Spectral Energies, LLC (4065 Executive Dr., Beavercreek, OH 45430)

Technology Testbed Center for Additive Manufacturing Needs

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1. Project Description

We describe the establishment of the translational research and entrepreneurial initiative in ***Additive Manufacturing*** (AM) technologies being developed in Dayton region in a multilateral partnership of local and global businesses, leading national universities, community colleges, government laboratories and non-profit organizations. The ***mission of this initiative*** is the enablement of US industrial competitiveness in the next wave of manufacturing technology, Additive Manufacturing. This wave does not evolve from the muscle-intensive heavy engineering of the last century. Rather, its progress depends on the innovation brought about by agile minds skilled in the latest advances in materials science, precision laser and electron beam energy deposition, systems engineering and fast topological 3D computational mapping, and an environmental network that moves this technology quickly to its pervasive adoption in the marketplace.

This concept is enabled to take advantage of 'America Makes' initiative and the wellspring of technical talent available in the Dayton area. It also taps into the broad patchwork of large and small companies that support many high-tech DoD, DoE and NASA programs amid a rapidly expanding educational eco-system of universities and community colleges focused on lasers and photonics, engineering sciences, nanoscience and advanced computational simulations. Our goal is to accelerate the propagation of AM technology nationwide through the progressive establishment of strategically located ***Technology Test-bed Centers (TTCs),*** each tailored to local needs to advance AM through 'technology-push, market-pull' enablement. We know that ***industry embraces this initiative*** as a means to rapidly establish a strong stake in this revolutionizing technology. Major corporations seek support at lower technology readiness levels (TRL) to expand the industrial base of AM while SMEs need access to AM technology and the means to develop their own intellectual property to bridge the gap between R&D and commercialization. The overall consequence is the increased industrial wealth not only of the Dayton region, but also of the nation through renewed leadership in manufacturing technologies and the creation of high-quality jobs for our citizens and their children in new, clean, energy-efficient industries.

The prime function of this initiative is the enablement of innovative AM and product development in the Dayton region. This goal will be accomplished through creation of the **Technology Testbed Center (TTC)** in additive manufacturing technologies, strategically located in Dayton according to the 'America Makes' technology dissemination plan. The Dayton TTC will be the first of the network of technology testbed centers aiming to help the many manufacturing Dayton-based companies that support DoD and Air Force programs to rapidly adopt AM techniques, and to enable rapid technology exchange between WPAFB, these companies, and US industry.

2. Technical scope.

The proposed Dayton TTC will advance additive manufacturing across broad fields of application, from turbines in the next generation of aerospace and energy systems, to intelligent multi-material lightweight net-shape components with embedded circuits and devices, to personalized, multi-functionalized bio-medical components for the war wounded. The technological backbone of the R&D activities will be composed of the following three major manufacturing technology fields:

Net-shape manufacturing of high-value structural components from metals (including high-γ' content, SX, PX, and DX alloys), ceramics, ceramics/metal composites and functionally graded materials for the power generation, aeronautics, defense, automotive, and tooling industries.

Highly individualized rapid manufacturing of lightweight components from bio-compatible and/or bio-resorbable materials e.g. titanium alloys, ceramics and polymers, for life-science and medical applications such as bone and dental implants, diagnostics, local drug supply devices, and prosthetics.

Multi-axis, multi-material printing of functional electronic, micro-mechanical and electro-mechanical devices including basic electronic elements, RF antennas, interconnects, insulators, and mechanical actuators for sensing, biomedical, defense, industrial and consumer electronics applications.

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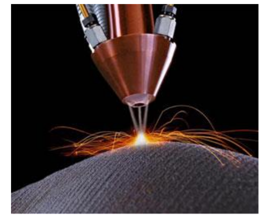
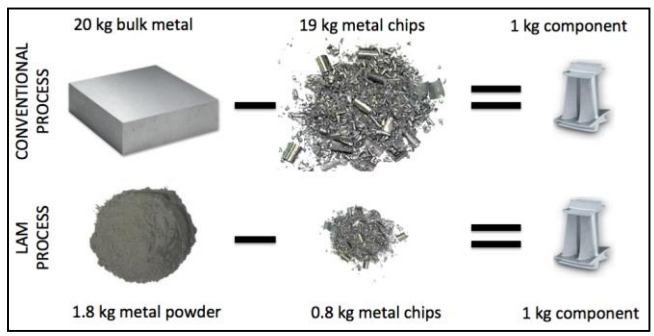


While based on different types of material deposition, (e.g. powder jet, powder bed, micro-dispensing), and on different energy deposition techniques, (laser radiation or electron beams), all additive manufacturing technologies offer inherent energy-, cost- and material-saving potential, environmental sustainability of utilized materials, and unique scientific technological novelty. They introduce entirely ***new design and integration freedom***, and ***new materials/material combinations*** that will revolutionize multiple industries and introduce paradigm shifts in the whole manufacturing philosophy. Their successful implementation in industrial environments can be ensured through the cutting-edge knowledge and expertise in laser materials processing technologies, mechanical and electrical engineering, energy research, aerospace and medicine.

The R&D agenda will include continuous development and optimization of various additive manufacturing techniques towards improvement of the manufacturing productivity, material, energy and cost efficiency, reduction of the manufacturing processing steps, and optimization of the supply and manufacturing chains for the new digital manufacturing era.

Different aspects of advanced process engineering science will be adopted to improve existing additive manufacturing processes, while developing novel experimental techniques to fully utilize the benefits of this new manufacturing approach. The research efforts will focus on identification of the optimal process conditions for defect-free additive manufacturing of selected superalloys, ceramics, polymer and composite materials.



For laser-based manufacturing processes, such as Laser Material Deposition (LMD) and Selective Laser Melting (SLM), advanced process monitoring using *in situ* diagnostics and NDC will be used to obtain enhanced process knowledge, including time-resolved measurements of physical conditions (e.g. temperature, powder flow, reflectivity), temperature-dependent reflectometry, and measurement of the chemical composition by emission spectroscopy and Laser-Induced Breakdown Spectroscopy (LIBS) across the solid-liquid phase interface. Laser scanning and other optical geometry acquisition techniques will be adopted to ensure the net-shape conformity of structural components, such as made by Fused Deposition Modeling (FDM). These studies will support efforts on optimization of the energy deposition, e.g. to reduce energy and material losses due to vaporization, improve performance of materials and components, and generate critical data as input variables to the mathematical models. This approach will also support investigations of material deposition dynamics, melting and re-solidification processes and, ultimately, will allow tailoring of the materials properties.

Continuous efforts will be made to improve the resolution of manufactured features, to improve the as-built geometric accuracy and surface finish. These advancements will be achieved by optimization of the material deposition/dispensing techniques, by the adoption of smart-pump technologies, next-generations of positioning equipment, industrial robotics, flow measurement systems, and the development of novel additive manufacturing concepts in close collaboration with the industrial partners.

One of the most important aspects of additive manufacturing currently hindering its ubiquitous adoption in multiple industry areas, is its limited productivity, its relatively small build-rates and overall manufacturing throughput. Using newest concepts of integrated manufacturing developed at participating academic institutions, we will identify supply chain requirements and supporting infrastructure, analyze raw material availability, supply stability, socioeconomic aspects, current production scales, capacity, and potential supply deficits throughout the entire manufacturing chain. Implications of the DoE critical materials strategy will be considered. A concept of novel material supply chain dominated by the utilization of AM technologies will be developed and adopted in industrial environments.

For the same purpose, appropriate post-processing techniques (e.g. heat treatments and mechanical machining) and inspection procedures specifically for AM-processed components will be determined and/or developed. The study will improve the recycling/ waste-reduction enabled by post-processing. The research will focus on the influence of chemical composition/material microstructure on selection of post-process treatments. Special efforts will be made towards minimization of the post-process subtractive machining and improvement of the material efficiency. Dimensional tolerances will be assessed using CAD-to-part comparison techniques.

To further increase AM technology dissemination, we will determine pathways to gain more greater acceptance from industry, particularly by providing concepts for common standardization and certification routines. For example, material and component properties crucial for the adoption of AM in fabrication of critical gas turbine, aerospace and medical components will be determined. We will leverage the expertise of existing certification/standardization committees such as the ASTM F42 committee on additive manufacturing technologies, to support the promotion of knowledge, stimulation of research and implementation of technology through the development of standards.

3. Workforce development, education and training

Talented manpower is ultimately the driver in any industrial success story. Additive manufacturing has special needs across the whole landscape of education and workforce development, industrial practice, certification and public awareness. This is at all levels, from K-12, through technician training, BS, MS, and Ph.D degrees. With the rise in employment in this industry, we are faced with real challenges in (i) attracting young people to this field, (ii) incorporating effective training methodologies and facilities, and (iii) developing acceptable certification standards recognized worldwide. Fortunately, several Federal agencies have already instigated innovative AM training programs, in particular NSF. The proposed Dayton TTC as well as the entire ‘America Makes’ Institute will be collaborating with most of these programs. We plan a multi-tiered education and outreach program in AM. The most crucial component is the education and training of technicians and the establishment of standardized workpractice and accreditation criteria.

The Dayton TTC will be a resource to industry and government for the development of AM technologies across a wide range of technological applications. It is the vision of this initiative that ‘society or customer pull’ and ‘industry-innovation and technology push’ are its principal driving mechanisms, aided by the underpinning of strong academic research, collaborations between companies, government laboratories and university research groups, and cooperation with other centers in advanced manufacturing in the US.

The ultimate goal of the proposed TTC center in additive manufacturing is the creation of a fertile environment in development, utilization and dissemination of additive manufacturing technology in the Dayton area that will result in creation of new businesses, private-public partnerships, and therefore jobs. TTC activities will support entrepreneurs in creating new business entities, by co-funding business innovation projects within the funding period, and sharing revenues resulting from business innovation.