

PUBLICLY AVAILABLE SPECIFICATION

**Classification of additive manufacturing and 3D-printing processes for
electronics**

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Classification of additive manufacturing and 3D-printing processes for electronics

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It is based on a document issued by Fachverband Elektronikdesign und -fertigung e. V. (FED) entitled *Classification of additive manufacturing and 3D-printing processes for electronics, White Paper Edition 2024*, and was submitted as a PAS document.

The text of this Publicly Available Specification is based on the following documents:

Draft	Report on voting
91/2105/DPAS	91/2114/RVDPAS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

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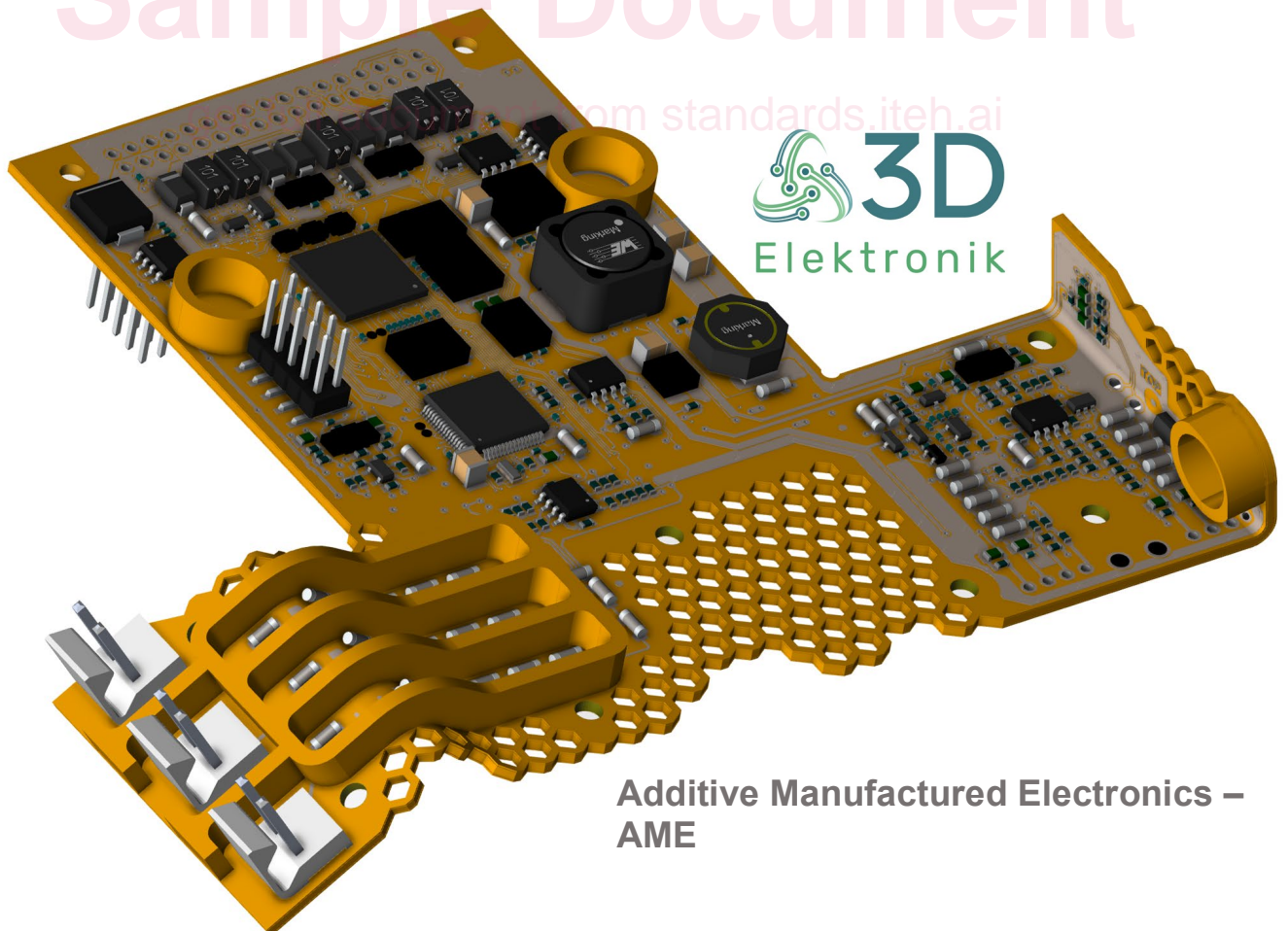
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FED-Working group 3D-Elektronik

Classification of additive manufacturing and 3D-printing processes for electronics

Sample Document



Additive Manufactured Electronics –
AME

White Paper Edition 2024

1 Foreword

The growing demands for miniaturization and increased performance of electronic devices today go far beyond system integration, which is described as "More than Moore" and driving forces regarding Additive Manufacturing in the electrical and electronics industry.

AM is becoming increasingly important, especially for 3D electronics concepts. New 3D printing processes enable heterogeneous and functional integration through multi-hybrid and tool-free production. Both, physical and/or electrical functions, can be printed, additionally electronic components can be assembled within a single operation.



With the new 3D printing processes multidimensional substrates (components) and circuit carriers with integrated functions such as sensors, actuators, electro-optical or bionic properties can be realized, without the need for a carrier substrate or already manufactured Printed Circuit Board.

At the same time rapid progress due to material development is carried out. Nanomaterials in combination with new developed materials printed in one process enable advanced or new possibilities. As an additional positive effect material, energy and transportation costs can be saved in further production processes.

Given the large number of processes and applications it makes sense to classify the methods from the perspective of manufacturing. The FED 3D Electronics Working Group developed this classification in a two-year project and defined five classes of electronics integration using AM.

The classes differ in the used substrate material and the printing process. The different classes build on each other and the requirements for complexity and handling as well as printing technology and precision increase with each class.

The classification for Additive Manufacturing in electronics is intended to help manufacturers and users to find an easy way of the new and extensive possibilities of 3D electronics concepts. This creates a level playing field for discussion between the partners and lowers the entry threshold for the new technologies for users.

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Content

FOREWORD.....	1
1 Foreword.....	4
1 Additive Manufacturing methods in electronic production, challenges and opportunities.....	6
1.1 Digital Printing in electronics production.....	8
1.2 Procedures according to ISO ASTM 52900.....	9
2 Classification of products using Additive Manufacturing (AM) methods.....	10
2.1 Class 1 – basic class, 2D-substrate (carrier) and printing.....	11
2.1.1 Material Application.....	11
2.2 Class 2 – Multidimensional carrier (substrate) + printing.....	12
2.2.1 Class 2 Examples.....	13
2.3 Class 3 – Printed multidimensional substrate.....	14
2.3.1 Application and drying (curing/hardening) of the material.....	14
2.3.2 Examples of material application and drying (curing/hardening).....	15
2.3.3 Internal and external shape (contour).....	16
2.3.4 Advantages and Benefits.....	16
2.4 Class 4 - 3D printed substrate + printed components.....	17
2.5 Class 5 - Shape-changing solutions (4D).....	18
2.5.1 Materials.....	19
2.5.2 Printing methods for 4D technology.....	19
2.5.3 Application examples.....	20
3 Overview of manufacturing technologies.....	21
4 Digital printing and environmental goals (European Green Deal).....	22
5 Growth of Additive Manufacturing (AM).....	23
6 Design tools for 3D electronics.....	25
7 Requirements for the data formats.....	27
8 Production and scalability.....	28
9 Thanks.....	29

Classification of Additive Manufacturing (AM) methods and processes and 3D printing processes for electronic

1 Additive Manufacturing methods in electronic production, challenges and opportunities.

Additive Manufacturing, 3D printing, Industry 4.0, digital twins and virtual manufacturing are hot topics throughout the manufacturing industry. The possibility of using Additive Manufacturing (AM) to create complex components or partial functions is inspiring people all over the world. AM is widely used in mechanical engineering, automotive engineering, aerospace and medical technology.

There are also initial areas of “classic” electronics and applications, suitable using AM for mass production and promising processes supporting electronics manufacturing. Substrates for electronics are usually “multi-material systems”, consisting of conductive and non-conductive materials. Today, various printing methods and printers are on the market available. For the new design paradigms, however, the eCAD design tools and data formats still need to be developed considerably further.

Possible **advantages** of AM

- Main advantage:
Only needed material will be printed!
- The design freedom of Additively Manufactured components seems endless!
- Printing directly “quantity one” without moulds or frames.
- When printing on site there is no need for logistics and transportation for the manufactured parts.
- If necessary, the re-design can start from “quantity one”!

Possible **disadvantages** of AM

- Depending on the complexity each part can take a long time to produce as it is printed layer by layer.
- Depending on the manufacturing process not all tolerances can be adhered to.
- If necessary, support structures must be taken into account in the design.
- Parts with a high surface quality may require extensive post-processing or post-processing may be necessary.

Various printing processes are known that are already in commercial use. Some of the processes listed are still in the early stages of development. The different processes each have specific areas of application that are not covered in detail in this document.

Possible printing processes in electronics production

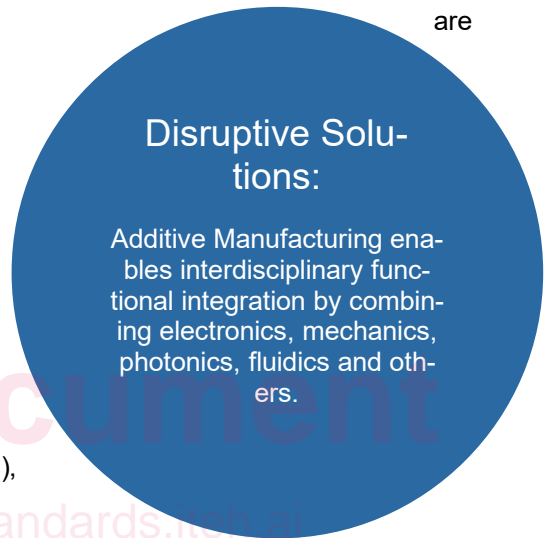
- Drop on Demand (e.g.: *Inkjet*)
- Aerosol Jet
- Dispensing (used for *3D-printing*)
- Impulse Printing
- Soft Lithography
- Electrohydrodynamic Printing (*E-Jet*)

Classification of Additive Manufacturing (AM) methods and processes and 3D printing processes for electronic

The "3D Electronics Working Group" of the Fachverband Elektronikdesign und -fertigung e.V. (FED) has looked in deep at the AM processes and made an initial classification into five groups. This structure helps for a future development of an "AM Roadmap: Electronics Manufacturing" for applications, processes and manufacturing methods, a consistent toolchain and data formats for Industry 4.0.

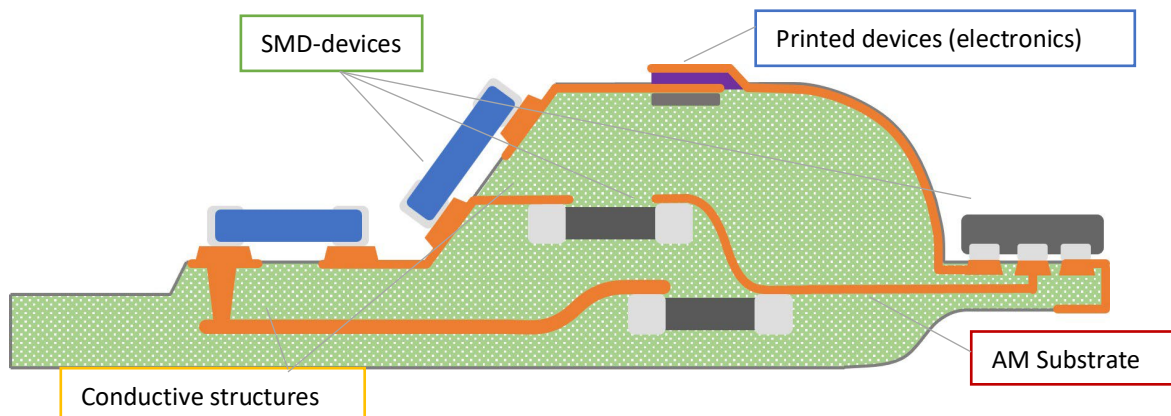
Comprehensive 3D Electronics offer the following features for which manufacturing processes are already available today:

- Many examples of multidimensional solutions, e.g.: known from 3D MID Technology, can only be described as 2.5D.
- Some technologies, such as sheet moulding, planar and only then brought into a mould.
- Printing or embedding electronic components is only possible with an additive process such as 3D printing is used.
- Components must be mountable in any 3D position (azimuth) within the substrate or on the surface.
- Conductive structures (traces) must be able to be routed through the whole and available substrate at any angle.
- Twisted or shielded conductive structures (traces), e.g.: coaxial structures.



3D-Electronics

Free-formed components can be combined with functional layers and with SMD components or dies at any angle or azimuth within substrate or on the surface. Conductive structures are possible on the surface or within the substrates at any angle and shape.



Principle drawing of a three-dimensional circuit carrier (AM Substrate)