical warfare agents. Biosensors can be used to monitor a soldier's health. Nano sized silicon carbide particles for physical protection.

3.3 NanoSensors

NT enable tiny sensors called nano-units, of which some simple types are available like "smart materials" that change in response to light or heat. "Nano-bots" are tiny mobile robots that have yet to be developed but are theoretically possible; and self-assembling nano-materials that can be assembled into larger equipment. Artificial "*electronic nose*" trained to detect toxic gases and vapours for detection of bio/chemical/ nuke agents. "*Nanowires*" built from sub-micrometer layers of different metals, including gold, silver and nickel, are able to act as "barcodes" for detecting a variety of pathogens, such as anthrax, smallpox, ricin and botulinum toxin. The approach could simultaneously identify multiple pathogens via their unique fluorescent characteristics.

3.4 Condition Monitoring

Modern maintenance philosophy is based on on-line monitoring and e-maintenance. Nanosensors are engraved in structure of aircraft. Important flight parameters can be monitored at base station even in case of aircraft is flying from one place to another.

3.5 War Tag

Smart NT alloy with RFID is proposed as war tag with nanosensor, presently, Indian Armed Forces soldiers use metallic piece on which name, number and religion is engraved. In miniaturization of gadgets like RFID/search and rescue mission, nano sensors embedded in combat suit can emit signal which can be picked by search and rescue operation. Nano enabled PDA, weapon, watch as shown in figure-1.

3.6 Artificial Muscles

Enhancing soldier capabilities with artificial muscles that could enable soldiers to leap tall walls, if wounded or required, uses nanotechnology and electricity. It flexes when jolted by electricity, and then relaxes when the electricity is turned off. So far, though, its reactions are much too slow.



Fig-1 Solider with NT enabled PDA, weapon and watch

- Nano enabled medicine for solders, for and curing crack bones in field without plaster. Field ambulance units of Armed Forces should carry these instant NT enable medicine for war. If a soldier is injured in the arm or leg, nano-fibers in the uniform, the fabric would constrict into a tourniquet. This will be a real life-saver, because half of all battlefield deaths are due to massive blood loss before wounded soldiers can be treated.
- Composite materials made of NT having no metals, light weight and more strength with low RCS in military aircraft can make military aircraft more lethal. Aircraft with NT materials have more thrust to weight ratio, less maintenance problems and more lethal. MEMS (Micro Electro Mechanical Sensors) reduce the overall size of equipment [4], now with NT it is NEMS (Nano Electro Mechanical Sensors) and OLED (Organic Light Emitting Diode); the future of television, as electricity passes over the thin nono-polymer film layer it produces colour and light. More Dots of lights mean a better picture, less power consumption. Displays will be better and small with less power consumption. Modern armies with electronic gadgets want less weight to carry by solders. NT will help to reduce the weight of electronics but also helps in, fast processing, better display and sleek dimension of palm tops, laptops or PDA by NT.

4. RESEARCH AREA

4.1 Nano sensor

Nano Air Vehicle (NAV) aims at an extremely small (less than 7.5 cm wing span), ultra-lightweight (less than 10 grams) air vehicle system, designed for indoor and outdoor urban military missions as shown in figure -2.

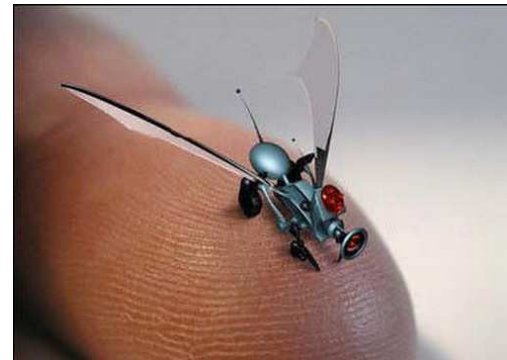


Fig -2 NAV

4.2 Mote

"Smart dust" as shown in figure-3, is a device which contains tiny wireless Micro Electro Mechanical Sensors (MEMS) that can detect everything from light to vibrations. "Mote" is a autonomous sensor with power source, processor, Tiny Operating system and Antenna. They form Adhoc networks in tactical / disaster area. "Mote" weighs not more than 10 grams and can carry a payload of up to 2 grams. The will help protect the lives and enhance the operational effectiveness of soldiers and first responders in case of disaster.



Fig-3 Smart Dust (Mote)

4.3 Nano Poisons

Most people think of poison as a tool for killing tool, but NT, with its ability to trigger specific brain functions, will provide a whole new menu of poison options. As an example, a liar-poison will make it impossible for someone to tell the truth. A *kleptomaniac* poison will make it impossible for the person to stop stealing things. An alcoholic poison will make a person unable to stop drinking alcohol. The obesity poison will cause a person to eat themselves to death, and favourite the "frontal lobotomy poison," that will make a person incapable of being angry or mean.

5. NT FOR IN-CAPACITATIVE AGENTS

5.1 Nano Mind Erasers

Neutralizing a person's memory can often be a more powerful defense than killing them. Micro fields flaring up in a succession of unnoticeable tiny brain bursts may wipe sections of a brain clean without anyone ever noticing.

5.2 Nano Needles

Invisible to the human eye, nano diameter needles will be shot like clusters of bullets from great distances to "pin" people to a wall or freeze their physical movement. Nano needles, because of their tiny diameter, will be the ultimate non-lethal weapon, leaving no visible wounds and causing no permanent damage. This may be used as arrest intruder without harming or killing him.

5.3 Water Bullets

As a different kind of non-lethal weapon, self-contained water balls, formed around an elevated surface tension containment system, will be used to knock people down, and temporarily rendering them harmless.

5.4 Desynchronized Energy Fields

Binary power, created by the intersection of two otherwise harmless beams, has the ability to disrupt the energy fields in an individual. A person with desynchronized energy fields will feel extremely fatigued, and pushed to a more extreme level, will drop unconsciously to the ground. New form of stun-gun with NT.

6. PROPOSED APPLICATION

NT enable survival kit is a part of ejection seat in fighter planes. For survival of pilot, military aircraft contains survival kit which is used in case of ejection. The survival kit contains essential items like (knife, water purifier tablets, high calories chock lets and pistol). It is proposed to modernize the contents of survival kit with following:-

- Nano enabled high calories eatables, Nano bandage, Nano medicine (nano-bio fusion), Nano water purifier, nanosensor (RFID, tag).
- Weapon and power source with NT reduces weight for soldier to carry by 20-30%. PDA and watch which will communicate with Net centric warfare control room.
- NT enable war tag with RFID, so that it can be used by rescue and search also.

6.1 Aircraft Canopy

Aircraft canopy can be coated with CNT which will not only give strength but also reduces Electromagnetic Interference (EMI) from space which is dangerous for pilot as well as for avionics electronics. "Argonide" using aluminum nanoparticles, argonide has created rocket propellants that burn at double the rate. They also produce copper nanoparticles that are incorporated into automotive lubricant to reduce engine wear.

6.2 NT in Aviation

CNT polymer composites have high Young's modulus, high thermal performance and crash resistance, some of CNT for aircraft structure are CNT/polyimide, CNT epoxy, and CNT/PP. Aero engine performance can be enhanced by SiC nanoparticles, SiC particle reinforced alumina. TiN nanocrystallites embedded in amorphous Si₃N₄ are used for Wear-resistant coatings. Nanographide nanosilica is used in gaskets for aircraft. Nano fabrics are used for Arrestor barrier and tail parachute for fighter aircraft. Nanochromium is used for corrosion resistant.

6.3 UCAV (Un-Manned Combat Aerial Vehicle)

NT enabled UCAV as shown in Figure -4 are very small with low RCS as most of the portions are made of composites. NT enable weapons are too small and more lethal as compared to conventional weapon. These pilotless UCAV can be deployed in Hostile terrain and adverse weather when fighter flying in not passable.

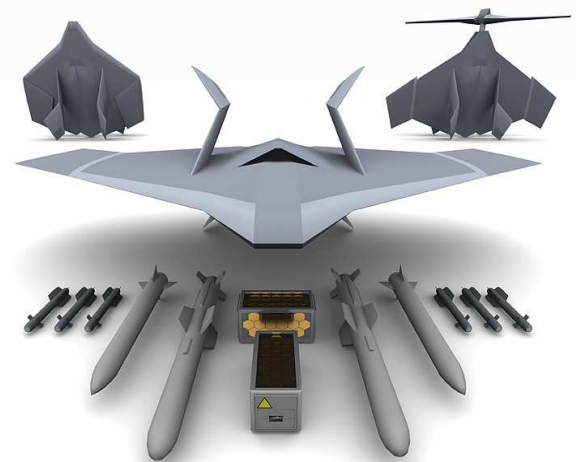


Figure-4 UCAV (Low RCS)

7. CONCLUSION

NT is multidisciplinary; it is used for improving existing technologies and exploring new compounds. Using NT to create materials with properties that will revolutionize military technology, from processors to display screens and body armor to air filters. This is a beginning and still lot to do, however there are potential applications in military technology. A future of nano-dust spies, sentinels, and defensive weapons, is one that most of the world's military specialists are unprepared. Yet most of these weapons are far closer and easier to devise and build, than the molecular nano-assembler, the horn of plenty that most people think of when they think of a future NT.

Nano-weapons combined with bio/chemical and genetic weapons; provide the budding world religious or ideological dictator with far more ultimate power than a few nuclear weapons.

Every measure has a counter-measure. But not everyone will have the resources to obtain counter-measures, when the means of deadly attack becomes nearly ubiquitous.

Soldier capabilities can be enhanced by NT with strong, lightweight materials for soldier systems and system components adaptive, multifunctional materials for soldier systems and system components novel detection and protection schemes for bio/chemical warfare threats and identification of friend or foe. Remote and local soldier monitoring systems, wound and injury triage and emergency treatment systems to enhance soldier survivability novel, non-combat and combat performance enhancement systems for the soldier system that would improve soldier survivability.

Still very little is known about NT and its side effects. It is unknown if producing items this small could be dangerous to the manufacturers or the soldiers using them for protection, as it is not known if the nanoscale devices could penetrate cell membranes and skin on the human body. As society continues, research will continue to be done, and hopefully the possibilities can do more protecting and helping than damaging as we enter in new "nano age".

It is proposed to modernize old systems with NT enable systems. Design of military weapons and platform should incorporate NT in each aspect for miniaturization effectiveness, less weight and more effectiveness. Old systems can replace subsystem with NT enable sub-system for enhance operation capability like survival kit modernization, display system of aircraft. NT enable combat suit, systems and weapons are need of the hour for Armed Forces.

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BIOGRAPHY

Anupam Tiwari , Senior Member , IETE- N-Delhi, 2008 received electrical engineering degree in 1996 (honors & topper of the batch). He has also received MSc (Disaster Mitigation) and M Tech (Modeling and simulation).

A Certified "*Power Engineer*" from Central Electricity Authority (CEA), Govt of India .Radiological Safety officer Grade -1, from BARC and "*Green Volunteer*" from IIEE- New Delhi.

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