

NOVEL MATERIALS AND ADDITIVE MANUFACTURING IN RELATION TO GLOBAL SECURITY

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ABSTRACT

Additive Manufacturing, also popularly known as “3D printing” and Novel Materials which can also be named “Advanced Materials” are part of Emerging and Disruptive Technologies because of their actual use nowadays, in the case of Additive Manufacturing and the big potential it could have on the world, in case of Novel Materials. More interestingly, both Additive Manufacturing and Novel Materials can be used together and would change many things about how we think in society, even starting from how we construct bridges and houses (AM can make both of them) to combining them and having impressive directions. In terms of Global Security, both Additive Manufacturing and Novel Materials can help on the military part.

KEYWORDS: additive, advanced, manufacturing, materials, military

1. Introduction

Advancements in materials and manufacturing are expected to significantly impact security and defence in the future. The emergence of Novel Materials (NM) could enhance the quality and accessibility of critical military equipment. These possibilities hold particular significance in the context of two key shifts in the global security landscape.

Countries that have Rare Earth Elements (REEs) will become even more important, with many Novel Materials being dependent on Rare Earth Elements (REEs). That can mean that NATO Allies

would depend on China for critical raw materials which could pose a security challenge.

With the war in Europe, we can see the essential role of sufficient weapon stockpiles, reliable supply chains and robust logistics for effective military campaigns. Additive Manufacturing (AM) combined with Novel Materials makes a solid combination for the flexibility needed in war combat and the transformative potential. A way how NM and AM can alter the security landscape is by reducing the exposed stockpiles in conventional warfare because parts would be more convenient to

build and would be transported more easily near military bases. Still, the NM and AM combined have a great perspective.

Another example of NV and AM working together is the defence department in the US. The investment grew in the period 2017-2021 for Novel Materials (“Advanced Materials”) such as Metals, Polymers, Rare Earths and Composites. The Additive Manufacturing focus was on digital engineering and industrial printing which are ways to make Additive Manufacturing more and more viable. It is to be noted that NM got a bigger budget during the same period.

The European Defence Matters also sees the potential for defence in AM. An interesting aspect of AM is the synergy that will be created between the Research and Technology community and the military personnel.

2. The Potential of NM

AM has a notable impact already on security and defence, where NM-related technologies will take longer to be adapted, but potentially be much more revolutionary than Additive Manufacturing. How we can understand what Novel Materials would mean for the future by looking at one part of it and that is nanotechnology. In the last 20 years, the National Nanotechnology Initiative (NNI) has coordinated investments in nanoscience R&D and with the help of government agencies and departments, it has invested more than \$38 billion. On the private part, in the year 2017, over 3700 companies with over 171,000 employees identified as primarily being in the business of Nanotechnology R&D (having the NAICS code 541713 “Research and Development in Nanotechnology”). These companies reported \$42 billion in revenue which exceeds 20 years of investments from NNI.

Nanotechnology is the manipulation of matter on a near-atomic scale to produce new structures, materials and devices. Integrated with Additive Manufacturing would

create new materials for groundbreaking innovations. Nanomaterials can facilitate the manufacturing process and improve material properties.

3. AM Advantages and Its Uses in Military

We can see that industries like aerospace take advantage early of AM technology, especially helping with the output it provides in the strength/weight ratio of materials through 3D printing methods. Overall less weighted components, greatly customisable and precise designs. It’s promising that one day an astronaut could print equipment in the space station.

US Navy is taking advantage of 3D printing for one-off needs and spare parts to be integrated into production like submarines, aircrafts, carriers and surface ship production. Manufacturers and suppliers are starting to decrease and recently the need for equipment increased, certainly, Additive Manufacturing can be the solution to the actual problems. Also, AM helps reinforce single components quickly compared to the traditional method, it could shorten the production time for some parts by an average of 80% and help not to set deadlines back months which would also increase the expected cost significantly.

Additive Manufacturing has an advantage because it’s more effective with the materials waste and it provides the possibility to recycle.

4. Examples of Practical Use of AM in the Military

For the military AM already shows great potential in making Drones, Explosive Landmines, Military Bunkers, Bridges and Runways.

For heavy vehicles, Additive Manufacturing already shows the capacity to build a Rocket Launcher Shelter, Hulls for Submarines, and Hulls for combat vehicles. Also, the French navy managed to build a one-tonne ship propeller.

5. Case Study: Building a Submarine with AM

According to the Department of Energy, a traditional SEAL Delivery vehicle would cost around \$600,000 and \$800,000 with 3 to 5 months to build it. It was reported that the cost of the submarine was at just 10% of the cost compared to the traditional method, the cost of this submarine could have been as low as \$60,000 with the hull of the submarine being printed in a number of days and the submarine finished in 4 weeks.

6. AM Standard Technologies

Work in improving and evolving Additive Manufacturing is still an important part. The Standard terminology for additive manufacturing technologies (ASTMA) established 7 Standard categories: AT Photopolymerisation, Material Extrusion, Binder Jetting, Material Jetting, Powder Bed Fusion, Sheet Lamination and Directed Energy Deposition. In general, there are many variations of AM, nowadays the most common AM technology used is Material Extrusion using the methodology Fuse Deposition Modelling (FDM) or Fused Filament Fabrication (FFF). The main difficulties that AM is facing today are because of speed, scalability, material property and cost.

7. AM Capabilities of Creating with Ease Pieces of Equipment like Guns

AM can be a serious threat in any country because of its capacity and the potential to construct military equipment, like small guns, uniforms, field equipment, artillery, and aircrafts. With its flexibility, not in industrial numbers, people from every country can build dangerous weapons without any problem. Already some governments take into consideration making it illegal to print plastic 3D firearms. Even people caught who had planned to print a 3D gun or had the instructions on how to build them. We can

see in the US that some States have regulated 3D printed guns, and some States have bans for ghost guns, but most of the States don't have direct regulations for 3D printed guns. If we took the State of California, according to California's Assembly Bill 2156 enacted in 2022, a person, a firm or a corporation shall not use "*A person, firm, or corporation shall not use a three-dimensional printer to manufacture any firearm, including a frame or receiver, or any firearm precursor part, unless that person, firm, or corporation is licensed...*". This method can work, but it doesn't resolve a part of the challenges, one of them being the Ghost Gun which does not have a serial number and evades standard background checks

8. Predictive Maintenance for Additive-Manufactured Equipment

There is the desire to make Additive Manufacturing a crucial part of the military. One example is the research conducted by the US Army researchers at the CCDC Army Research Laboratory, Aberdeen Proving Ground, Maryland, US where they developed ways for monitoring the performance of parts that were additive manufactured using predictive maintenance with the help of sensors. The important part is that soldiers will know when parts will degrade or fail and need replacement. This is especially useful in urgent situations or contested environments where time is often limited.

9. Graphene, a Very Good Novel Material

The most researched Novel Material today is graphene. The discovery of graphene won the 2010 Nobel Prize. It is important to know that graphene has a remarkable strength-to-weight ratio, tensile strength (stress that a material can withstand before failure) and high elasticity, being able to absorb shocks without becoming permanently deformed. Graphene

can also disperse and store kinetic energy, allowing it to absorb energy in a manner that decreases damage from impacts, such as gunfire. Additionally, graphene possesses distinctive conductive properties: it is an excellent conductor of electricity and can transfer heat more efficiently than copper, despite being lighter.

In 2017, the European Defence Agency (EDA) launched a project, in collaboration with the company TecNALIA Research and Innovation based in Spain, The Technical University of Cartagena and Cambridge Nanomaterial Technology Ltd located in Cambridge, UK. The project, which concluded in 2019, offered a detailed examination of graphene's possible applications within the defence sector and assessed the timeline that graphene would take to integrate into the defence industry market based on potential application areas.

The study identified the applications of graphene that are nearest to market adoption are supercapacitor electrodes, which would allow for its use in batteries and energy storage systems (predicated within four years from March 2019); multifunction coatings (within three to five years, as of March 2019); and lightweight ballistic protection materials (three to five years, as of March 2019). EDA observes that multifunctional coatings need further cost-benefit analyses and technical improvement must be demonstrated while multifunctional coatings being extensively used in non-defence industries, suggesting that the defence sector could adopt these advancements and acquire technologies from civilian sectors without needing to invest in its technologies.

Regarding materials for lightweight ballistic protection, the EDA acknowledged that this application is close to market, but highlighted the need for more cost-benefit studies and additional technical advancements in using graphene. The report also projected that defence applications such as drones, materials with high thermal dissipation,

coatings for reducing radar signatures, flexible and lightweight batteries, devices that operate in low light, membranes for water and air filtration and chemical/biological/radiological/nuclear sensors would enter the market at a later stage. The conducted study cites that there are challenges for the market to adopt, from high investment that you need in the initial phase to packaging issues. In the end, graphene established a capacity to significantly enhance performance in a wide range of applications, affirming the revolutionary impact of Novel Materials on defence.

10. Conclusion

AM and NM will be clearly a big part of our society and will play an important role in global security. Equipments that need pieces in small quantities are of great use of AM. Important parts can still be made today with AM for submarines and combat vehicles. AM is a technology that needs to become even more efficient in the industrial part, which it lacks today, even though the products it makes can be more eco-friendly, and more lightweight. If AM has its particular use today and is relatively developed and adapted to the Global Economy, the NM still needs to find ways to a more broadly used and to be adopted more in the society. It's promising based on the research that will have a true impact on advancements in many directions, including military equipment. Even beyond Novel Materials like graphene which has lots of interesting properties, we should look to nanotechnology. AM in combination with nanomaterial would revolutionise the world and we saw how much revenue companies made from Research and Development in Nanotechnology. Looking back again at the internal security of every country, AM can help people make their ghost guns. From a Global Security, AM is helping to supply soldiers with the parts they need in a faster way compared to the old solution, which makes the technology of AM effective and

groundbreaking. In conclusion, Additive Manufacturing and Novel Materials are very interesting Emerging and Disruptive

Technologies and have clear impacts in relation to Global Security.

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