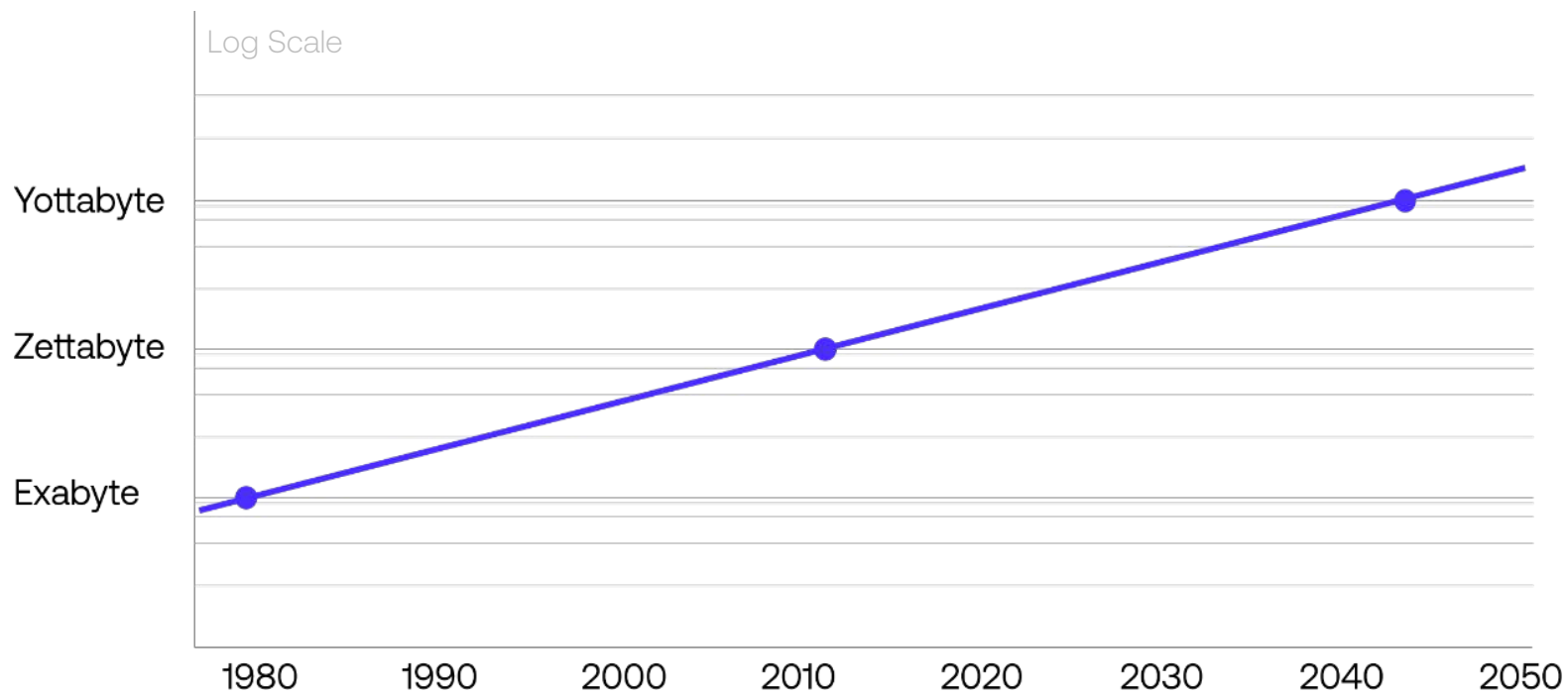




# Reinventing Data Storage for the Yottabyte Era

Sebastian Kirsch – MD Technology – Cerabyte

# Global Installed Data Storage Base & Forecast



Source: Horison Information Strategies

Every ~30 years:

**1000x  
growth**

# To Keep the Digital Age Running, the Industry Needs



a new storage technology that is poised to deliver within the next two decades

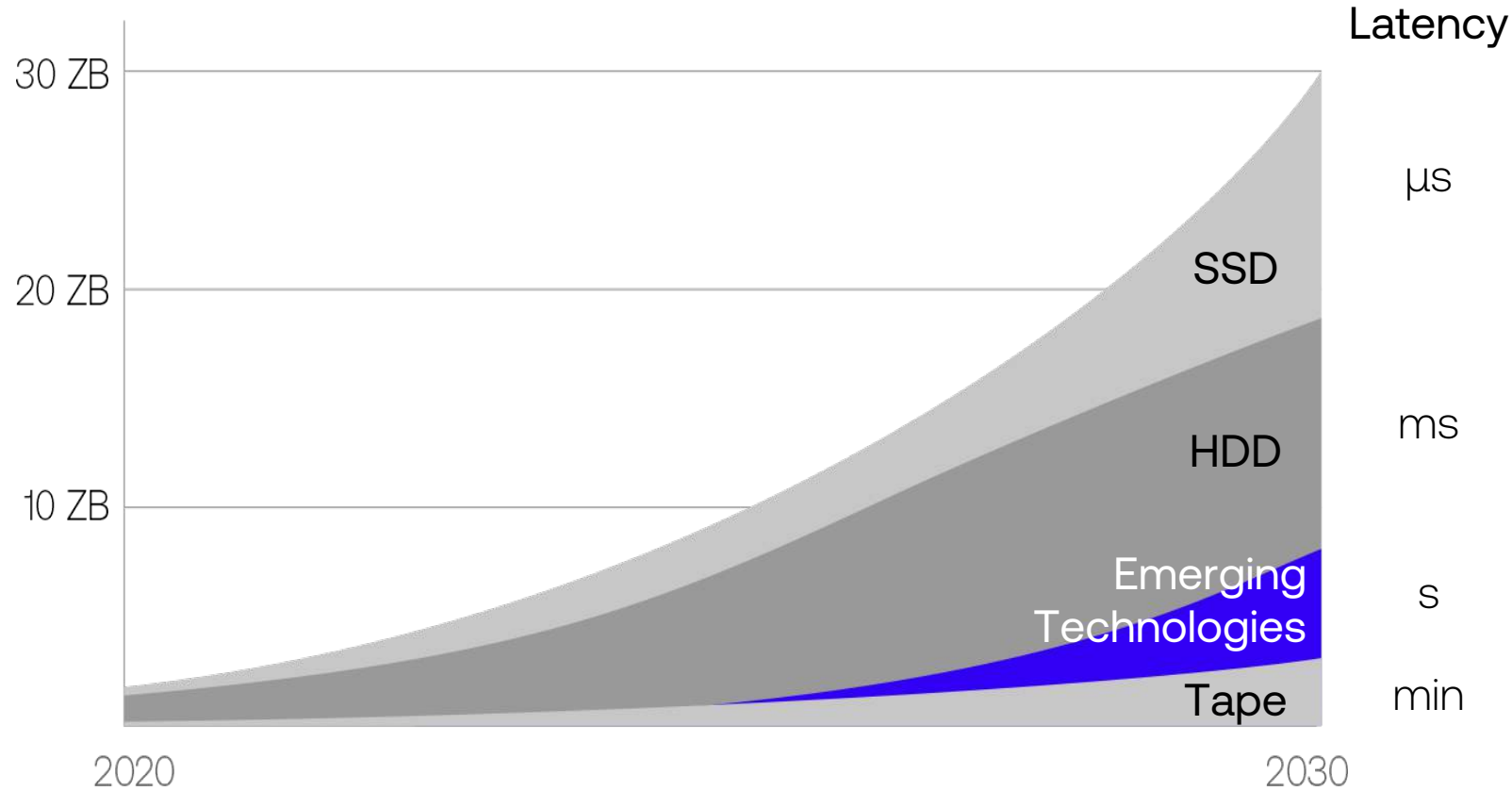
**>100x**  
improvement of

- **Storage Capacity**
- **Performance**
- **TCO**
- **Energy Efficiency**
- **Media Life**
- **Bit Error Rate**

# New Accessible Permanent Storage Tier Needed



Durable, Fast Write/Read, Low Latency, Low Cost



Source: Gartner 2022, Updated 2010-2030 Long Term Scenarios

**”Need for an additional green & scalable storage tier by 2025”**

*Fred Moore, 2021, Horizon Information Strategies*



<https://vimeo.com/880519680/14efe30232>

# Ceramic Data Storage, 5000-Year Track Record



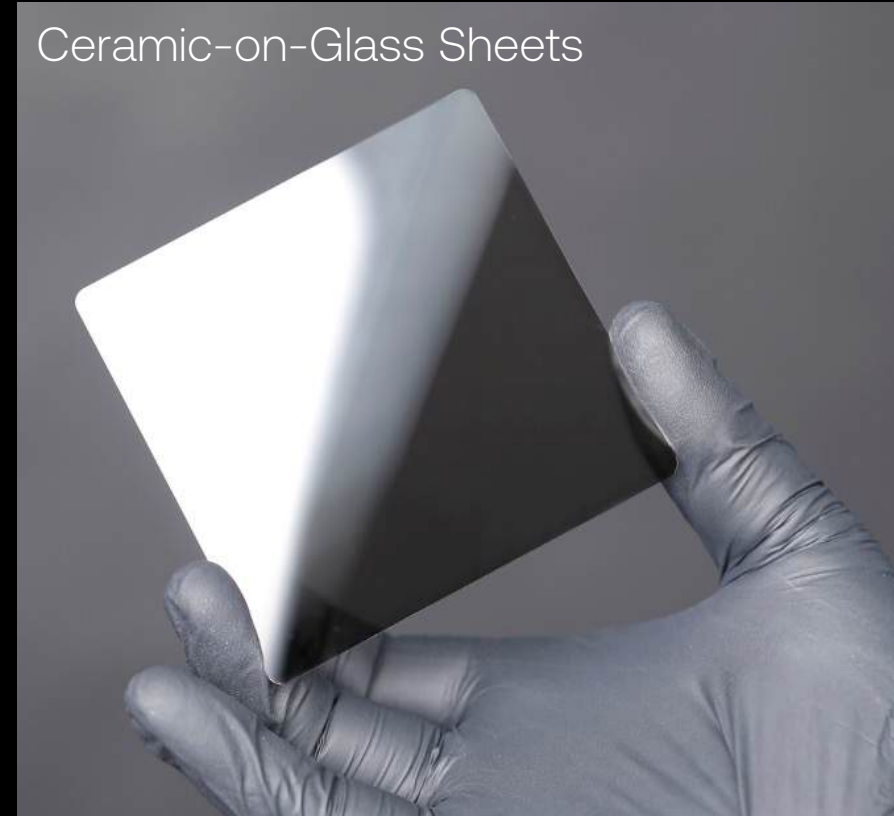
From clay tablets to ceramic punchcards at nanoscale

Cuneiform Clay Tablets



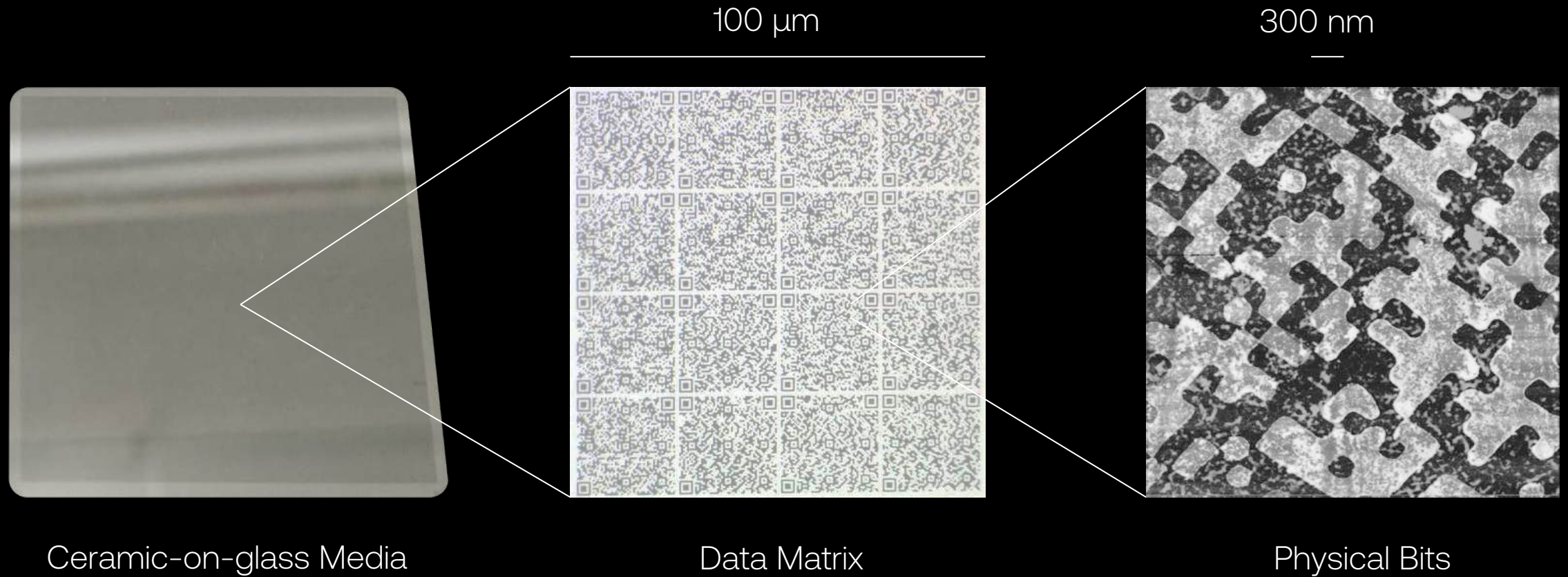
**Low** Density & Write/Read Speed

Ceramic-on-Glass Sheets



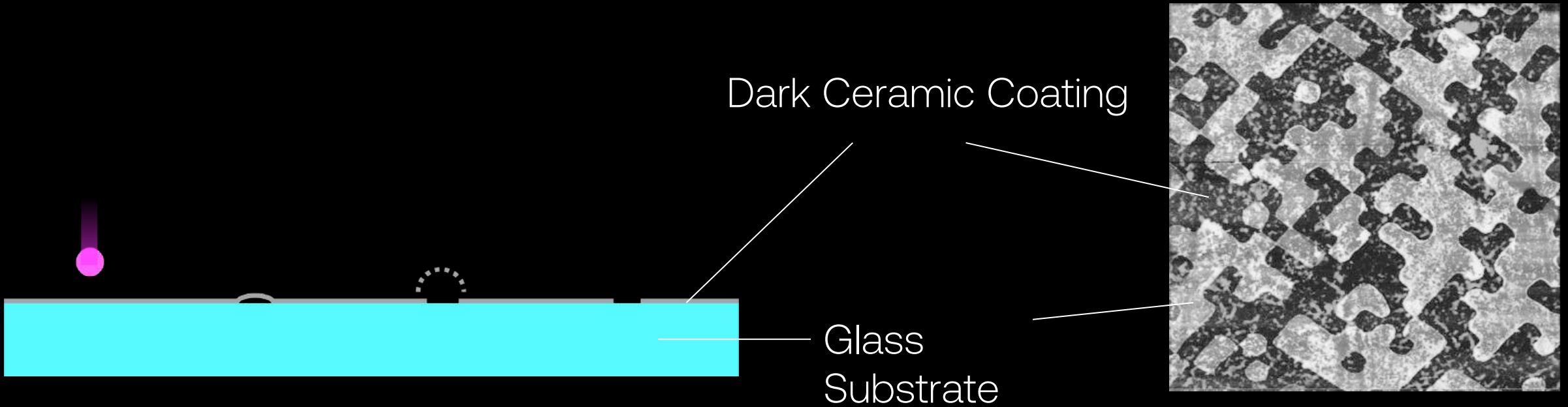
**High** Density & Write/Read Speed

# Ceramic Punch Cards at Nanoscale





# Writing Bits by Ablating the Ceramic Coating

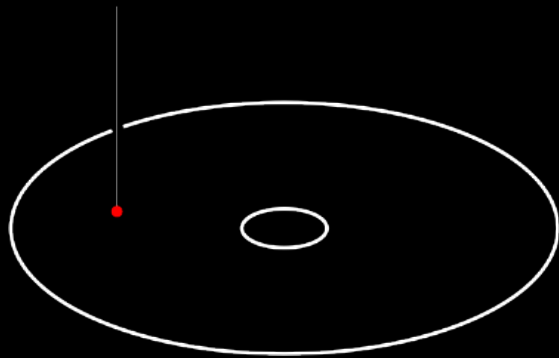




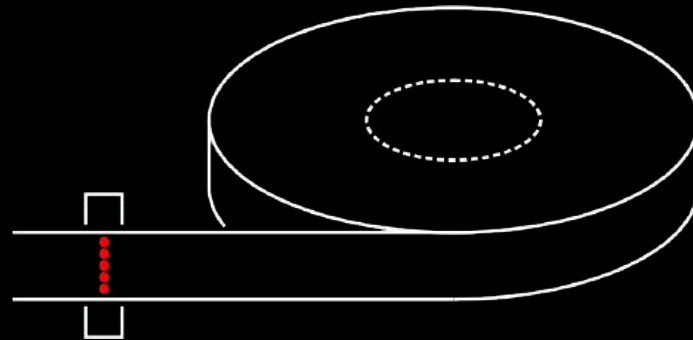
# Matrix of Spots Enables High-speed Writing



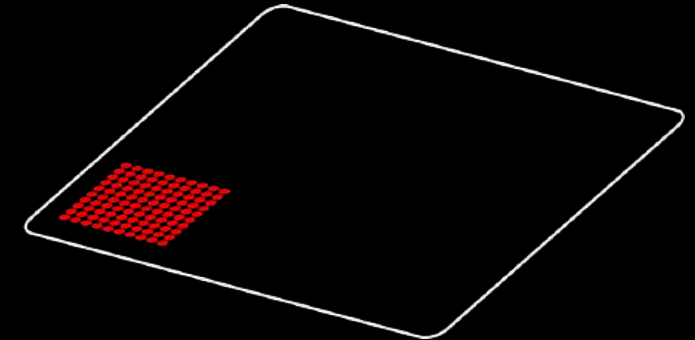
Single Spot



Row of Spots



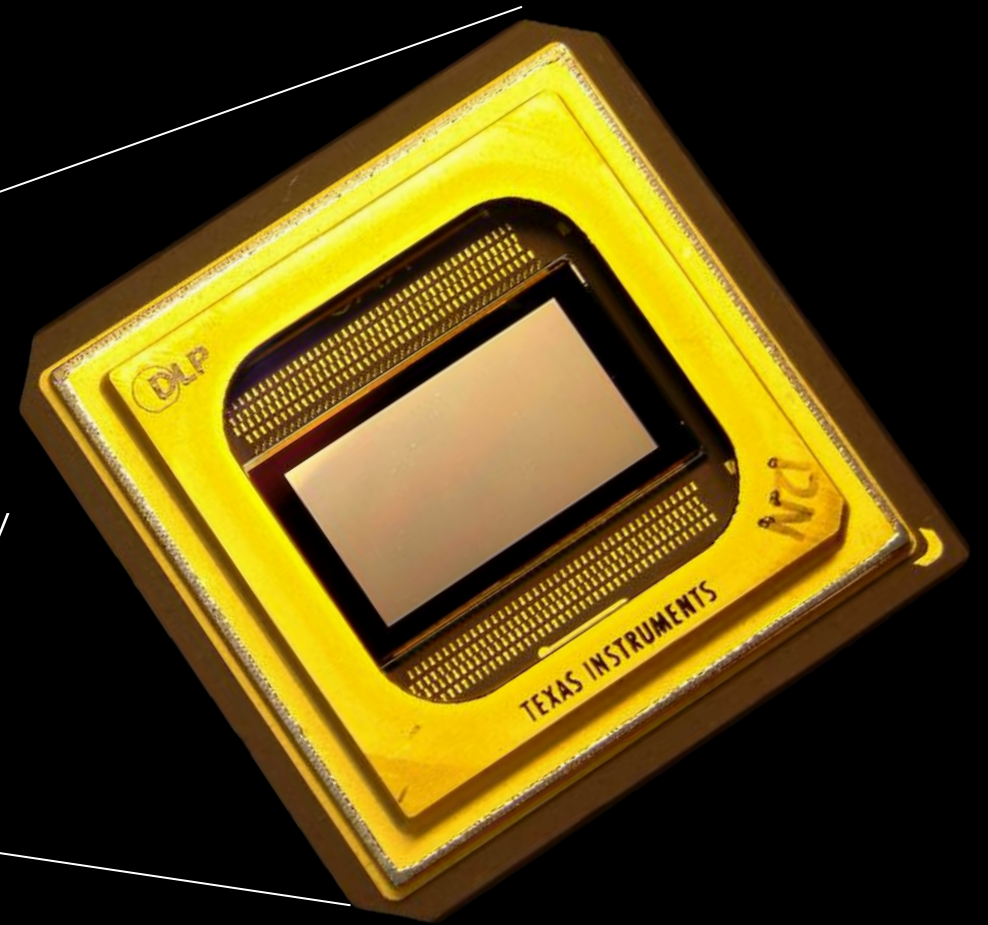
Matrix of Spots



# Writing Using a DMD - Digital Mirror Device



2 mio seperately  
switchable  
micromirrors



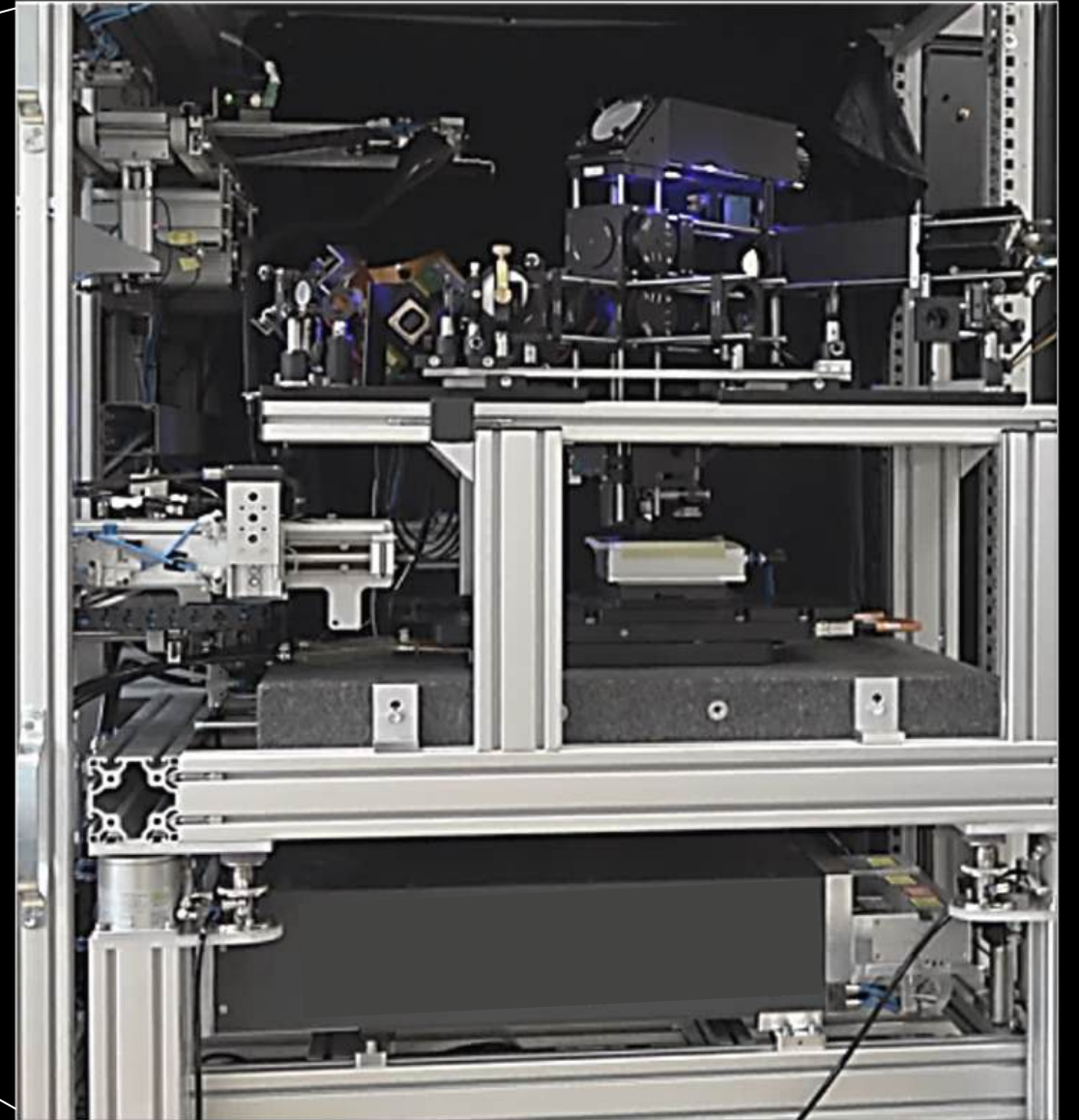
# Write/Read Rack Combining Optics, Stage and Laser



Optics

Stage

Laser

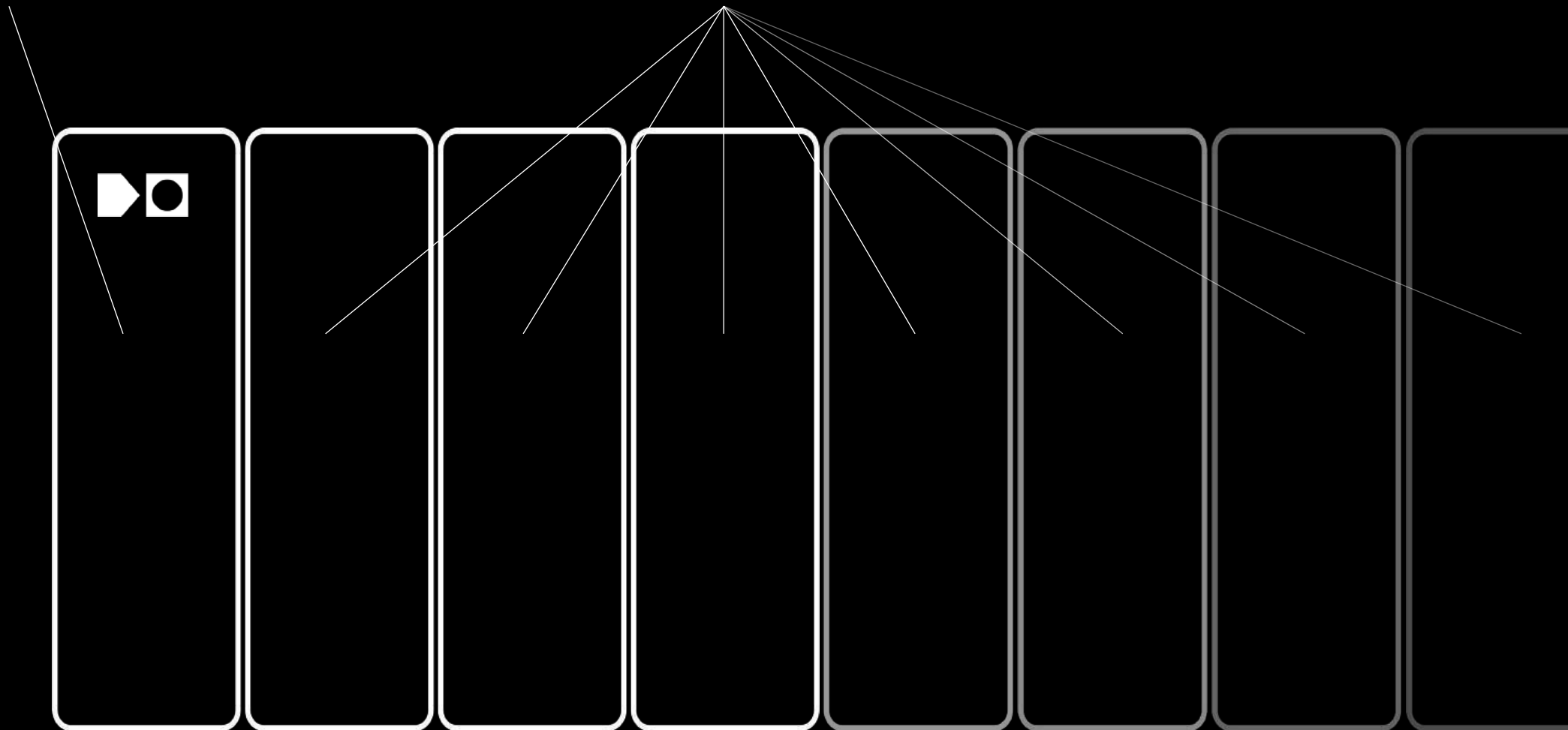


# System Overview



Write Rack

Library/Read Rack





S3 Access

Object Storage Layer

Virtualization Layer (RAID Logic and Filesystem on Rack Level)

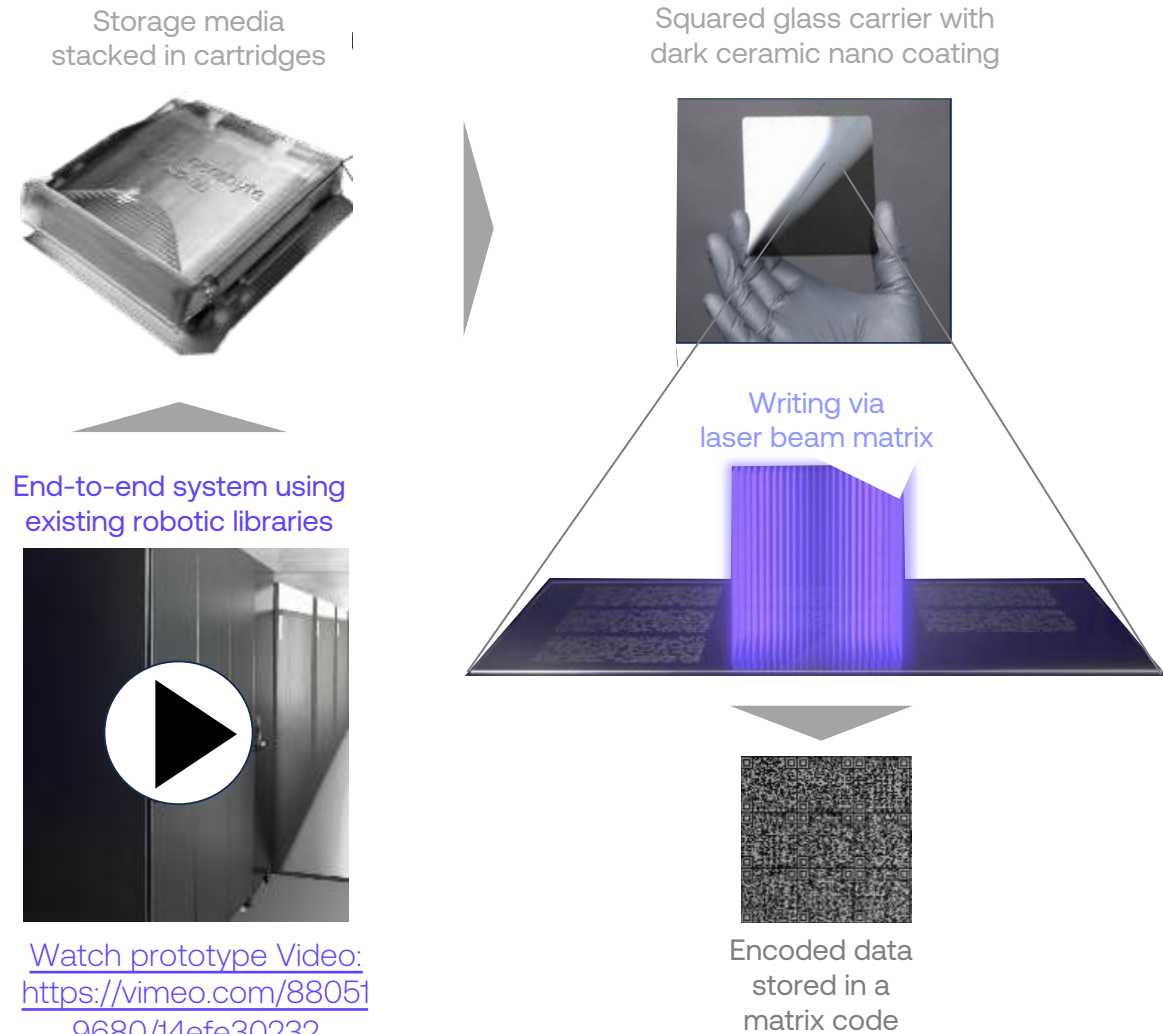
Cerabyte File System + Erasure Coding on Local Carrier/Cartridge

Block Storage with Local Error Correction on Local Data Carrier

# Summary



Display glass, ceramic coating, laser, and standard industry robotics



▶ **Ultra low-cost display glass** with **PVD coated ceramic nano-layers**

▶ **Fast writing using laser beam matrix** with up to 2 Mb per shot

▶ **Fast reading** using microscope with **ultra-fast image sensor**

▶ **Fast random access to first bit** avoiding spooling time of tape

▶ **Stacking media in cartridges** using existing robotic libraries

▶ **Standard Software Interfaces**

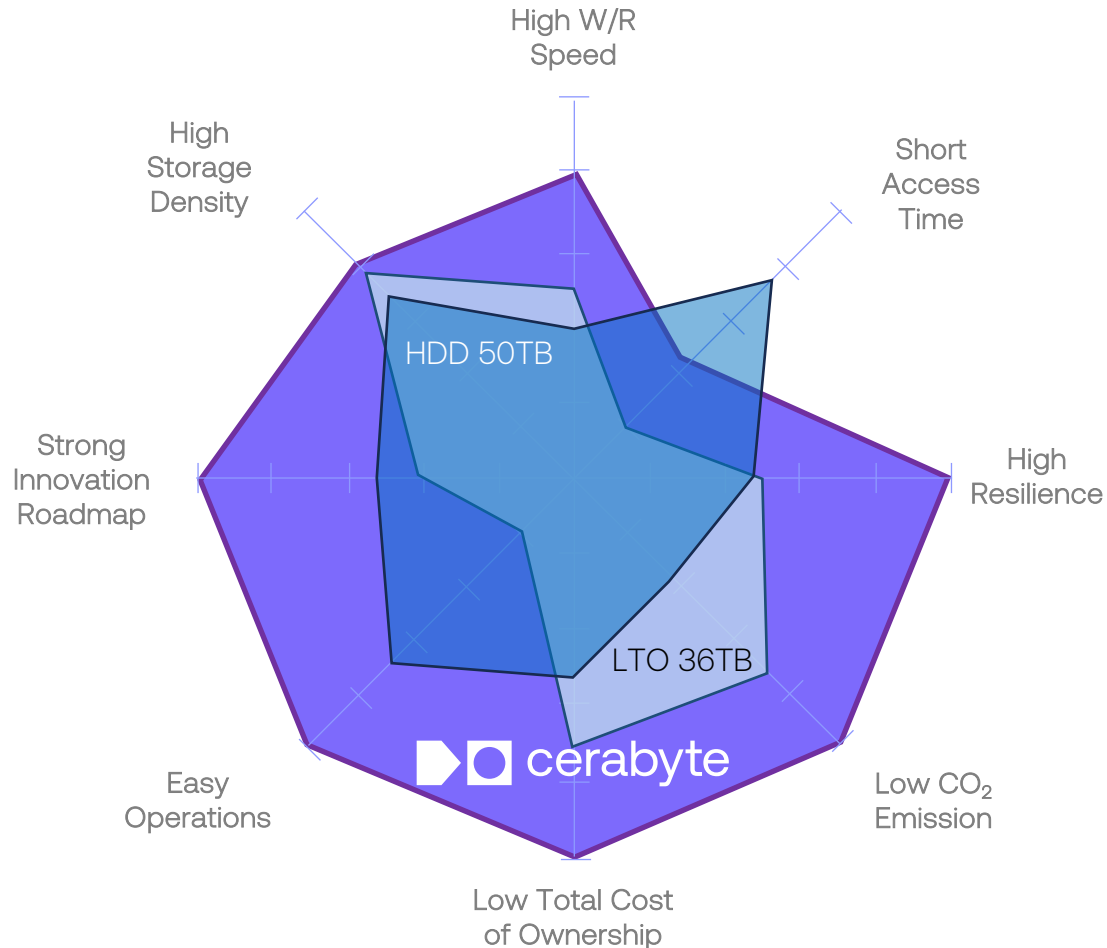


# Positioning



## Performance positioning between tape & HDD, **due to ...**

Fulfillment of customer needs in 2028 (schematic)

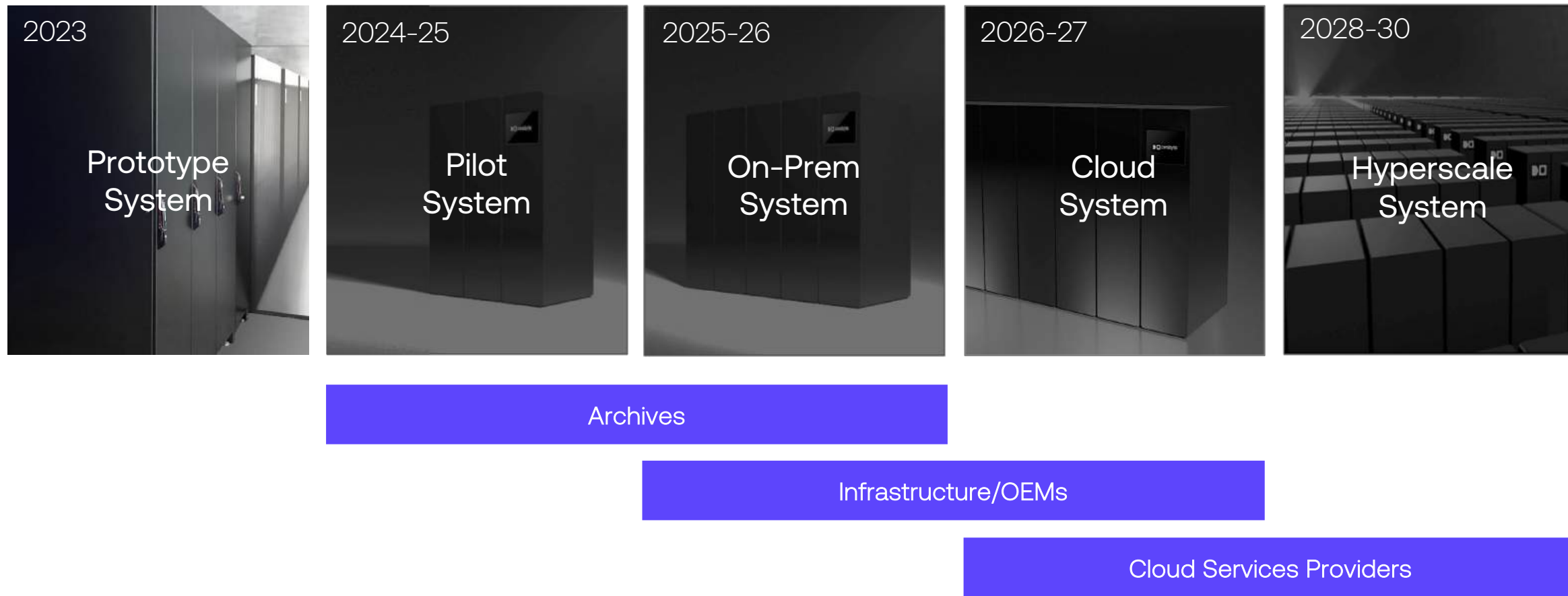


- ▶ **Extreme resilience:** High lifespan – temperature & humidity resistant etc.
- ▶ **Strong performance:** Fast W/R speed, reasonable access time
- ▶ **Easy operations:** Standard data center environment, no climatization
- ▶ **High sustainability:** 99% reduction of CO<sub>2</sub> vs. HDD & 100% recyclable
- ▶ **Low TCO:** Reduction of 95% vs. HDD, 75% vs. tape.

# Product roadmap



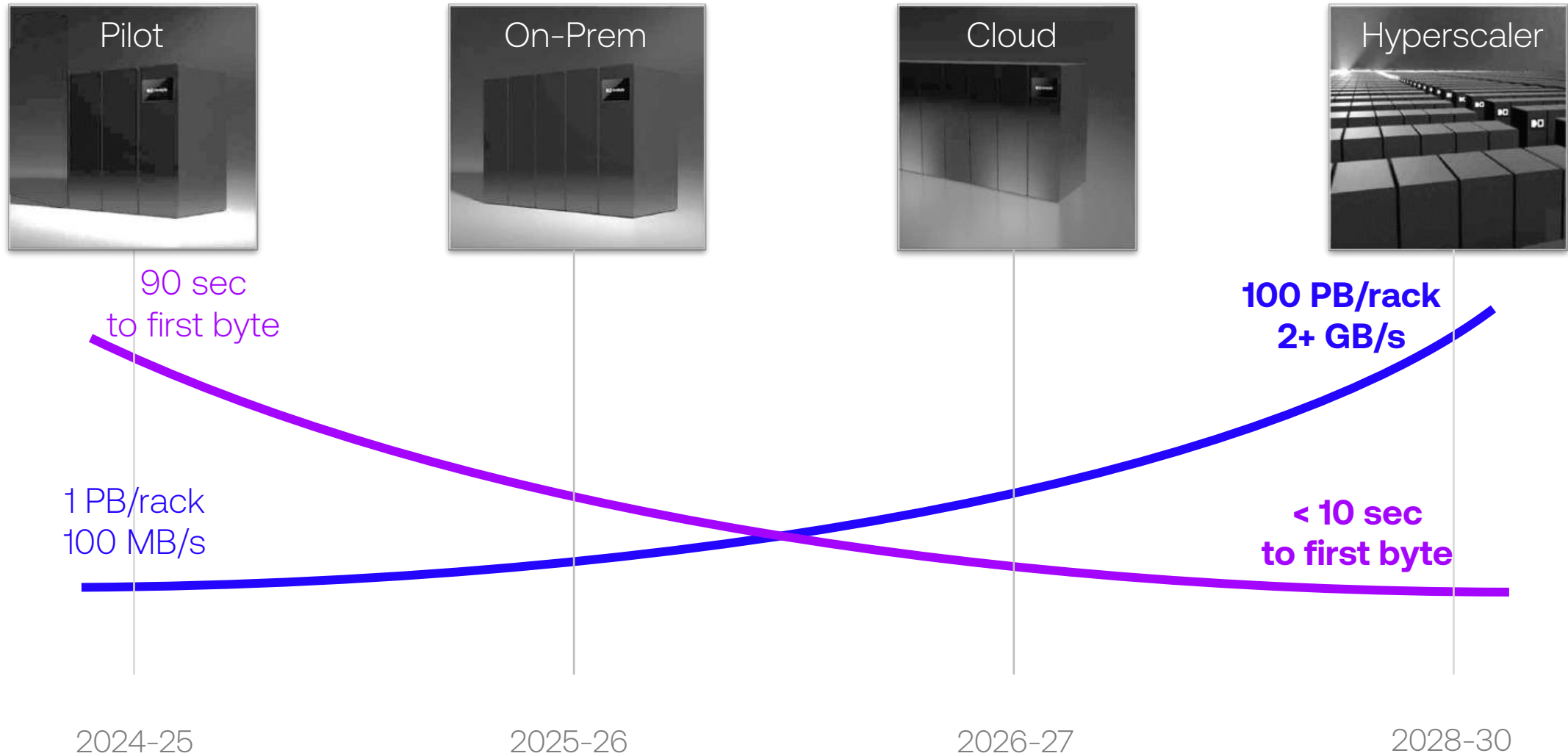
Scaling from pilot, on-prem, cloud to hyperscale system



# Key Specs



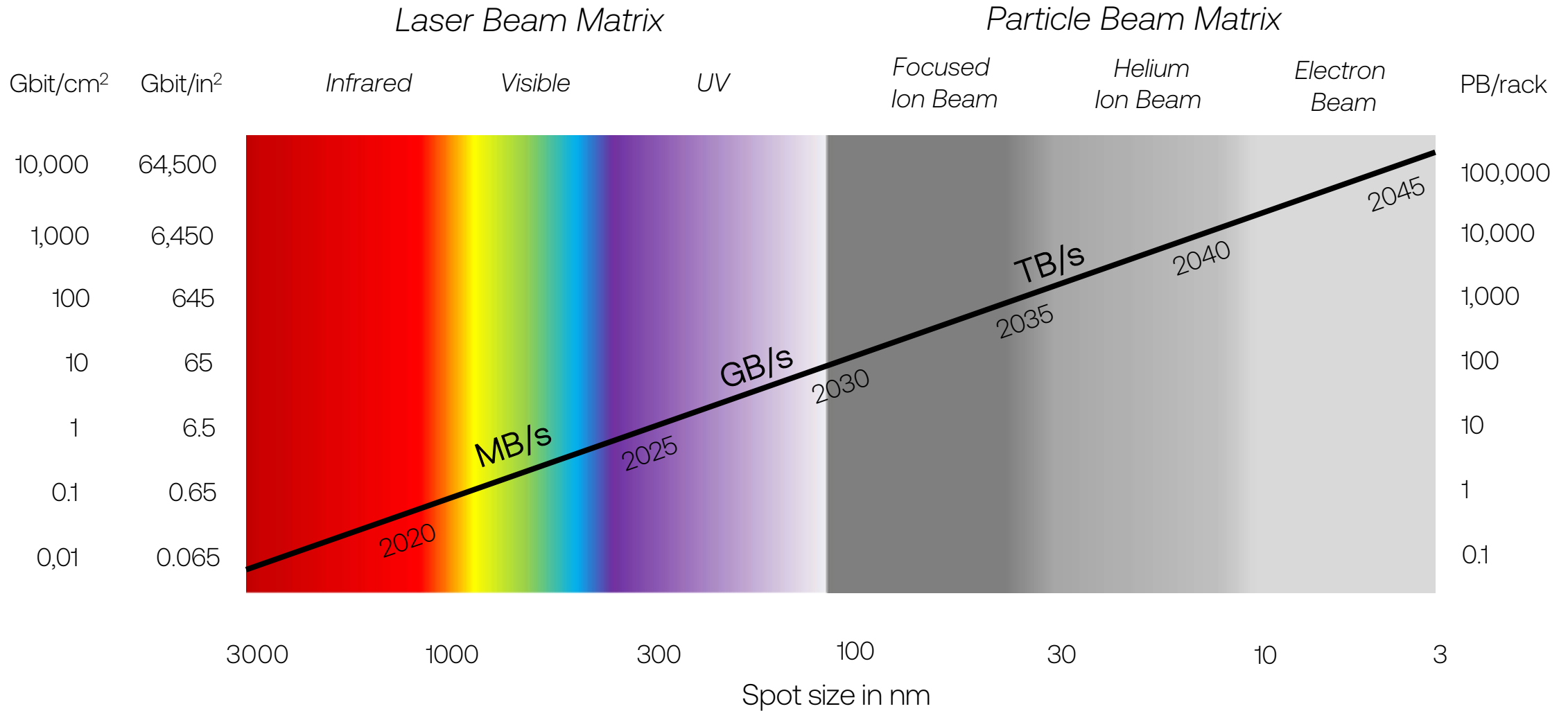
Increasing Capacity and Speed while reducing Access Time



# Leveraging Semiconductor Fab Tool Technology



to scale density and access speed



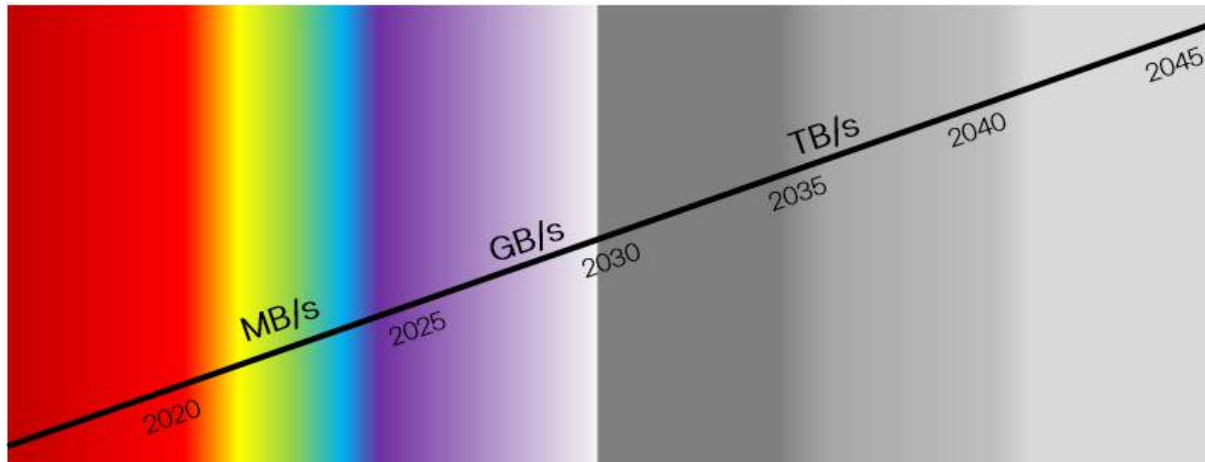
# Semicon Fab Tool Tech Roadmap



Particle Beam Matrix Enables Capacity Growth beyond 2040

*Laser Beam Matrix*

*Particle Beam Matrix*

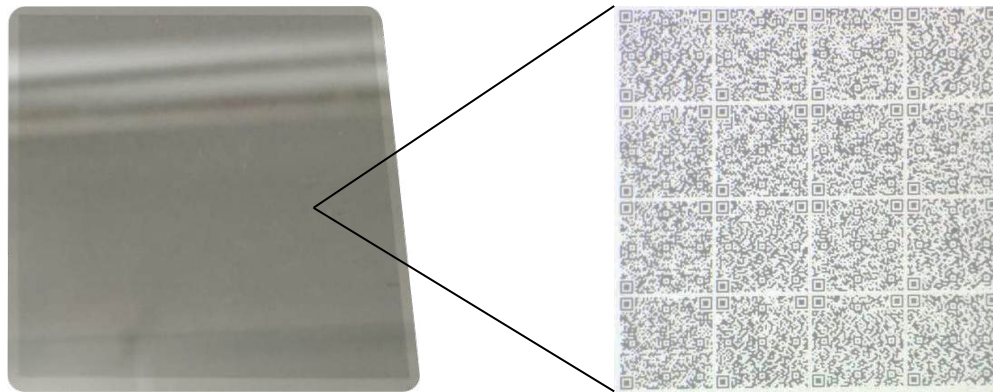
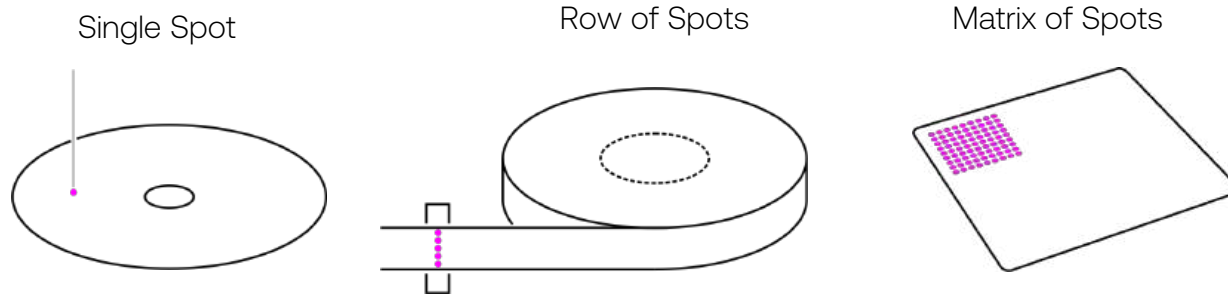


- ✓ **Storage Capacity**
- Performance
- TCO
- Energy Efficiency
- Media Life
- Bit Error Rate

# Matrix Enables High-Speed Writing



High data throughput, reading with high speed camera

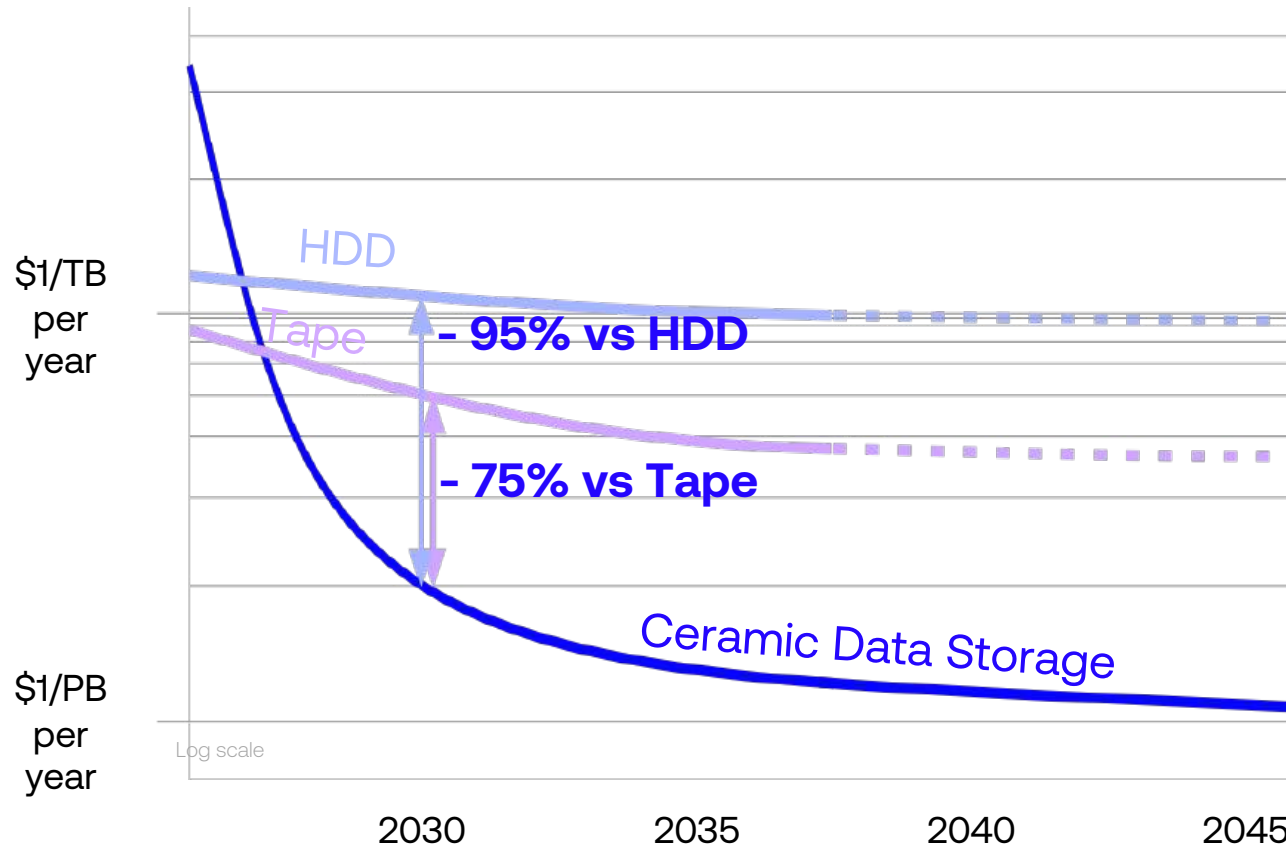


- ✓ **Storage Capacity**
- ✓ **Performance**
- **TCO**
- **Energy Efficiency**
- **Media Life**
- **Bit Error Rate**



# Cost Scaling

Orders of Magnitude Lower TCO



- ✓ Storage Capacity
- ✓ Performance
- ✓ TCO
- Energy Efficiency
- Media Life
- Bit Error Rate

# Durable & Sustainable



Ceramic-on-glass enables durability, sustainability and recyclability



-272 °C  
-459 °F



Energy free retention,  
no AC for storage



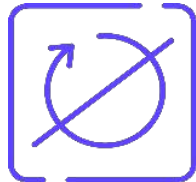
+500 °C  
+930 °F



Immutable record, cyber  
secure / WORM media



Moisture &  
flood proof



No media degradation  
forcing replacement



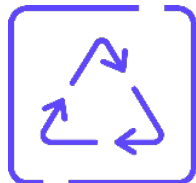
Corrosion  
resistant



No data migration,  
no bit rot



Radiation &  
EMP proof

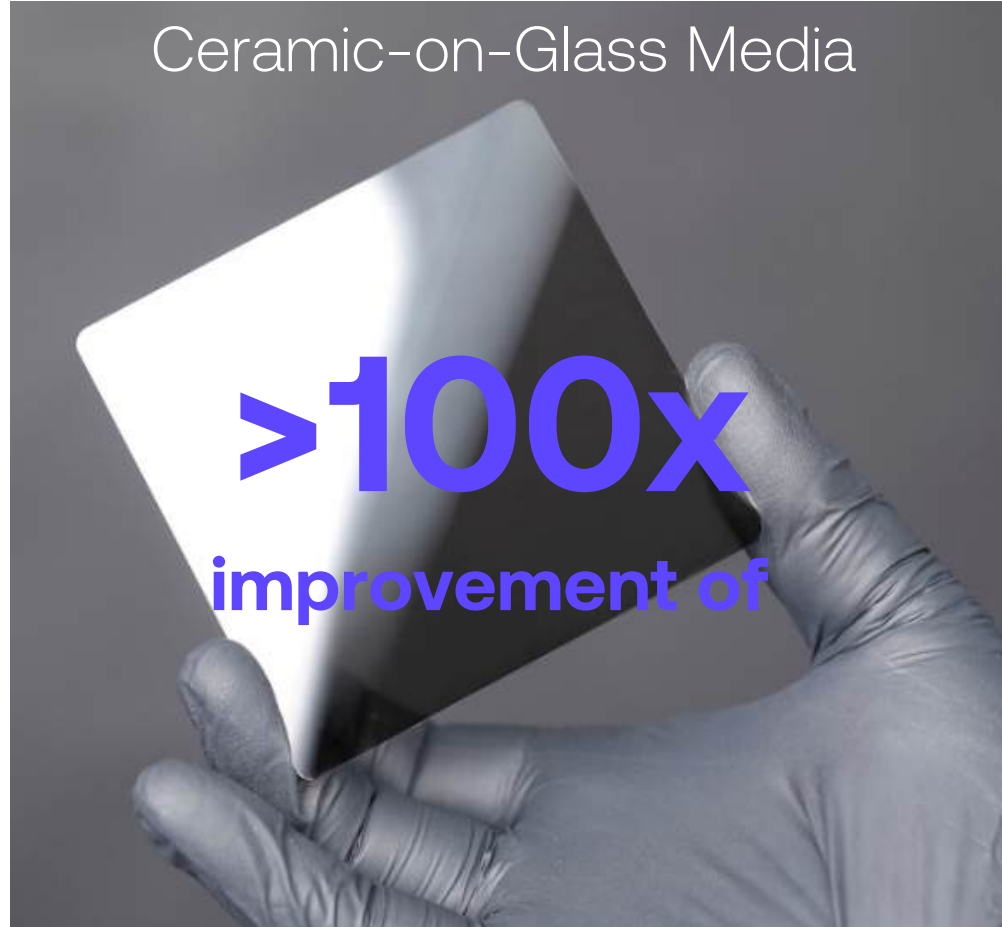


Deletable,  
100% recyclable

- ✓ **Storage Capacity**
- ✓ **Performance**
- ✓ **TCO**
- ✓ **Energy Efficiency**
- ✓ **Media Life**
- ✓ **Bit Error Rate**

# Ceramic Data Storage

Enables >100 x Improvements

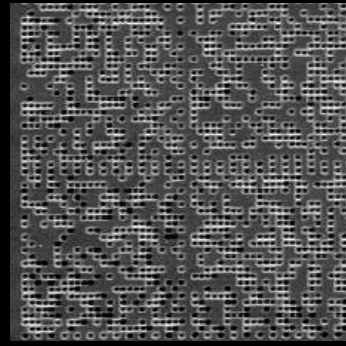


- ✓ **Storage Capacity**
- ✓ **Performance**
- ✓ **TCO**
- ✓ **Energy Efficiency**
- ✓ **Media Life**
- ✓ **Bit Error Rate**

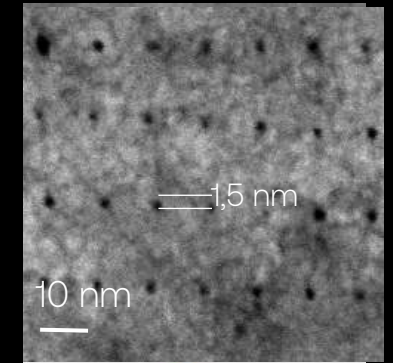


Electron-beam is pushing pixel size to **1,5 nm or 400+ TB per 4 x 4 in<sup>2</sup>**

## Laser beam matrix



## Particle beam matrix



ps Laser

fs Laser

Ion Beam

Electron Beam

Pixel size

1,0  $\mu\text{m}$

100 nm

30 nm

1,5 nm

Data capacity  
per 10x10 cm<sup>2</sup> or 4x4 in<sup>2</sup>

1,25 GB

125 GB

1+ TB

400 TB



## Cerabyte & Leading Research Partners are exploring ICSD Laboratory

### Ceramic Nano Coating

#### Fluorescent materials

Reflective Ceramics

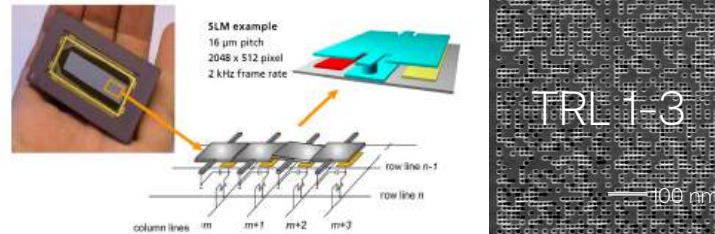
Fluorescent Ceramics



Research Partner: Recendt (AT)

### Laser Beam

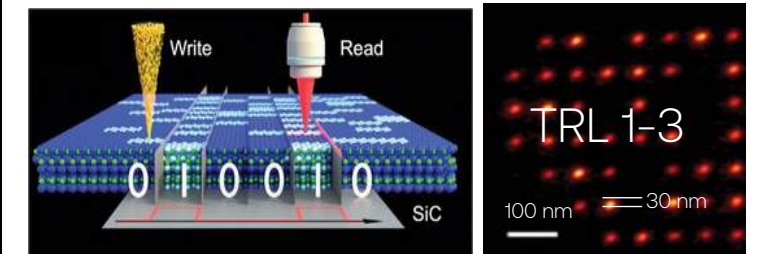
#### UV – laser (100 nm - W/R)



Research partner: Fraunhofer IPMS – Dresden (DE)

### Particle Beams

#### Helium Ion Beam (30 nm W/R)

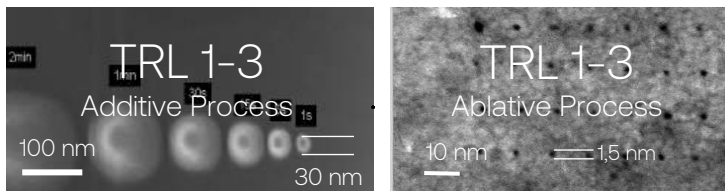


Research Partner: Helmholtz HZDR Dresden (DE)

#### Magnetic materials

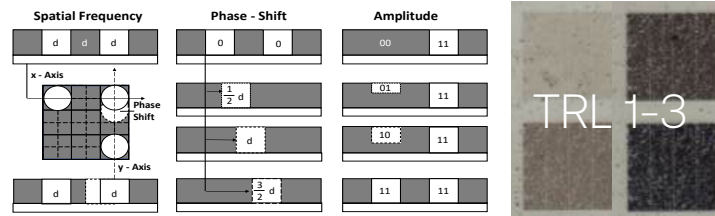
Conductive Ceramics

Magnetic Materials



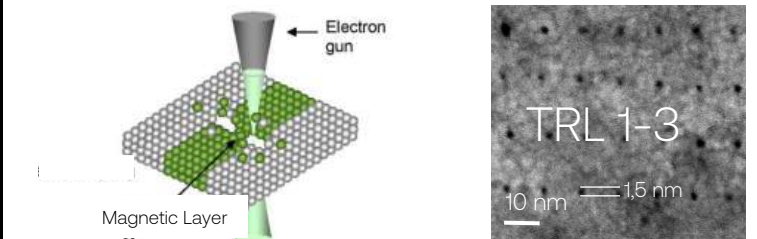
Research partner: IMEC (BE)

#### Multi-Layer & Overlapping Matrix



Research partner: FH Bern (CH)

#### Electron Beam Matrix (1,5 nm W/R)



Research partner: TU Vienna (AT)





## USA Technology Cluster

- Pure Storage
- UC Santa Cruz
- University of Colorado Boulder
- **YOUR ORGANISATION**

## European Technology Cluster

- Technical University Vienna
- CERN – Geneva
- IMEC – Leuven
- Helmholtz HZDR – Dresden

## **YOUR PARTICIPATION**

- Contribute to Ceramic Data Storage architecture.
- Define Ceramic Data Storage hardware and software platform.
- Input from the SNIA Community is highly welcome!





# Store & access data forever

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