Multi Material 3D Printing Technology

Océ Print head technology

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From the World of Print…to …Printing the World?

https://www.oce.com/about/mission-vision/
Multi Material 3D

• Definition
  • Printing 3D structures
  • Combination Material properties
    • Insulation <-> Conduction
    • Hard <-> Soft
    • Transparent <-> Opaque
    • Mono colour <-> Full Colour

• Technology
  • Print heads
  • Jet-able materials
  • MM3D Workflow Software
  • Colour Workflow
  • Controllers
Potential MM3D

• Markets
  • Dental
    • Now: $1.4 B, CAGR 18%. 2023: $3.5 B
  • 3D Printing
    • Now: $6 B, CAGR 28%. 2023: $15 B
  • Semiconductor Industry
    • Now: $437 B, CAGR 9%. 2023: $1.1 T

• Examples
  • Teeth
  • Marquette's/ CAD GIS\(^1\)
  • Personal
  • Printed Electronics
    • LED
  • AM products
    • Blue tooth speakers

\(^1\) fjve [https://ahn.arcgisonline.nl/ahnviewer/](https://ahn.arcgisonline.nl/ahnviewer/)
MM3D Examples
Océ C29 print head

- **Basic specifications**
  - Piezo Ink Jet
  - 256 nozzles, 2 rows of 128 @ 75 npi per row
  - 18.7 kHz, 29 pl, 6 m/s
  - Ink viscosity range (6-12 mPa·s)
  - Operating temperature 130 ºC (145 ºC max)

- **Electronics**
  - Testability: PAInT nozzle status detection
  - Integrated ASICs for jet pulse generation

- **Multi Material**
  - C29: Color Wave (Toner Pearls)
  - C29L: Industrial Printing

- **Dimensions**
  - HxWxD = 152 x 155 x 20 mm (C29)
C29 Print head Evaluation System

- Van Mierlo¹

VAN MIERLO INGENIEURSBUREAU
Intelligente elektronica voor meet- en regeltechniek

- 2002 Inkjet Process Monitor
- Developer
  - C29(L) - Print head Ethernet Interface
  - Print head Evaluation System
- System Integrator
- Support

Print head Evaluation System
- Ready to use
- Evaluation of C29+Inks
- Ethernet interface
- Print stage

¹ https://www.vanmierlo.com/
MEMS (Micro-electro Mechanical Systems)

- Scalable Resolution
  - 100 NPI
  - 300 NPI
  - 600 NPI
  - 1200 NPI

- Adaptable
  - 64 × 16
  - 128 × 8
  - 256 × 4

- Modular

Printhead assembly
From 2 to 6 MEMS chips are mounted onto the printhead assembly.

MEMS wafer
MEMS (Micro-Electro-Mechanical Systems) chips are actually complete printheads. They are produced on silicone wafers via microfabrication techniques. Each wafer contains hundreds of chips, each of which is a printhead. Each chip is less than 1 millimeter thick.

Cross section MEMS chip
Inside each chip is an ink channel (1), a mechanical piezo membrane (2), and a nozzle (3). With an electronic pulse, the membrane draws ink from the reservoir, and jets it out onto the printed material at very high jetting speeds.
2D cross-section of MEMS print head stack

Design based on extensive in-house models (acoustics, drop formation, etc.) and knowledge of system-integration behaviour.
Typical MEMS dimensions

Current prototypes:
- 2-5 um sol-gel PZT
- nozzle 30um, several nozzle shapes
- 100s x 100s um actuator size
- Membrane thickness ~3-5 um
- $d_{31}$ around 140 pm/V
- 5-10 pL droplet
- resolution 600 dpi
3D Relief Processor

3D model (.stl, .obj, .ply, .amf..)

Sparse Voxel Rasterization

Multi-material Voxel slice raster

Multi-material Pixel slice raster

Printer drop jetting driver

Surface processing:
- Color texture
- Gloss texture
- Relief texture
- Contour lines reduction
3D Relief prints
MM3D Dental

- **3D printed Teeth**
  - Economics
  - 60 min
- **Fieldlab MultiMaterial3D**
  - Hybrid MM3D Technology
    - VAT+C29
  - Demonstrate Feasibility

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1. [https://www.youtube.com/watch?v=pdGHFhAHQa4](https://www.youtube.com/watch?v=pdGHFhAHQa4)
Océ MetalJet

- Jetting of liquid metal drops by electrical current pulses
- Drops generated using Lorentz force

Advantages:
- Molten metal
  - Max 2000 °C
  - No powders, paste needed
  - Bulk Characteristics
- Multi Metals
  - Si, Sn, Cu, Au, Ag
- Multi Substrate
  - Si, Metal, Polymers
- Fine Pitch

\[ F_{\text{act}} \sim I \times B \]
MetalJet: Direct Metal Jetting

Metal Additive Manufacturing

Direct

- Powder bed fusion
  - Selective laser melting
    - EOS
    - Concept laser
    - SLM solutions
    - Renishaw, Phenix, Realizer, 3D Systems (Phenix/Layerwise)
    - Shining3D
  - Electron beam melting
    - Arcam Exclusive
- Directed Energy deposition
  - Trumpf
  - Optomec
  - Sciaaky
  - LENS
  - DMG-Mori Seki
  - POM
  - Irep
- Material jetting
  - Optomec, Xjet, Vader
- Sheet lamination
  - Fabrisonic
- Binder jetting
  - Digital Metal (Hoganas)
  - ExOne
  - VoxelJet
  - Viridis3D
  - DesktopMetal

NorskTitanium

Indirect

Binder jetting

- Sand molds and cores
- Sand casting
- Lost models
- Lost Model casting
- Other technologies for lost model production
  - 3D Systems (PrimeCase: SLS)
  - Quick cast (SLA)
  - RapidShape (SLA)
  - SolidScape (inkjetting lost wax)
  - Projet/Polyjet (Stratasys-Objet / 3DS)
Océ MetalJet

- 2006: First MetalJet experiments Océ
- 2014: Contract UoN/Demcon
- 2016: Equipment upgrade in Venlo
- 2018: External Application Research