

INKJET FUNCTIONAL AND ADDITIVE MANUFACTURING FOR ELECTRONICS

Market & Technology report - January 2018

How inkjet is building a success story drop by drop within 2.5D and 3D manufacturing?

KEY FEATURES OF THE REPORT

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- Inkjet printhead - market volume and value metrics 2017 - 2023 for electronics, microelectronics, display, and micro-optics applications
- Market drivers for inkjet printing technology as a manufacturing tool
- Inkjet printing segmentation, by applications for 2.5D and 3D printing for electronics, microelectronics, and micro-optics
- Overview of the different segments and trends
- Technology trends in inkjet printheads and modules
- Inkjet printing - manufacturing roadmap for applications
- Comprehensive landscape covering players, supply chain, and collaborations
- Functional ink challenges for printing and consumption estimates

WHICH APPLICATIONS ARE DRIVING INKJET PRINTING'S ADOPTION?

Between a sheet of paper and a flat-screen TV, a common theme exists: each can be printed with inkjet printheads. Inkjet printers were invented by IBM in the 1970s as an alternative to dot-matrix printing. However, at the time IBM's researchers probably didn't think that their invention would be a key process step in the manufacturing of TVs, electronic components, and solar cells. It wasn't until the end of the last decade that inkjet printheads stepped up to support all three of these categories – fueled by the need for fast, low-cost prototyping of printed circuits, as well as technologies able to deposit very thin conductive lines on solar cells without compromising efficiency.

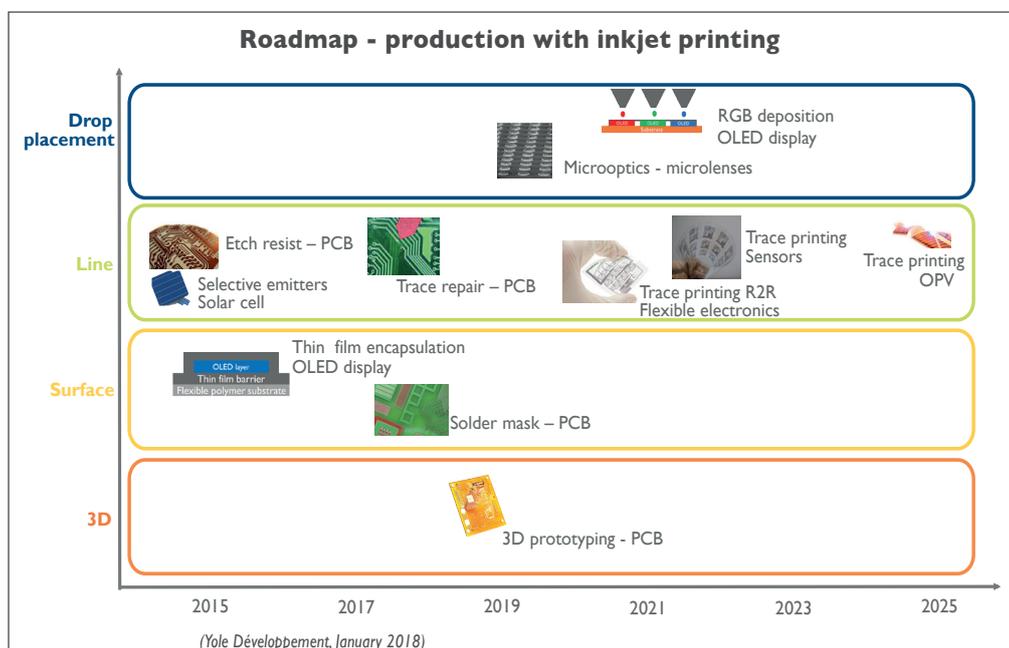
Drop-on-demand (DoD) piezoelectric printheads are the most suitable devices for depositing a picoliter of inks where you want, when you want, and at high frequencies. Compared to thermal ejection, which is largely used in consumer office, and commercial printing, piezo printheads are used in industrial applications because of their higher resistance and longer lifetime in harsh environments. Furthermore, piezo ejection offers more choice in ink selection: for example, aqueous, solvent, and UV-curable inks.

After lengthy R&D dedicated to utilizing inkjet printing as a prototyping tool, the first mass-production market emerged with OLED thin-

film encapsulation for displays (smartphones, TVs). Now driving the market, OLED display is doing much more than creating opportunities for inkjet printing. It is also democratizing inkjet technology as a new process for manufacturing electronics and microelectronics. Kateeva, a US-based company manufacturing printers for OLED displays, is one of the leading companies using inkjet printing technology. After being the first to reach mass production for thin-film encapsulation, the company is now targeting RGB (red/green/blue) OLED material deposition by inkjet for TV LG display is currently in pilot production using Kateeva printers.

A strong increase in wearables requiring miniaturized, "close to the skin" devices in certain applications, is paving the way for flexible printed electronics. Expensive photolithography processes with mask technology could be replaced by inkjet printing processes to deposit conductive lines on-demand. Inkjet technology demonstrates consistently improving performances in terms of deposition accuracy, high-resolution printing, and droplet volume control. Printheads are one of a printer's key components, and they're becoming increasingly complex, requiring strong knowledge and experience.

High throughput printing is now reached with high number of printhead modules in a same printer. It is worth noting that nozzle positioning



and well-controlled ejection are key to printer manufacturers and targeted applications. Printhead quality is improved by using MEMS technologies and thin-film PZT (Lead Zirconate Titanate), helping them attain the required level for electronic applications.

This report describes the technology requirements and improvements made in order to meet functional, additive printing requirements.

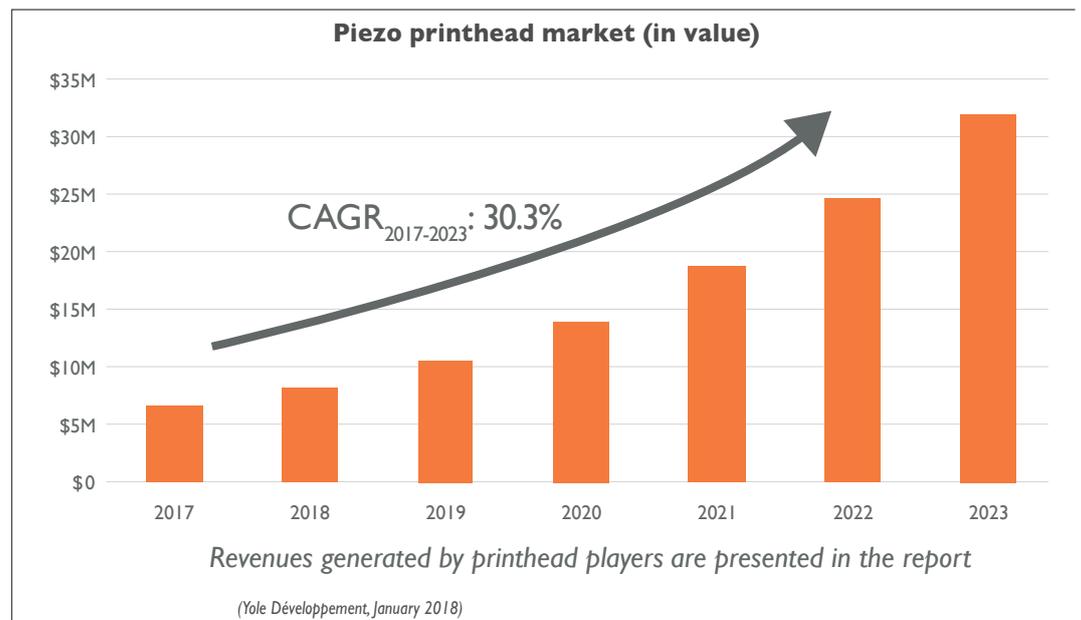
Can inkjet printing manufacture a full electronic device? The answer is yes, but only in prototyping applications. Using an inkjet printer, 3D inkjet printing can now manufacture a PCB card from A - Z. Nano-Dimension, a developer of 3D printing equipment solutions, released at the end of 2017 its Dragongfly 2020, which uses Konica Minolta printheads. In mass applications, inkjet remains one of the key steps in the manufacturing process.

A PRINTHEAD MARKET REACHING MORE THAN \$31 MILLION IN 2023

Functional printing is leveraging the use of inkjet printing and opening new market opportunities for printhead manufacturers. The manufacturing digital revolution is underway and inkjet printheads integrated in industrial printing equipment are expected to reach more than \$31 million in 2023, with a CAGR of 30.3% from 2017 - 2023. Key players in this field are Konica Minolta, Fujifilm Dimatix, Océ-Canon, and Xaar. Other Piezo printhead players are currently very active in the graphics domain, where the market is growing, However, competition is focused on gaining its slice of the pie too.

This report contains printhead market share and printhead market forecasts for functional and additive printing, along with estimated printer market shipment by application.

R&D still represents a large portion of inkjet printer acquisition, with 93% of total printers shipped. Mass production has only just begun for OLED display thin-film encapsulation. It's a good sign that the industry is showing interest in RGB deposition, PCB, and flexible electronics.



INK: THE OTHER KEY PARAMETER OF THE PRINTING PROCESS

Overview of functional ink players by major applications

OLED display	MERCK, DUPONT, SUMITOMO CHEMICAL, BASF
PCB solder mask – etch resist	DOW, AGFA, MERCK
Printed electronics – PV – conductive inks	DUPONT, pvnanocell, ANP, INTRINSiQ, NOVACENTRIX, InkTec

(Yole Développement, January 2018)

In an inkjet printing process, the “golden triangle” of key parameters is: Printheads – Inks – Substrates. Formulating functional inks is a key challenge in manufacturing applications, since a diversity of materials must be ejected: conductive inks, metallic inks, resist inks, and OLED-based material inks. This report presents an estimate of the ink volume required in the field of functional and additive manufacturing. Inkjet printheads’

tolerance in terms of viscosity and surface tension is limited, and could only be optimized for a certain type of printhead.

This report also covers the challenges linked to ink formulation, and the ideal ink properties for piezo printheads. Collaborations are mentioned, describing which ink players are currently interested in developing a functional printing market.

OBJECTIVES OF THE REPORT

- Get an overview of emerging printhead applications & market
- Give the current status of inkjet printing technology adoption on the different market
- Provide an application roadmap
- Access market metrics at inkjet equipment and inkjet printhead devices for electronics, microelectronics and microoptics applications from 2017-2023
- Understand the technological and economical challenges of using inkjet printing in those applications
- Give an overview of the key players and key supply chains in related applications
- Learn about inkjet printhead technology trends to access electronics, microelectronics market
- Introduce ink players and collaboration

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TABLE OF CONTENTS (complete content on i-Micronews.com)

Executive summary	6	Market application	82
Introduction	28	> Application market – OLED display / PCB & Printed electronics (2.5D and 3D) / Solar cells / Microoptics / MEMS & Sensors	
> Inkjet printing introduction		- Introduction	
> Functional and additive manufacturing concept		- Major development	
> Inkjet printing applications		- Inkjet printing processes	
> Functional and additive market applications		- Players and collaboration	
> Drivers for the adoption of Inkjet technology		> Global roadmap	
> 3D printing concept		Inkjet printing trends	152
Printheads	50	> Printhead technology trends	
> Major printhead types		> MEMS vs. conventional printheads	
> Printhead chips, module and printers		> Thin film PZT piezo ejection	
> Industrial inkjet printhead players		> Single pass printing	
>Major industrial printheads on the market		> Ink recirculation concept	
Market for functional and additive printing forecast 2017 – 2023	67	Functional inks	161
> Introduction		> Introduction	
> Hypothesis		> Market estimation	
> Inkjet printer shipment market and installed base		> Product formulation and cost comparison	
> Inkjet printhead market – shipment, value and market share		> Players and collaboration	
> R&D and manufacturing shares in value 2017 and 2023		Conclusions	180



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