Aircraft Structural Parts via Direct Digital Manufacturing

ONR Program Code 35 | September 2012

At a Glance

What is it?

Innovative research programs that provide the technologies to rapidly manufacture "one-off or low-volume" aircraft structural metallic components from alloy powders using high-energy Direct Digital Manufacturing (DDM) technology

How does it work?

The DDM structure-property-processing relationships are complex and not well understood. During DDM processing, layers are melted, solidified and re-melted repeatedly as the part is fabricated; there are repeated solid state transformations (e.g., $\beta \rightarrow \alpha + \beta$, $\alpha + \beta \rightarrow \beta$). This effort will look to develop:

- Physics-based processing algorithms for defect (micro-porosity, surface quality, etc.) control. Dimensionless quantities controlling defects/quality must be linked to process controls.
- Technologies required for Intelligent Process, Sensing, and Control System (IPS) to ensure consistent part microstructure and porosity.
- A heuristic Accelerated Certification Technology (ACT) moving from simple to complex geometries and non-structural to fatigue-critical parts to enable rapid certification.

What will it accomplish?

When fully implemented, DDM repair or manufacture of metallic components could significantly reduce the lead time and cost to acquire high value components.

- 35-45% lower part cost
- 2-7 weeks vice 8-28 months to acquire out of production parts
- Conserves strategic material, lowers energy consumption, and significantly reduces the needed logistic foot print
- Enables the design/manufacture of far more structurally efficient future weapon systems

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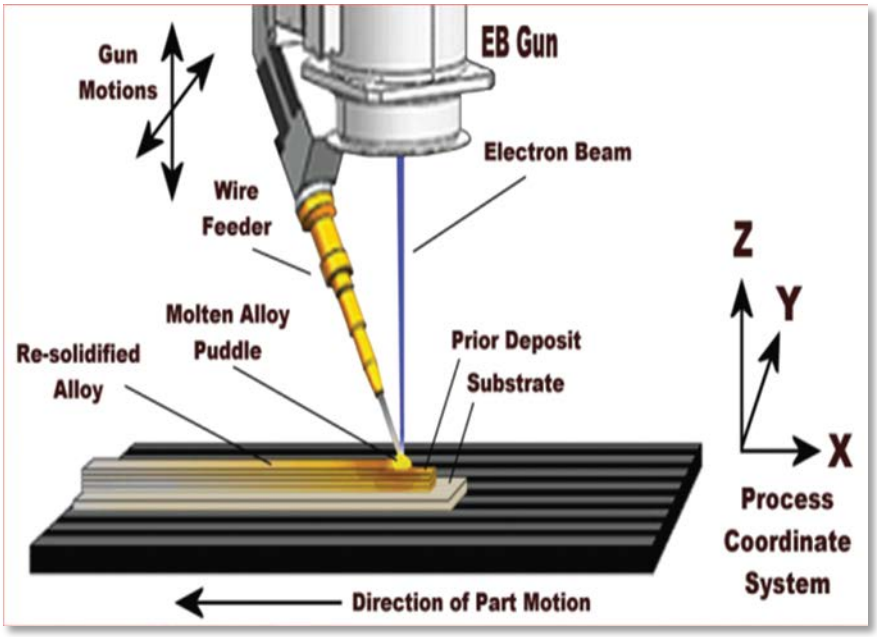

Increasingly the Navy's inventory of aircraft is being extended in service beyond the design life. As a result, components fail that were never expected to be repaired or replaced. With no replacements available in the supply system, long lead times develop for the repair or manufacture of the replacement items. During those times, the aircraft are grounded, directly impacting warfighter readiness levels.

When fully implemented, the DDM repair or manufacture of metallic components could significantly reduce the lead time required to acquire high value components. It is estimated that lead time for an F-35 candidate part could be reduced, for example, as much as 75%. Further cost savings are anticipated because DDM eliminates the need for tools and dies, reduces the need for machining, and increases material utilization.

In order to control the DDM solidification process and solid state transformations which ultimately control properties, the thermal properties of the melt pool and the thermal profiles through the part/test bed must be known.

Research Challenges and Opportunities:

- Develop empirically derived process maps and predictive algorithms for accelerating qualification and certification
- Develop new sensor algorithms to measure melt pool temperature in 3D; currently limited to planar capability
- Develop new sensor algorithms to measure through-thickness part temperature; no systems exist
- Develop algorithms to access internal part thermal profiles
- Understand the effect of beam power, size, raster rate
- Develop models that relate the effect of part geometry and beam repeat rate