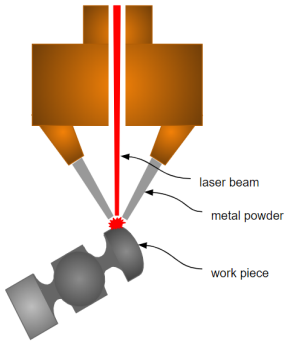
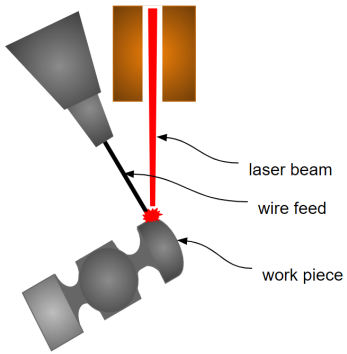
# Quick Guide to Metal AM

Based on ISO/ASTM 52900 *Additive Manufacturing-- General Principles -- Terminology*

OPTOMEC®
Production Grade 3D Printers... with a Material Difference

| Technology | Description | Materials and Deposition Rates | Applications, Advantages, Disadvantages |
|---|---|---|---|
| **Directed Energy Deposition (DED), Powder-Fed**<br>  <br> | A focused laser beam impacts the workpiece creating a precise melt pool. Into the melt pool, streams of powder are blown which quickly create a dense solid structure with metallurgy on par with wrought metal. The process can take place in an inert gas atmosphere, allowing the building of reactive metals like titanium.<br><br>**DED is also referred to as**<br>• Laser Melt Deposition, LMD<br>• Laser Energy Net Shape, LENS™<br>• Direct Metal Deposition, DMD™<br>• Laser Cladding | • Steel alloys<br>• Stainless alloys<br>• Copper<br>• Titanium<br>• Bronze<br>• Nickel alloys<br>• Cobalt alloys<br>• Aluminum<br>• Refractory metals<br>• Ceramics<br><br>**Typical deposition rates:**<br>Up to 2.25 kg per hour | • Excellent for Repair<br>• Prototyping<br>• Materials research<br>• Cladding, coating and resurfacing<br>• Load-bearing components<br><br>**Advantages:**<br>• High strength metallurgy<br>• Low heat input<br>• Processes reactive metals<br>• Can be combined with machining in same system<br><br>**Disadvantages:**<br>• |
| **Directed Energy Deposition, Wire-Fed**<br>  <br> | Similar to powder-based DED, wire feed DED uses a focused laser to create a melt pool. The difference is that the additive material consists of wire, much like a wire-fed MIG process. | • Titanium and Titanium Alloys<br>• Inconel<br>• Copper Nickel Alloys<br>• Stainless Steels 300 Series<br>• Aluminum Alloys Alloy Steels<br>• Cobalt Alloys<br>• Zircalloy<br>• Tantalum<br>• Tungsten<br>• Niobium<br>• Molybdenum<br><br>**Typical deposition rates:**<br>Up to 2.5 kg per hour | • Production<br>• Repair<br>• Prototyping<br>• Materials research<br>• Cladding, coating and resurfacing<br>• Load-bearing components<br><br>**Key advantages:**<br>• Wide variety of available wire materials |

# Quick Guide to Metal AM (continued)

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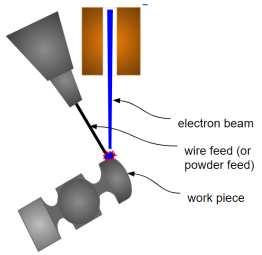
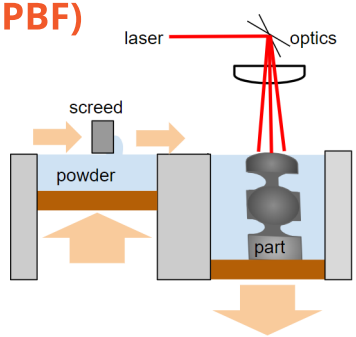
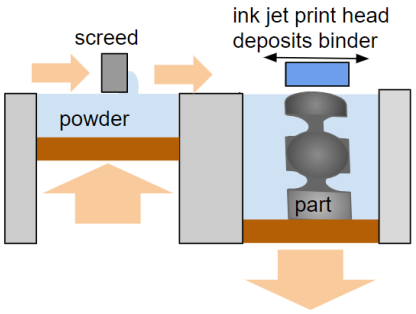
| **Directed Energy Deposition, Electron Beam**<br>  | Using an electron beam as the energy source is another way to accomplish DED. The advantage over laser is that higher energy outputs can be achieved. However, the disadvantage is that the process must be completed in a vacuum, drastically increasing the cost of the system.<br><br>**Electron Beam DED is also called**<br><br>EBAM (TM) | The available materials are the same as in laser-based DED.<br><br>**Typical deposition rates:**<br><br>up to 10 kg per hour | • Prototyping<br>• Large part builds<br><br>**Key advantages:**<br><br>• Very high deposition rates<br>• Near-wrought metallurgy<br>• Largest build envelopes<br><br>**Disadvantages:**<br><br>• Expensive vacuum chambers required, high capital cost |
| **Powder Bed Fusion (PBF)**<br>  | PBF systems use a steerable laser beam (or electron beam) to solidify a 2D image onto a bed of metal powder. After the 2D image is created, the workpiece is lowered, a new layer of powder is screeded across the part. and the laser process repeats. Next, the part is removed and typically processed in a furnace to further fuse the powder material.<br><br>**PBF is also called** DMLS, SLS, SLM, LMF, DMP, EBM | There is a wide variety of materials available for PBF processes.<br><br>• Stainless steels<br>• Titanium<br>• Aluminum<br>• Cobalt-chrome<br>• Maraging steel<br><br>**Typical deposition rates:**<br><br>up to 0.25 kg per hour | • Prototyping<br>• Low volume production<br><br>**Advantages:**<br>• Fine features are possible<br><br>**Disadvantages:**<br>• Slowest metal AM process, highest cost per cc of printed volume<br>• Low material utilization (high waste) |
| **Binder Jetting**<br>  | Binder jetting is similar to PBF except that, instead of using a single point laser to solidify the powder, a binder material is jet-printed across the top of the build surface. This enables a drastic increase in print speed as compared to PBF. As in PBF, the part must be processed in furnace to fuse the powder and drive off the binder. Significant shrinkage occurs, and the metallurgy is altered as a result of the binder. | • Stainless steels<br>• Inconel<br>• Aluminum<br>• Tungsten carbide<br><br>**Typical deposition rates:**<br><br>up to 50 kg per hour | • Prototyping<br>• Low -stress components<br><br>**Advantages:**<br>• Much faster than PBF<br>• Fine features are possible<br><br>**Disadvantages:**<br>• Higher porosity<br>• Lower mechanical properties |