

Metal Additive Manufacturing Trends

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Our Background

- We provide research reports and services exclusively to the additive manufacturing/3D printing industry
- We have published market models and analysis on at least 13 in-depth areas where AM/3DP is being utilized

Agenda

- Review of metal additive manufacturing industry in 2015
- Applications driving growth in metal additive manufacturing
- Metal powder materials, supply chains, and production trends
- Future predictions for metal additive manufacturing

Review:

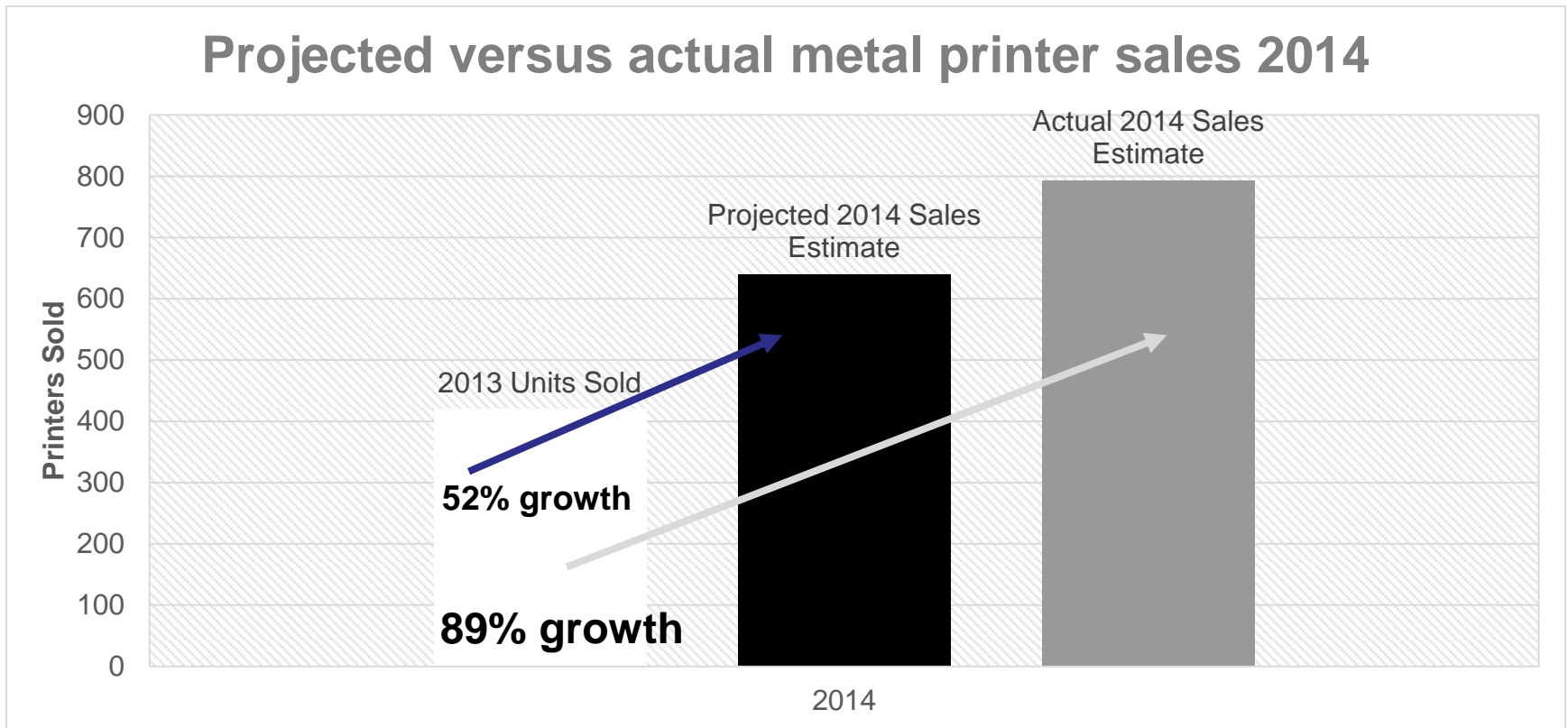
METAL AM INDUSTRY 2014

Quantifying An Explosion

- Metal AM systems are being placed at rates which surpassed our original very positive outlook
- System providers cannot deliver systems as fast as they are selling them

Quantifying an Explosion

Actual market growth exceeded our original (bullish) growth estimates by almost 27%



Source: SmarTech Markets Publishing, *Opportunities in Metal Additive Manufacturing*

Major Market Trends in Metal AM

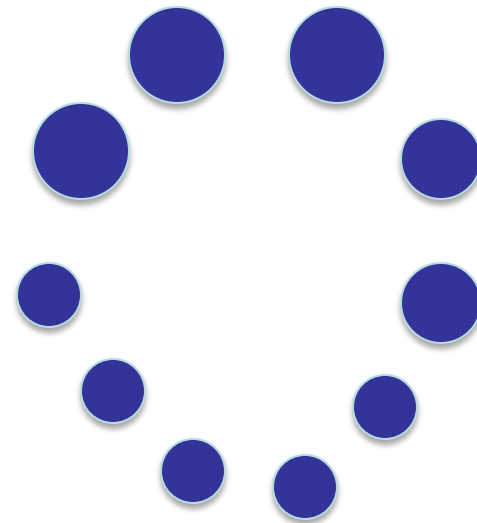
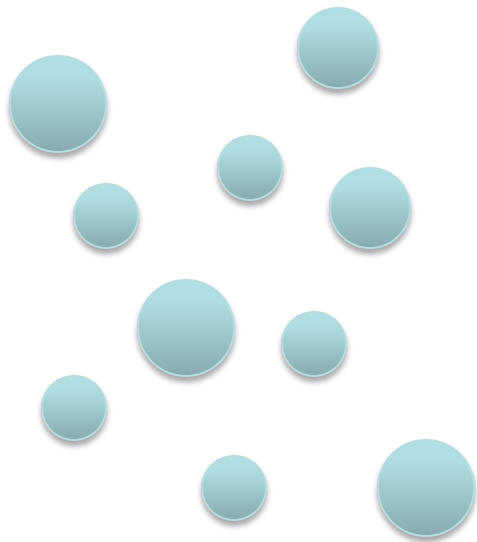
- Standards development initiatives can significantly impact demand in certain applications
- Growing demand in serial production of metal components

Technology Development Trends in Metal AM

Powder Bed Fusion Technology

- Integrated Process Monitoring
- Parameter selectivity & control features, powder coating and bed image recognition, networking advancements for multiple printer environments

Future Metal AM System Capabilities

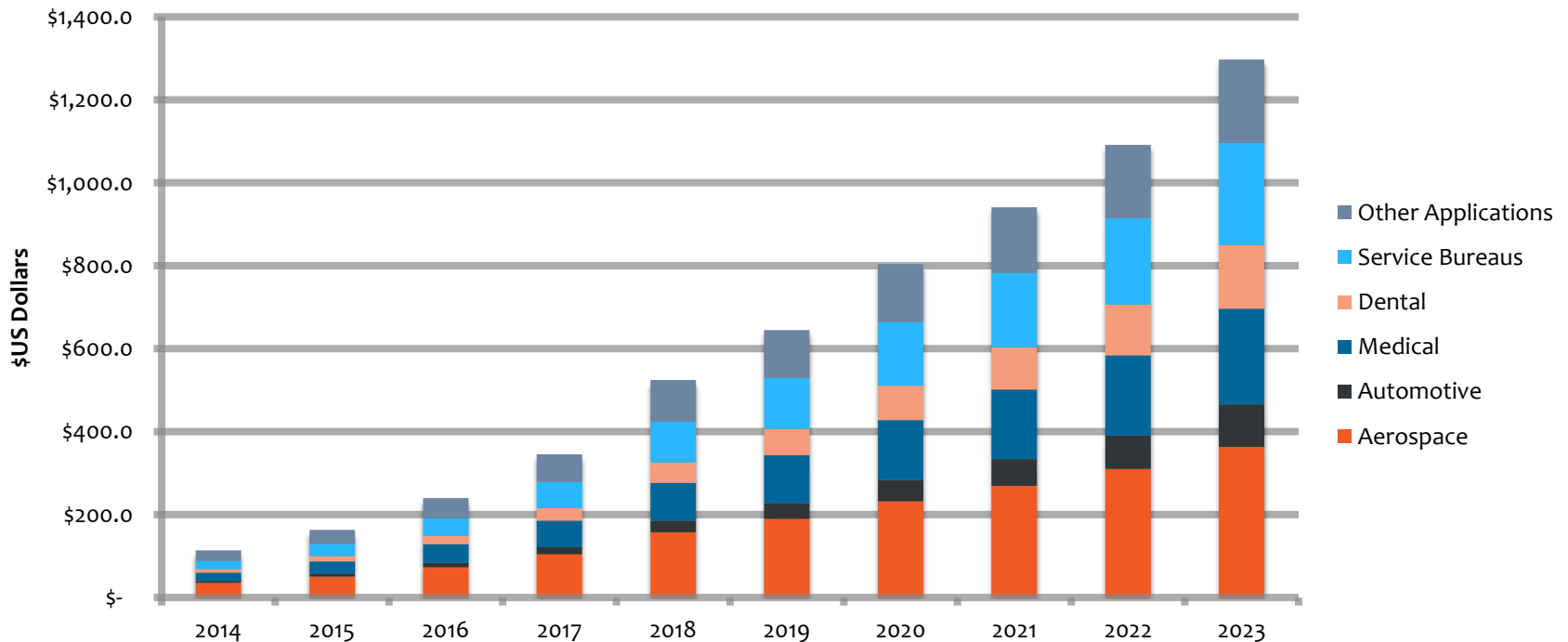


Applications & Metal Powder Materials

Applications Driving Growth in Utilization of Metal AM

Dental, orthopedic implants, and rapid manufacturing of prototypes growing fastest

Total AM Metal Powder Revenues by Industry (\$US)



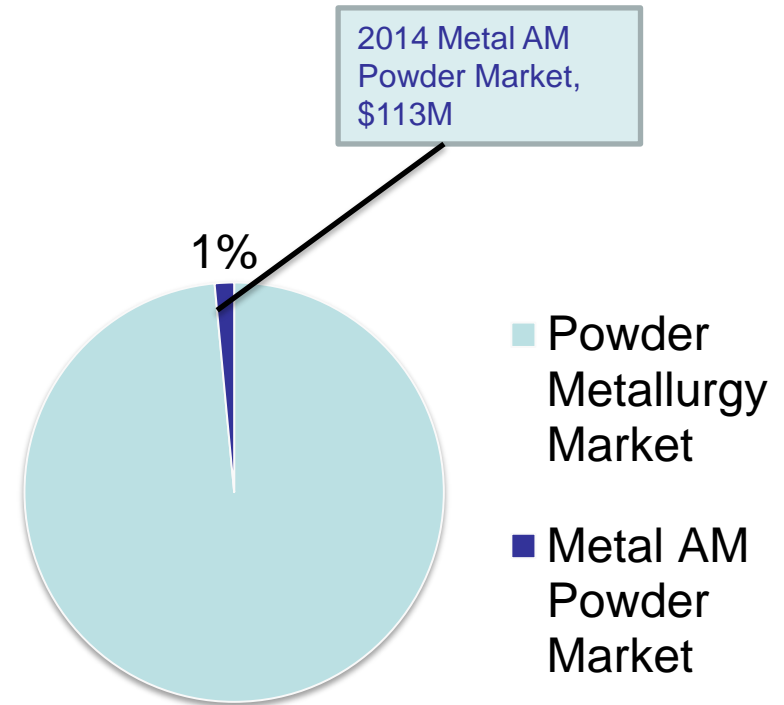
Source: SmarTech Markets Publishing, *Opportunities in Metal Additive Manufacturing*

Applications Driving Growth in Utilization of Metal AM

- In general, three common qualities stand out in metal AM applications
 - Extreme high value parts
 - Small metal components of medium to high volumes with high degree of unique variation
 - Components that can be reengineered

Metal Powder Materials for Additive Manufacturing

- Metal powder materials are commonly utilized in a variety of production techniques broadly known as powder metallurgy (PM)
- Metal additive manufacturing is of growing interest to the powder metallurgy industry
- Powder materials are the current material of choice for AM



Source: SmarTech Markets Publishing

Requirements for AM Powders versus Other Metal Powders

- AM metal powders have to be produced using processes that can provide specific powder characteristics
 - Spherical shape
 - Flowability
 - Low porosity
 - Particle size
 - Purity
- Certain characteristics need to be matched to specific AM processes

AM Process	Powder Size	Unique Considerations
EBM	Coarse (45-100 micron)	Reusability/purity
SLM/DM LS	Fine to Very Fine (15-45 micron)	Powder packing
LENS/DED	Fine (25-45 micron)	Multiple flow concerns

Myth Busting Metal AM Powder

- Powders for AM are not inherently difficult to produce
- The global capacity for powdered metal production is enormous
- Cost of powders is artificially inflated today

Competitive Landscape for Metal Powders

- Smaller specialty powders companies can succeed
- Larger suppliers are having to make a decision to invest for the long term
- OEMs significantly influence the supply chain for powder

Future Predictions for Metal Additive Manufacturing

Technology Predictions

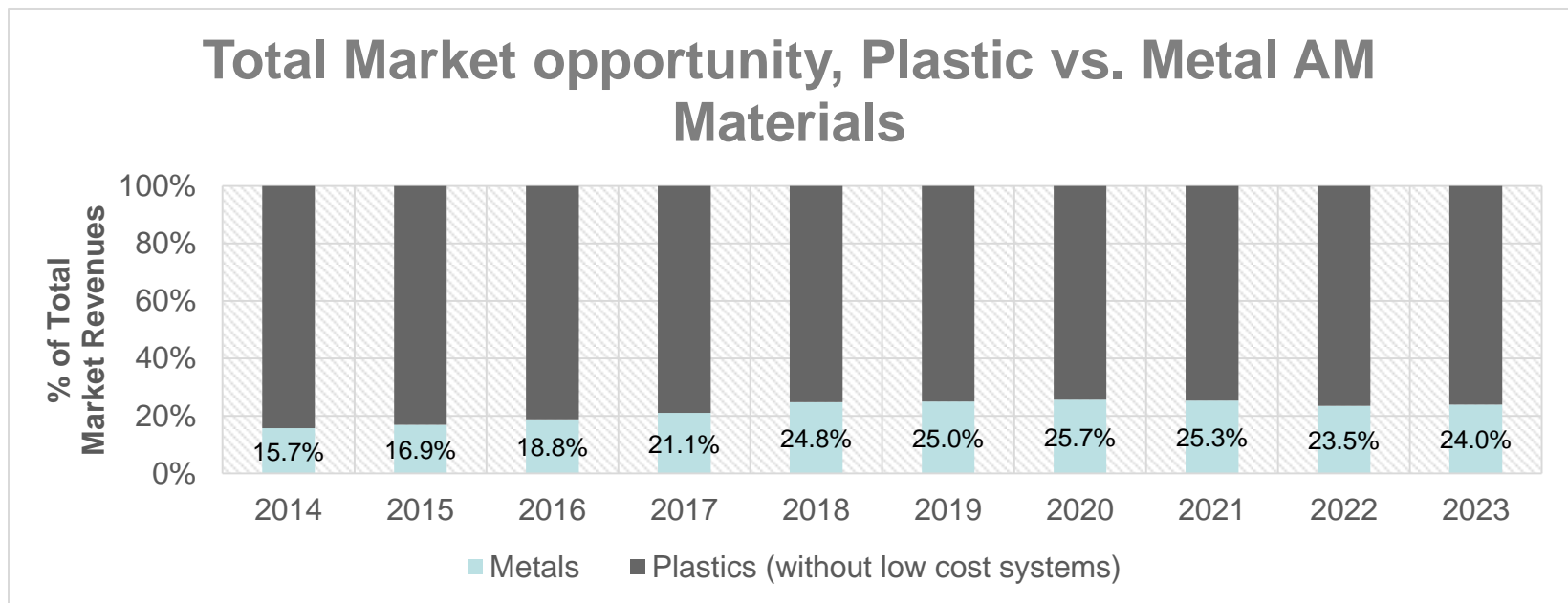
- Potential to branch out from powder bed fusion
- Alternate processes can bring value through materials and approach to volume
- Development of standards is complex due to the uniqueness of each metal AM process

Challenges for Metal AM

- Consistency print-to-print is an issue for all current processes for a variety of reasons
- Expertise varies greatly by service provider
- Dissemination of benefits for additive manufacturing still have a long way to go

Market Predictions

- The opportunity for metal AM is growing rapidly, and there is a significant commercial market developing to supply print materials in the next decade



Source: SmarTech Markets Publishing

Final Thoughts and Summary

- Metal AM is being increasingly explored as a viable means of production for difficult to source components and potential series production of parts
- Continued explosive growth in this segment is changing the future dynamics of the total AM market
- It takes time for multi-national manufacturing organizations to transition to new processes, and even longer for industry design paradigms to begin shifting towards a new way of thinking for additive

Thank You!

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- Questions?