



cerabyte

Permanent Data Storage

Christian Pflaum, CEO – Cerabyte



There`s a mismatch

of required
retention time

and

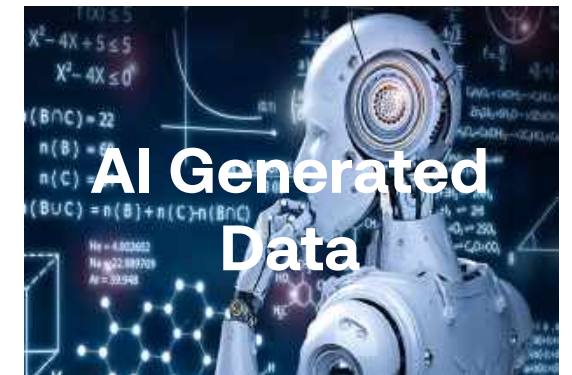
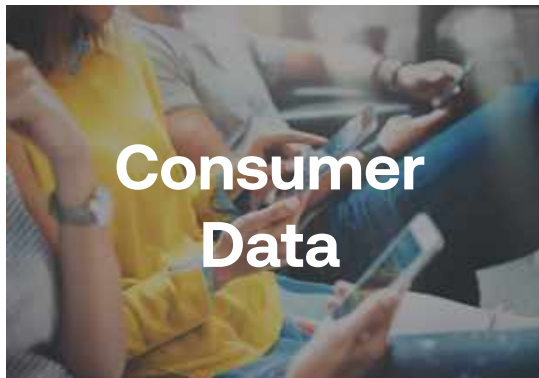
the lifetime of
storage media

**>100
years**

**<10
years**



>**70%** of all data is **cold**
rarely retrieved after **90 days**
but stored for more than **a decade**

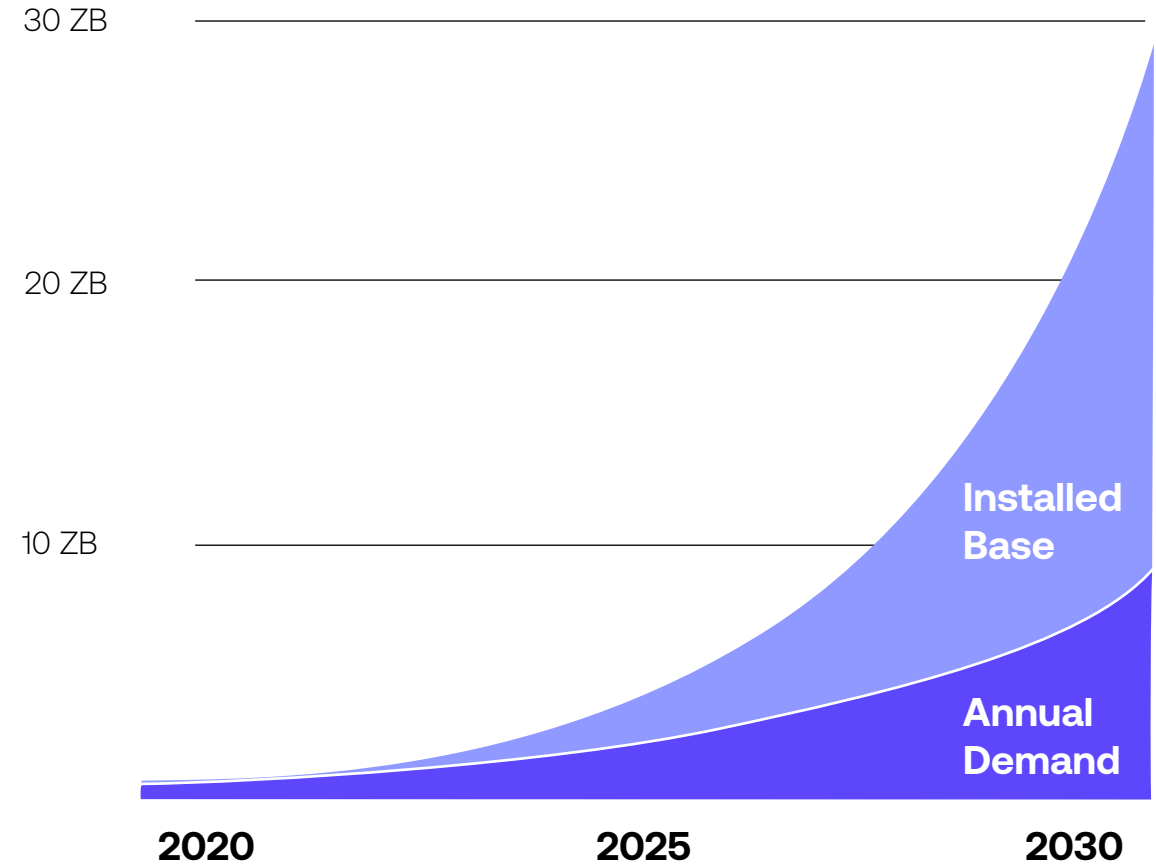


Cost explosion 2030



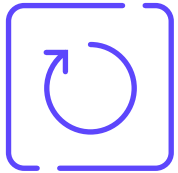
Massive growth
of Cloud Data
storage cost

\$500 bn





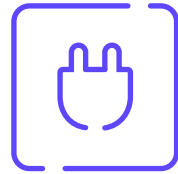
Replacement Every 5-7 years



2%

of global electronic waste

Electricity Consumption



2%

of global consumption

Carbon Footprint



1%

of global CO₂ emissions

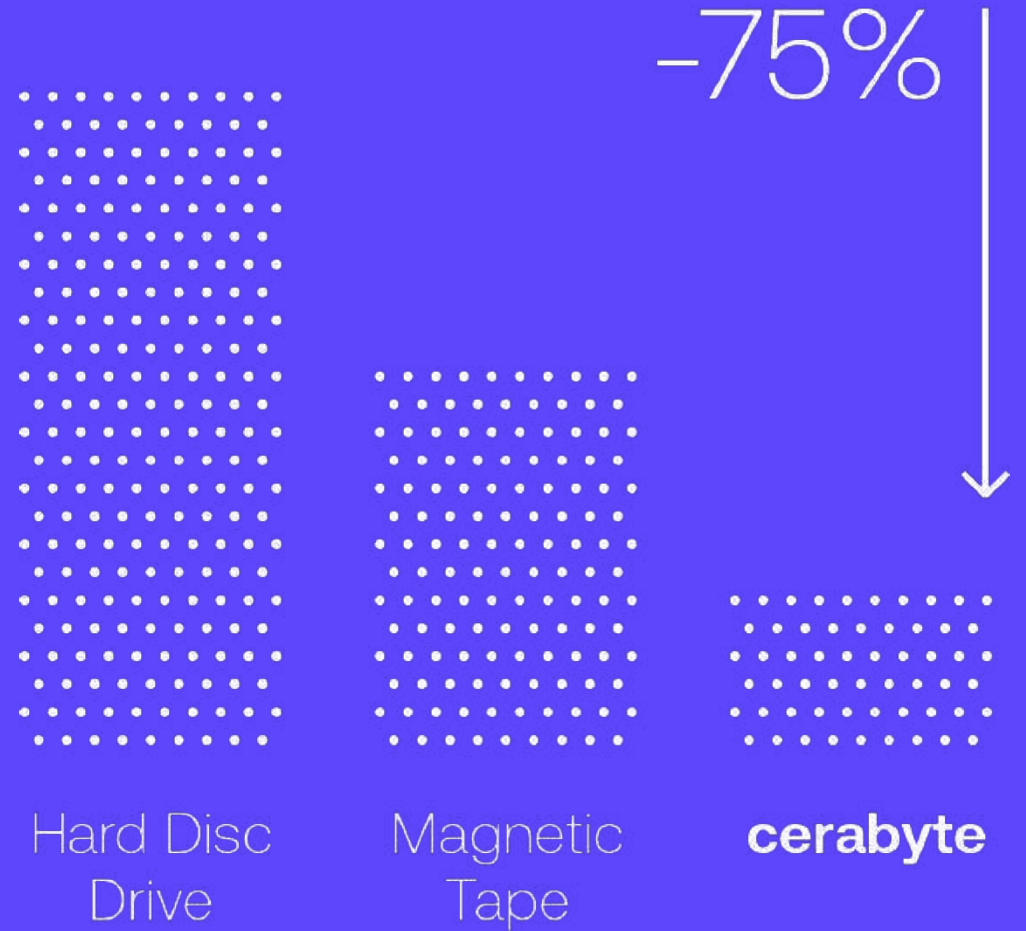
Inside the monolith





Reduction of Total Cost of Ownership by

75%





Zero energy for storing data

99%
less energy

100%
recyclable

99%
CO₂ reduction

100%
less waste

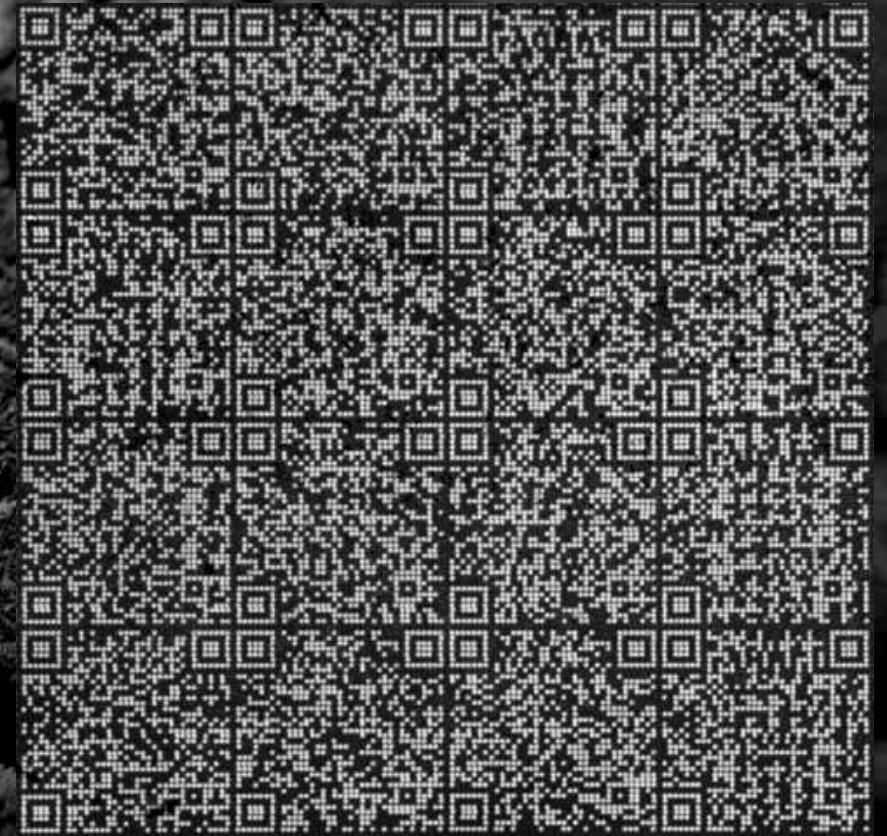
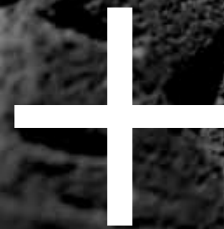
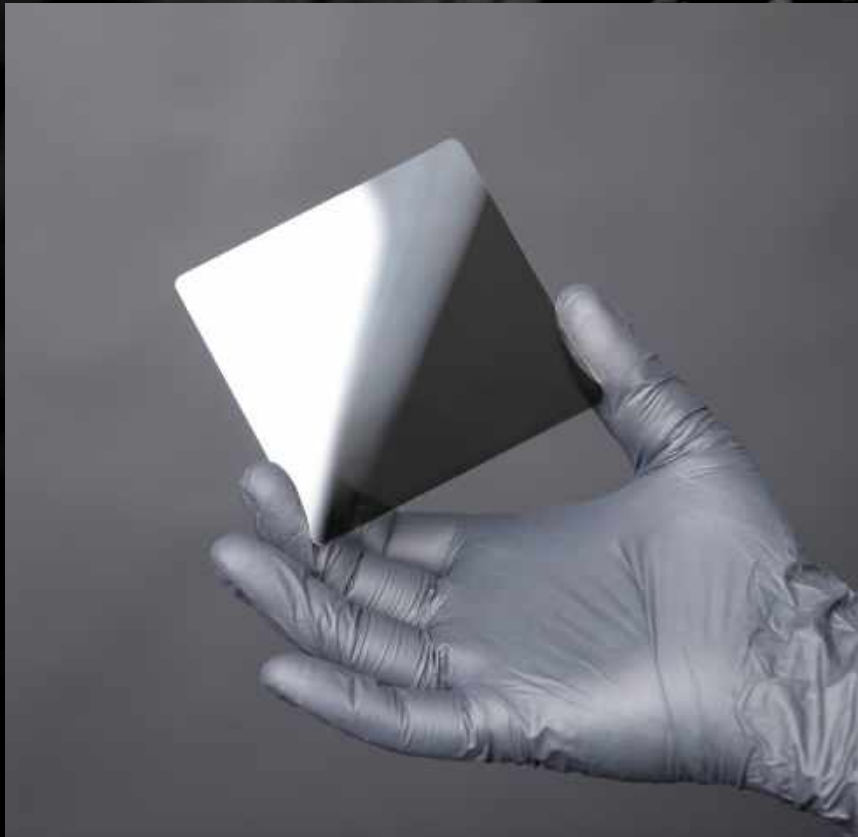
First Principle

Extremely durable material
instead of electric charge or magnetic polarization





Ceramic nano-coating and laser nano-structuring



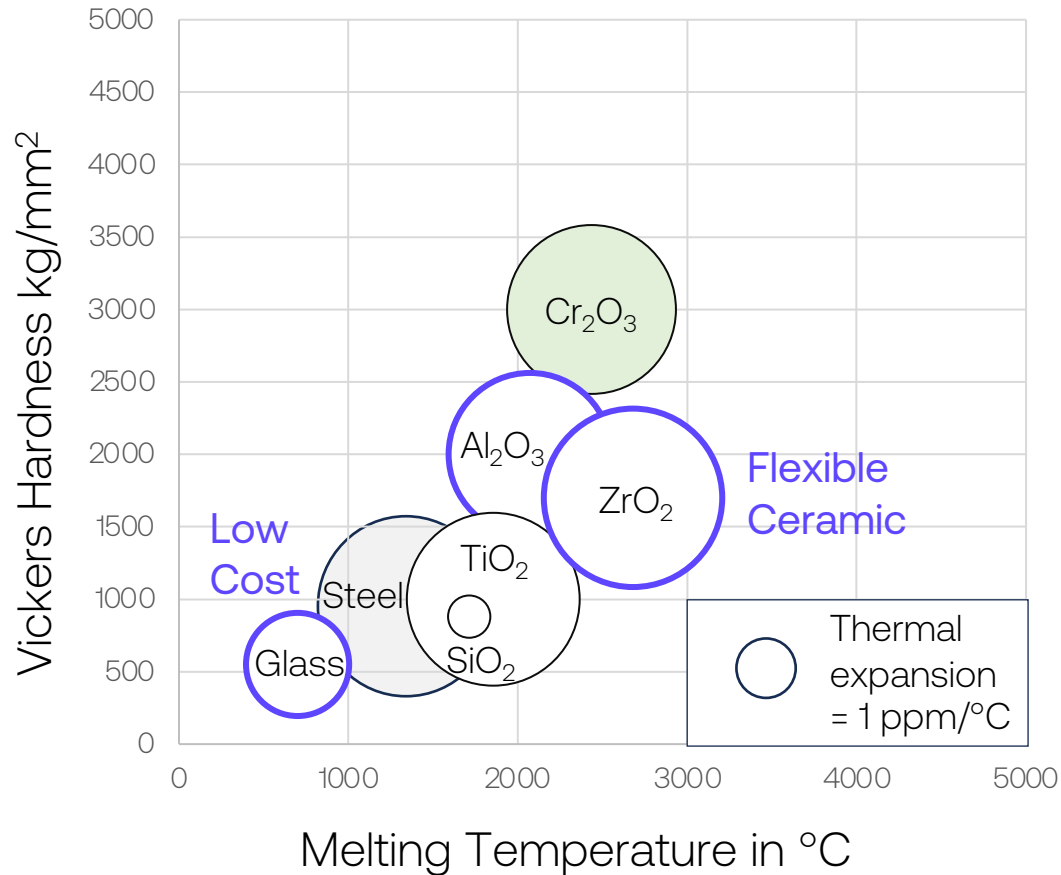
Ceramic nano-coating

Laser nano-structuring

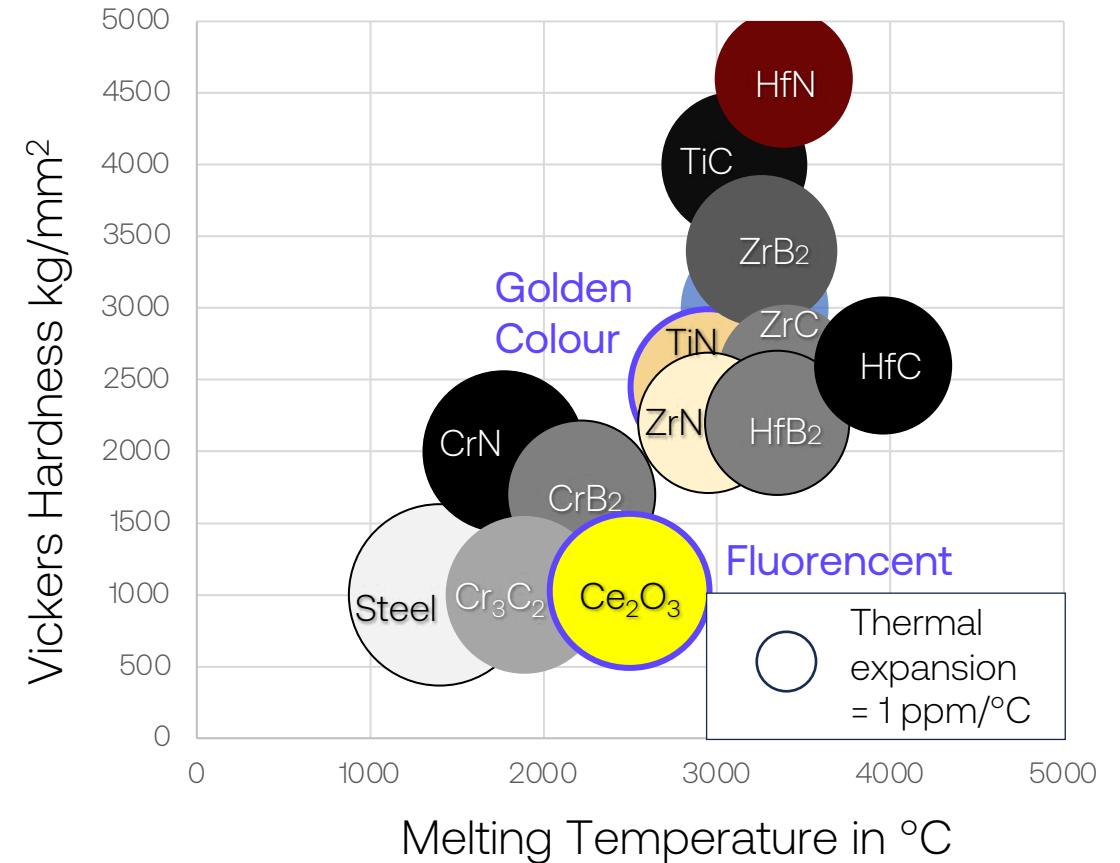


Ceramics are harder & more temperature resistant than steel

Transparent Substrate Material



Absorbing Coating Material



A wide range of material combinations enable various designs



Glass substrate - Temperature, EMP, UV and radiation resistant

Before Aging

- 273 °C (80 mK)



3 days @ 300°C - air



3 days @ 500°C - SO₂

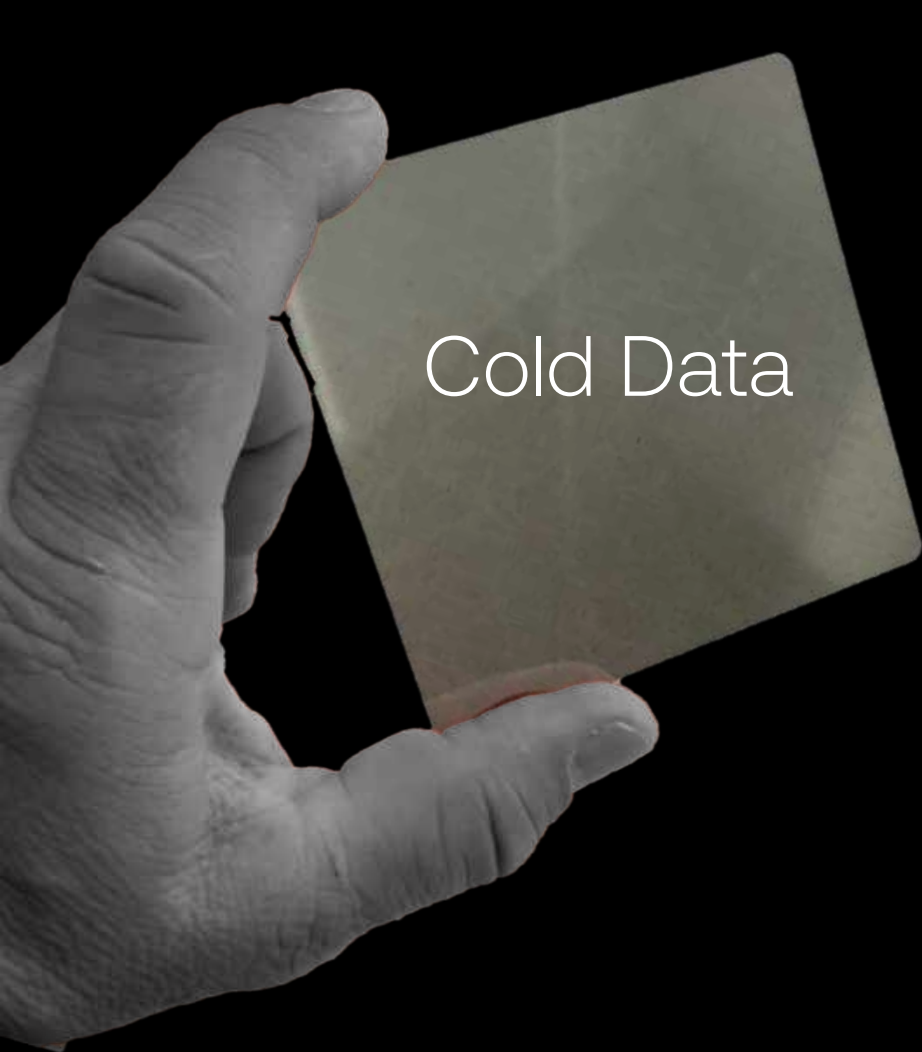


EMP, UV & radiation



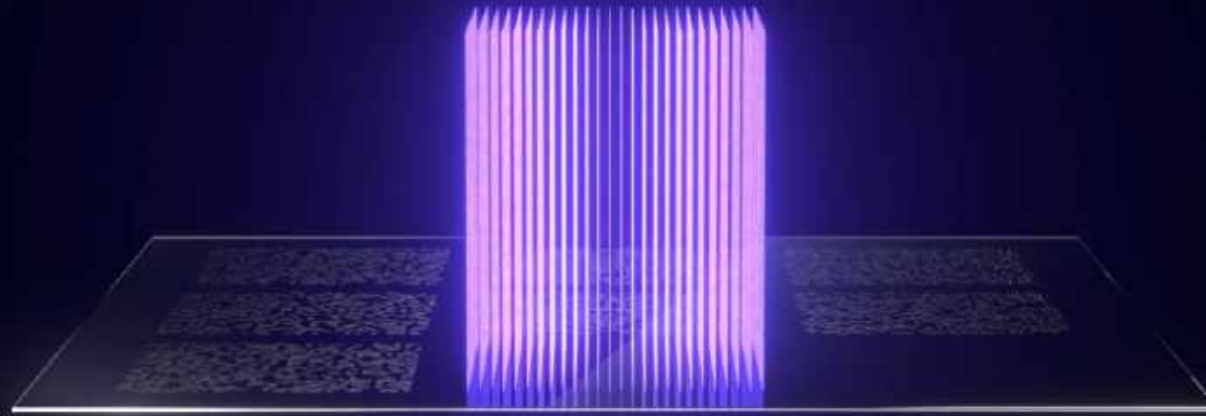
After Aging







Second Principle



Watch Video <https://vimeo.com/859682540/34a6d3e02b>

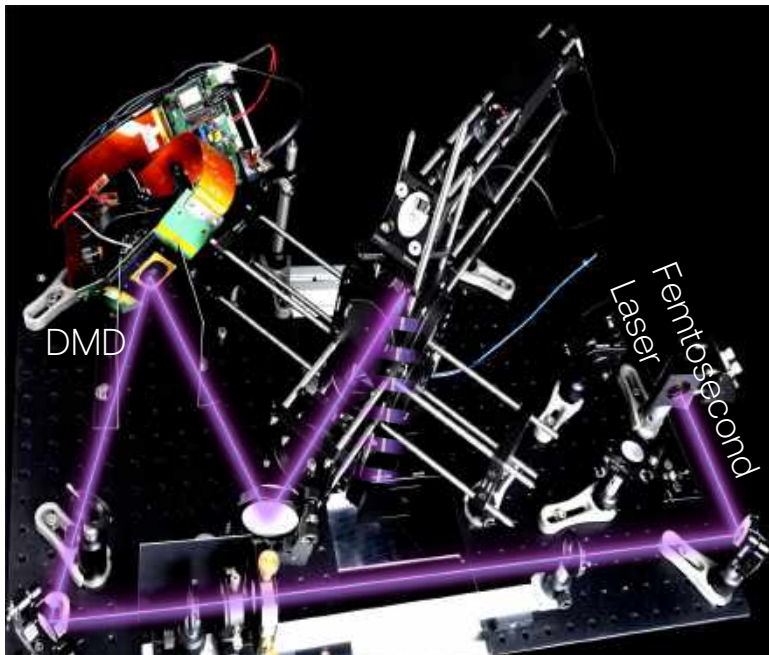
Speed with
Laser Matrix

up to 2 million
bits in one shot

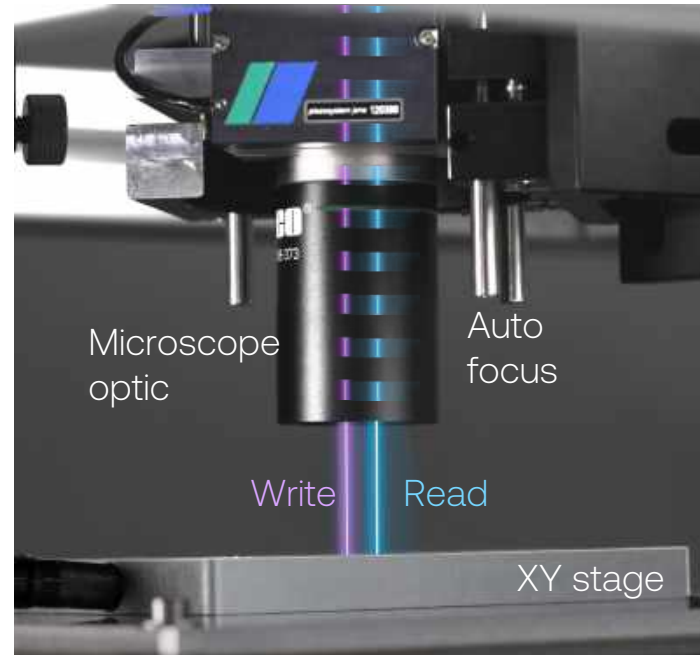
Inside the monolith



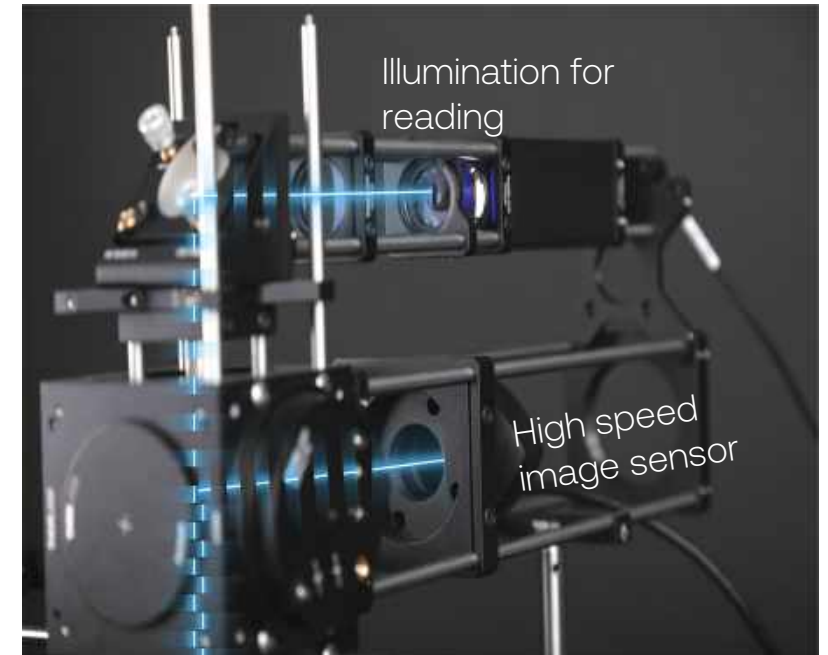
High-speed laser writing with DMD



Microscope optic for writing & reading



High-speed reading via image sensor





Development Roadmap from Demo to Hyperscaler Deployment



Demo Systems

1 PB/rack
100 MB/s
<90 sec to first byte

On-Prem Systems

5 PB/rack
500 MB/s
<30 sec to first byte

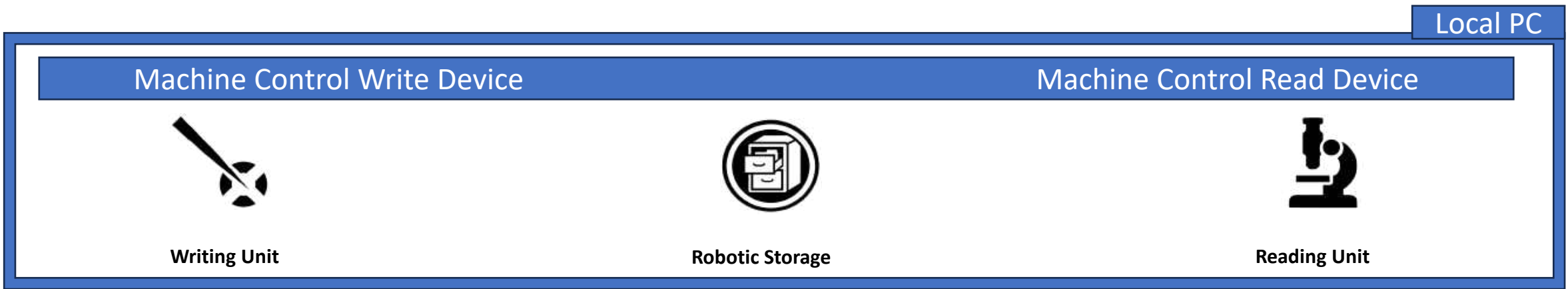
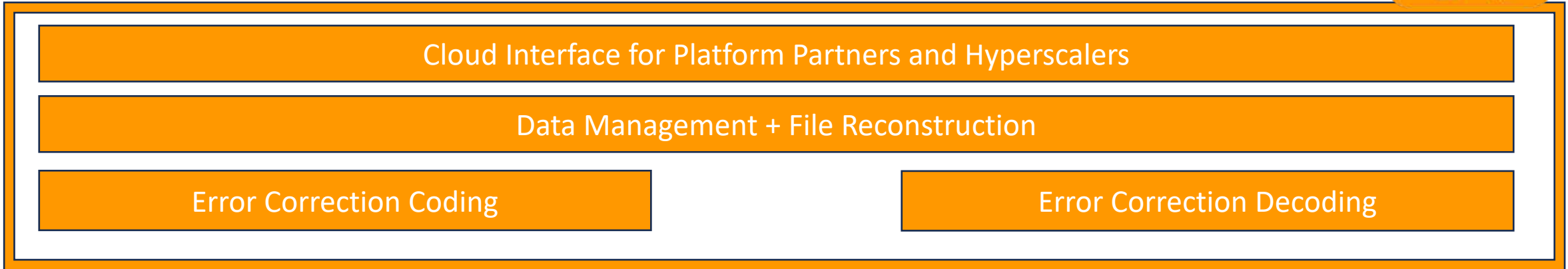
Cloud Systems

10-30 PB/rack
1+ GB/s
<15 sec to first byte

Hyperscaler Systems

60-100 PB/rack
2+ GB/s
<10 sec to first byte

High-Level Software Architecture of Cerabyte Systems



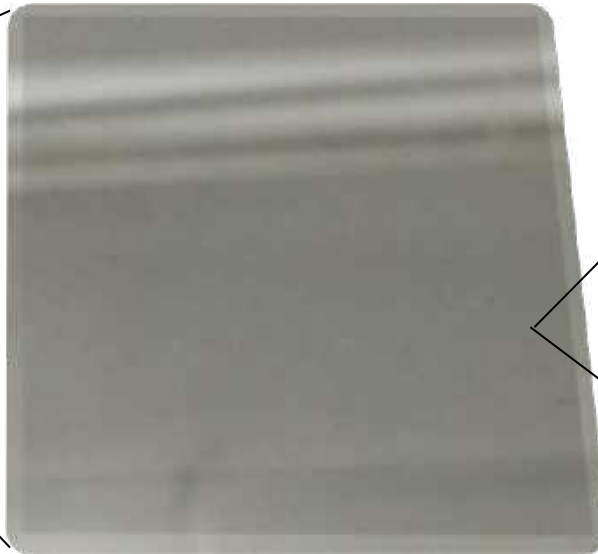


Low error rate is achieved with error correction on three levels

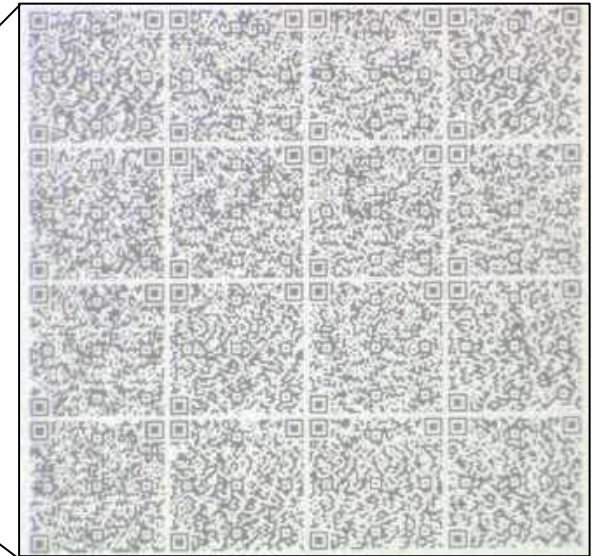
System Level



Media Level



Matrix Level

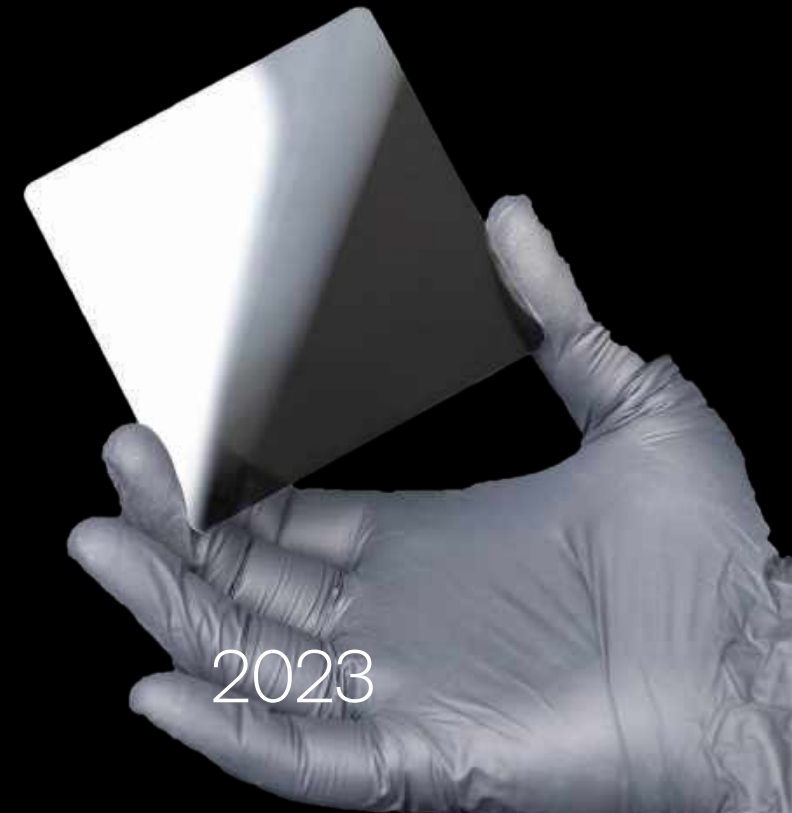


Third Principle

Squaring the Circle



1980



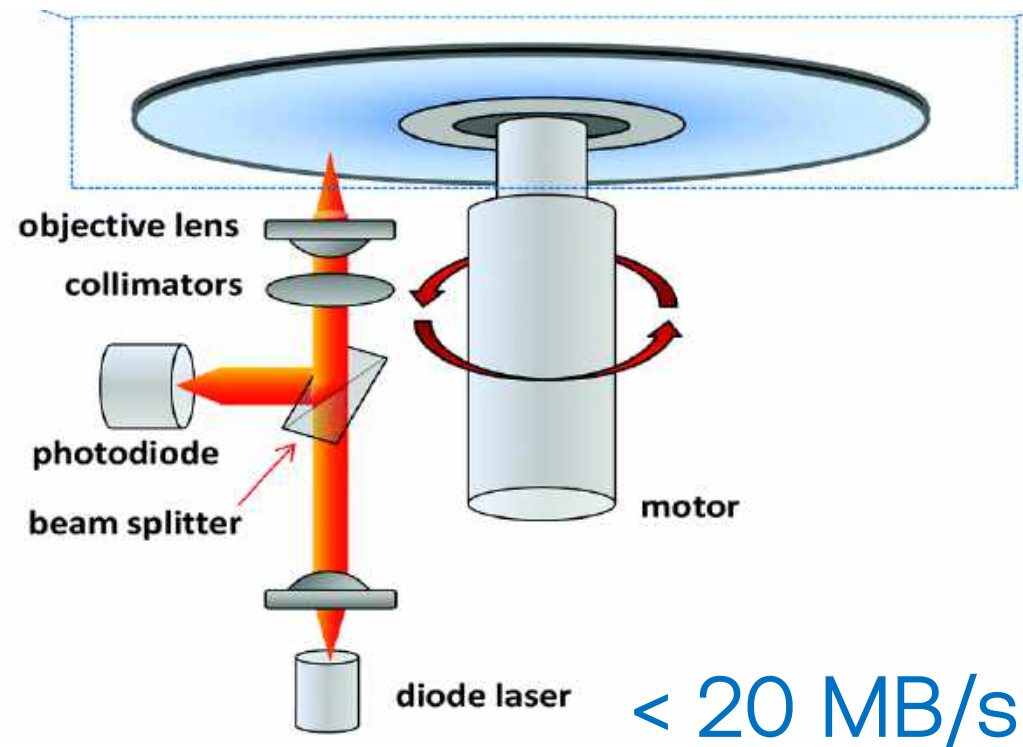
2023

Speed comparison



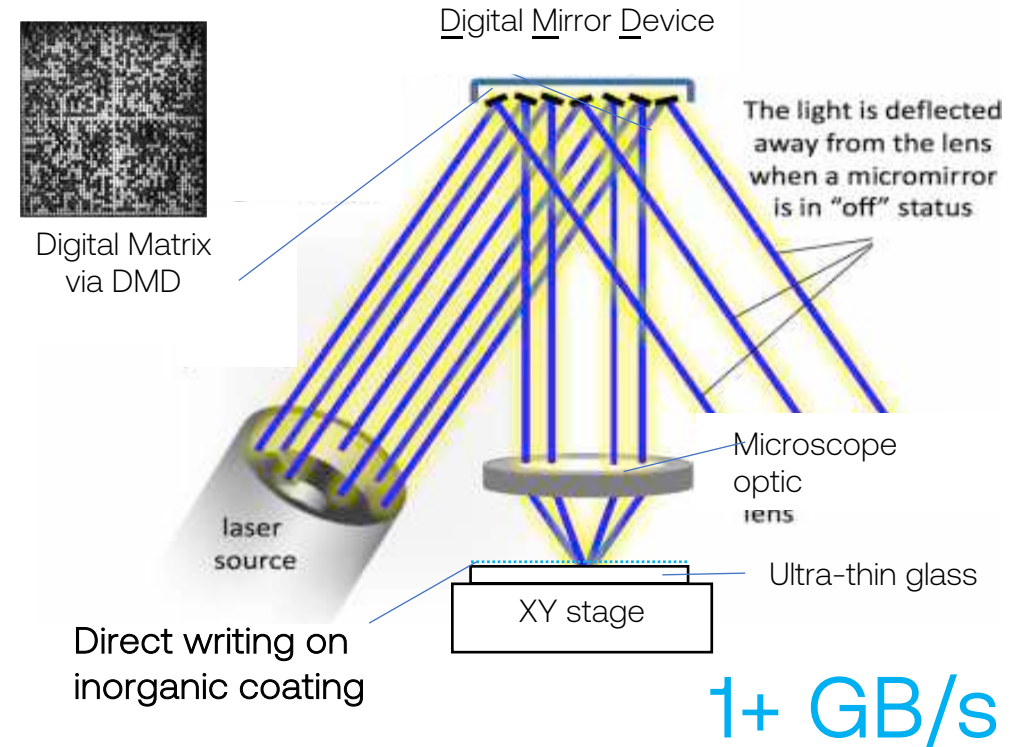
Laser beam matrix is at least 50x faster than optical disc drive

Optical Disc Drive



Speed limitation due to centrifugal forces

Laser Beam Matrix

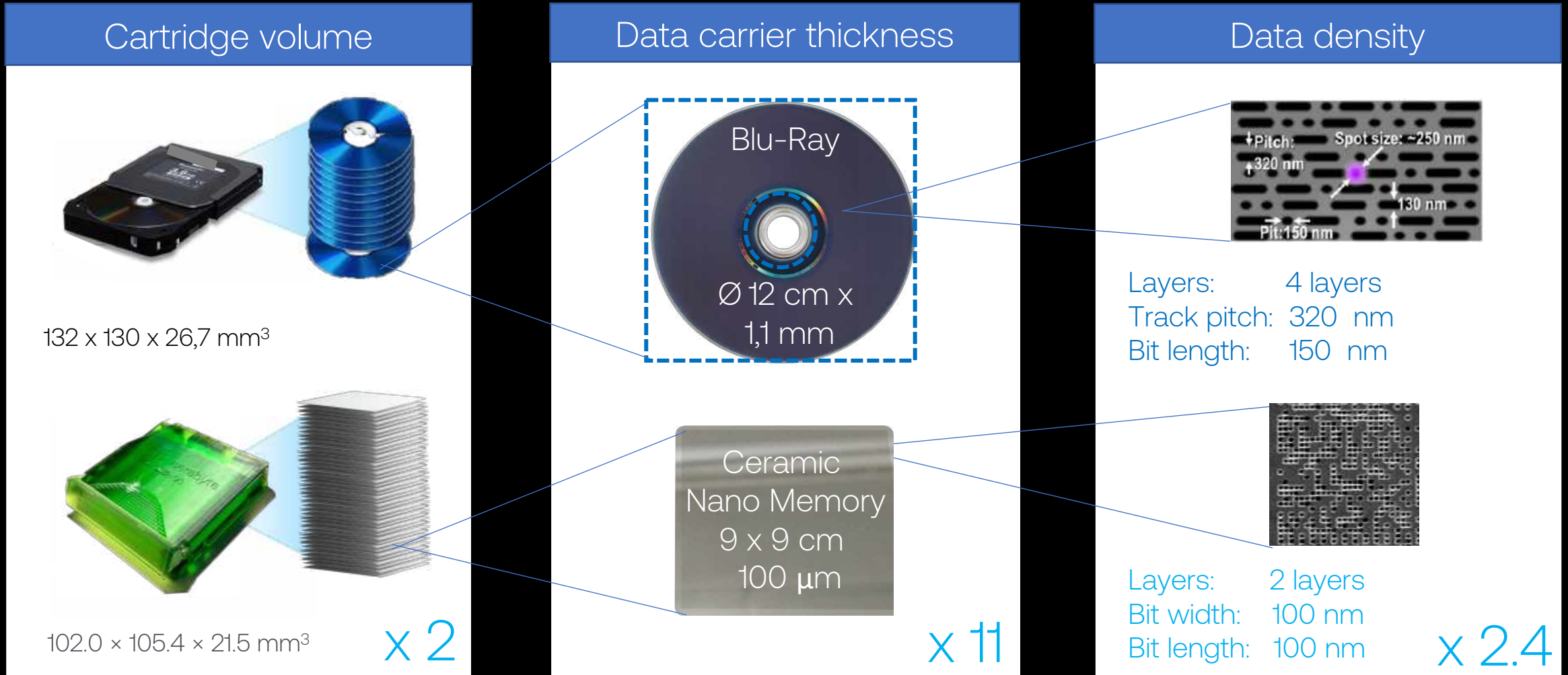


DMDs enable further speed improvements

Higher Data Density



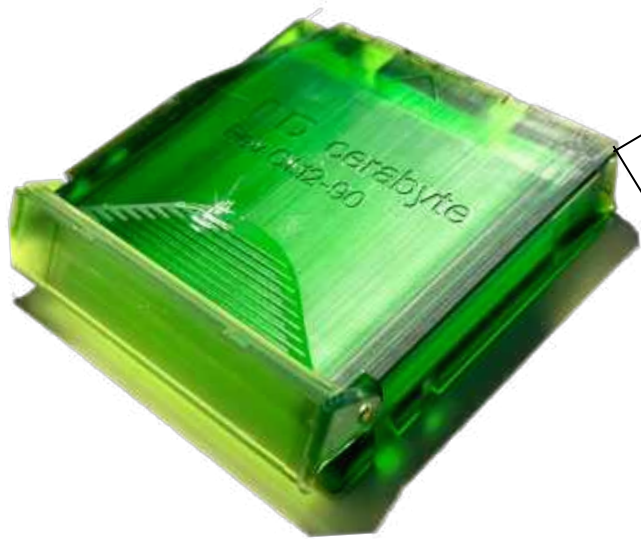
Matrix coding & thinner substrates enable 50x higher data density



Inside the cartridge



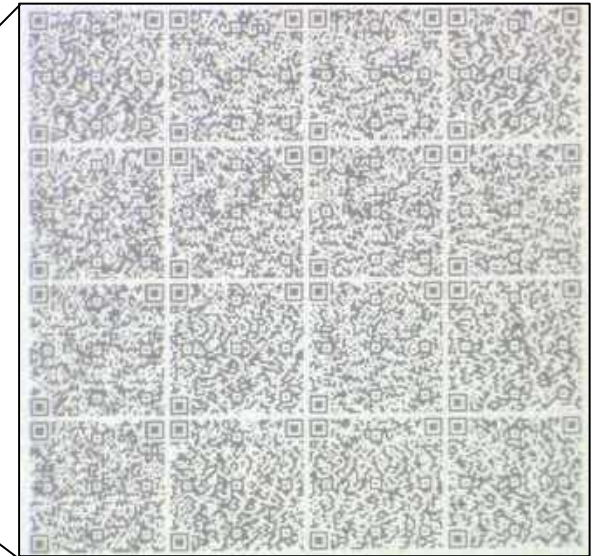
Media stacked in cartridge



Ceramic data storage medium



Data coded in matrix format



100 μm

Robotic Storage



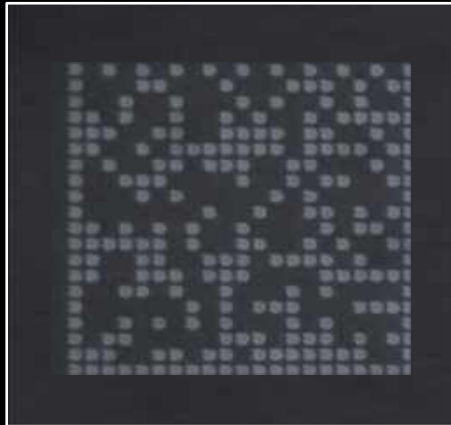
<https://vimeo.com/859017821/a22b7a150d>

Proof of Concept



Cerabyte demonstrated 1+ TB per 100 cm² in PoC studies

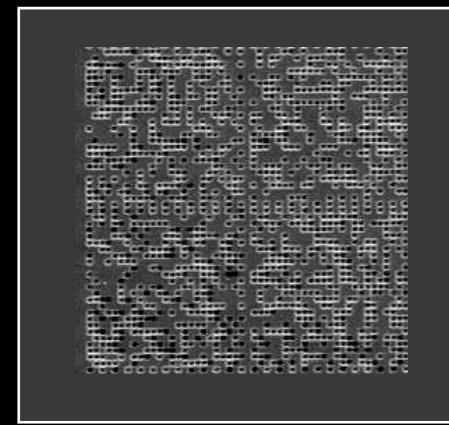
Nanosecond Laser



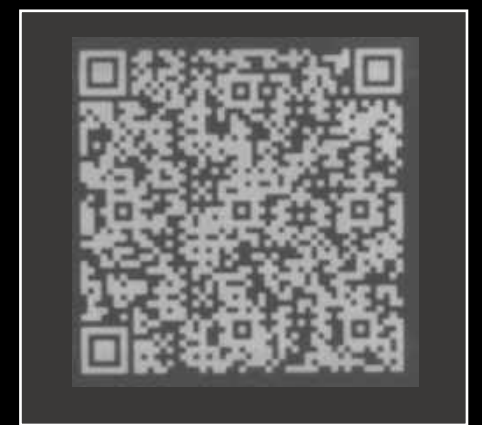
Picosecond Laser



Femtosecond Laser



Particle Beam



Process size

35 μm

1,0 μm

100 nm

30 nm

Data capacity
per 100 cm² - 15,5 in²

1,0 MB

1,25 GB

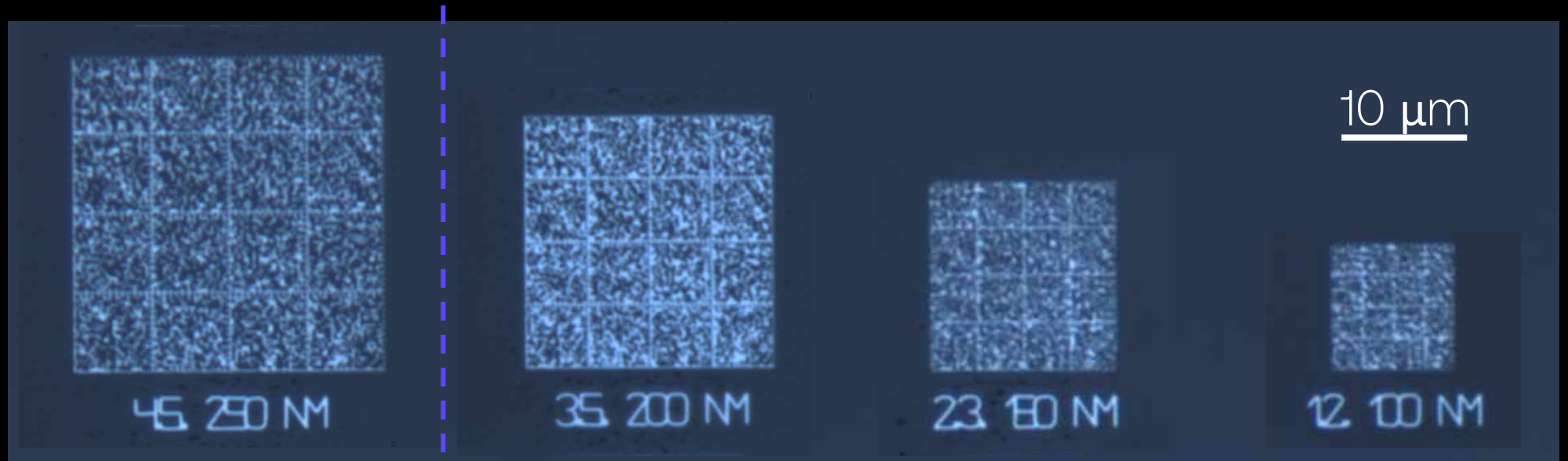
125 GB

1+ TB

Resolution Limit



Super resolution microscopy to read data below diffraction limit



Matrix Code
per 100 cm² - 15,5 in²

20 GB

31 GB

55 GB

125 GB

Reading
Methode

Digital
Microscopy

Diffraction-Limit

Super Resolution Microscopy

Super Resolution

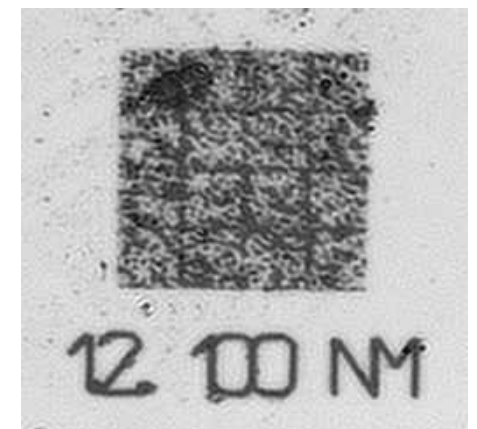
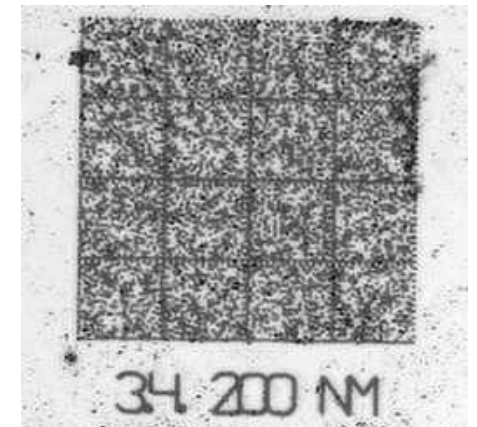
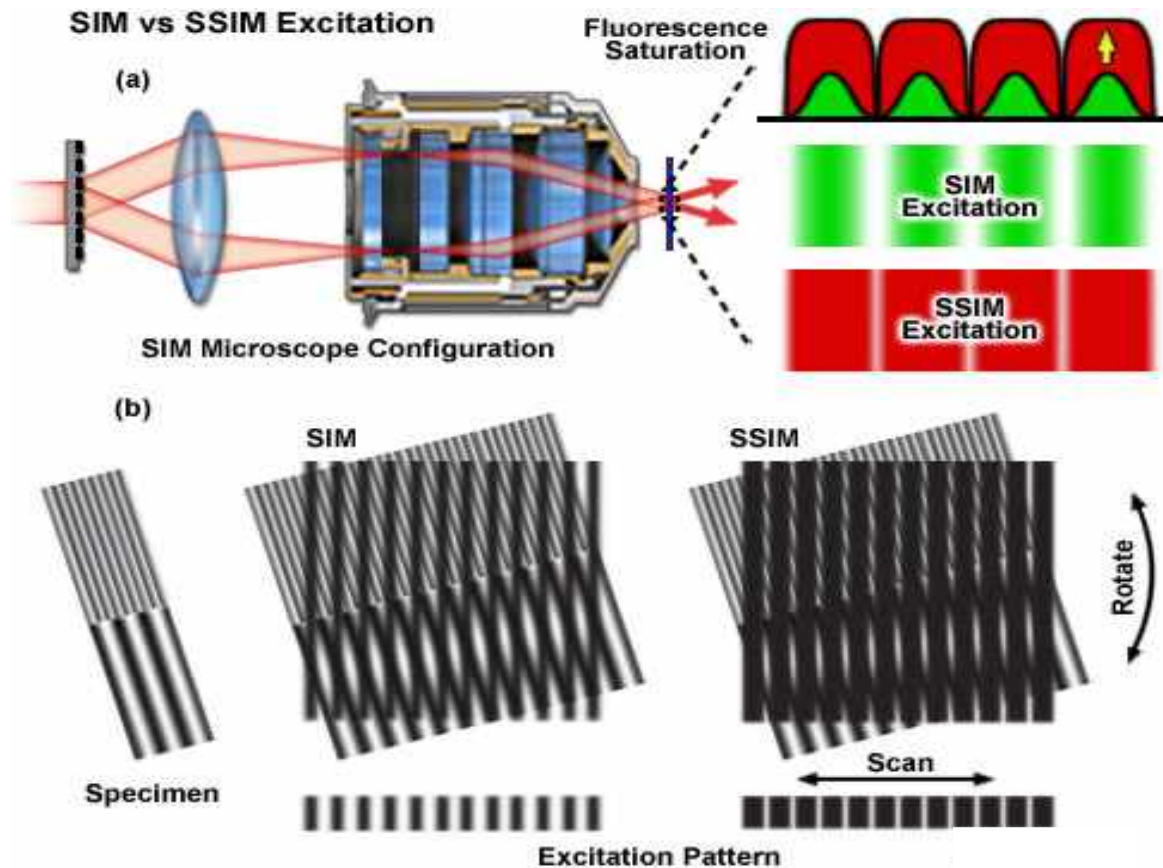
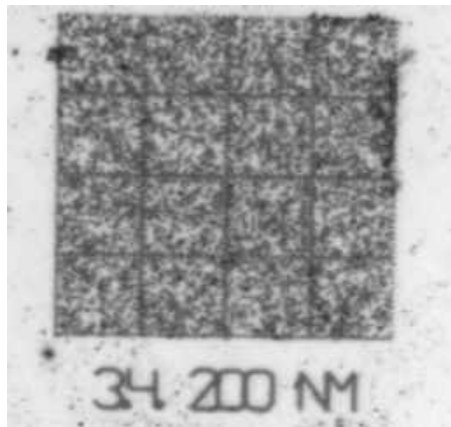


Structured illumination enables improvement of resolution

Digital
Microscopy

Super Resolution Principle - Structured Illumination

Structured
Illumination



Fourth Principle

Particle Beams
New frontiers 2030-45



Visionary Roadmap



Leveraging semiconductor technology to scale density and speed

Roadmap

2020

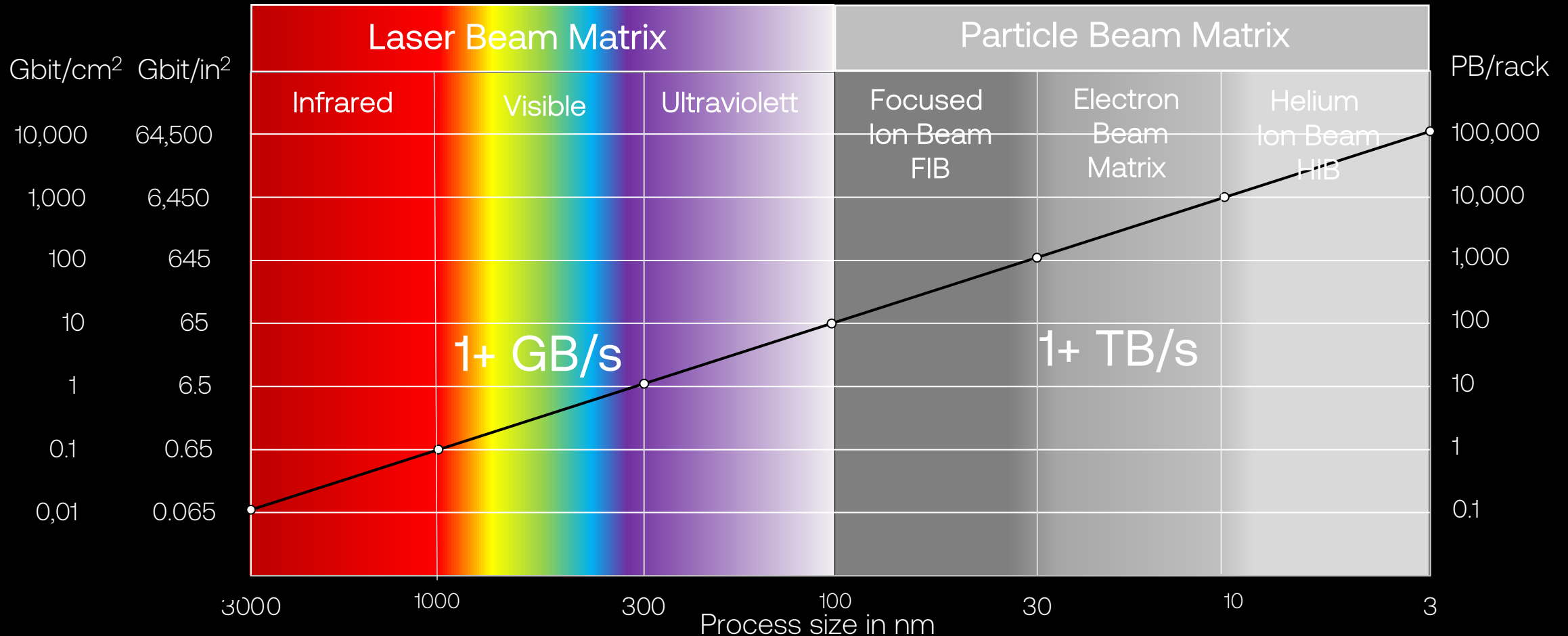
2025

2030

2035

2040

2045



Fast track design

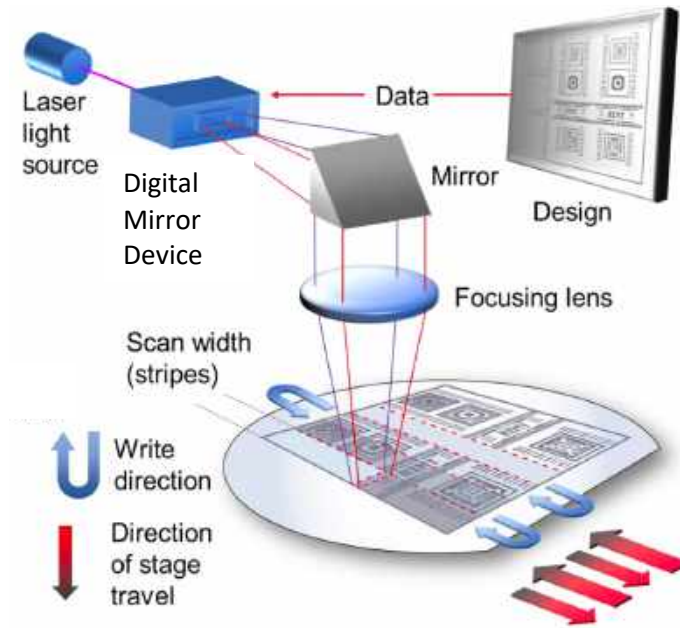


Write/read unit was built on 19" footprint in less than 12 months

Maskless Lithography System



Working Principle



Cerabyte Write Read Unit



WxDxH: 3000 x 4000 x 2200 mm

WxDxH: 600 x 1200 x 2150 mm

Design inspired by maskless lithography systems available since early 2000s

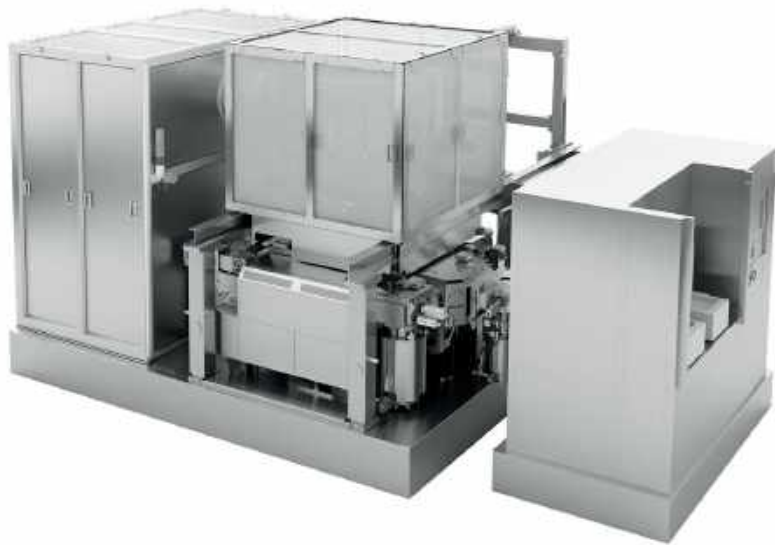
Future design 2030 +



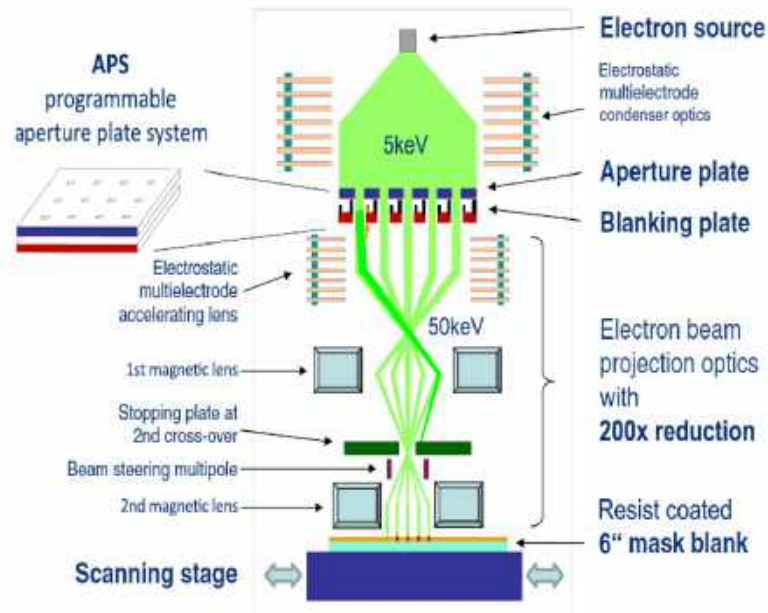
Multi-Beam Mask Writer might serve as blueprint for future design

Electron Beam Matrix

Beam matrix = 512×512
= 262,144 beams per shot



Working Principle



Future Design



WxDxH: 5000 x 3000 x 2000 mm

WxDxH: 5x600x1200x2150 mm

Node: 28-5 nm - writing speed: 120 Gbits/s - planned: 1 Tbit/s - **Too expensive today**



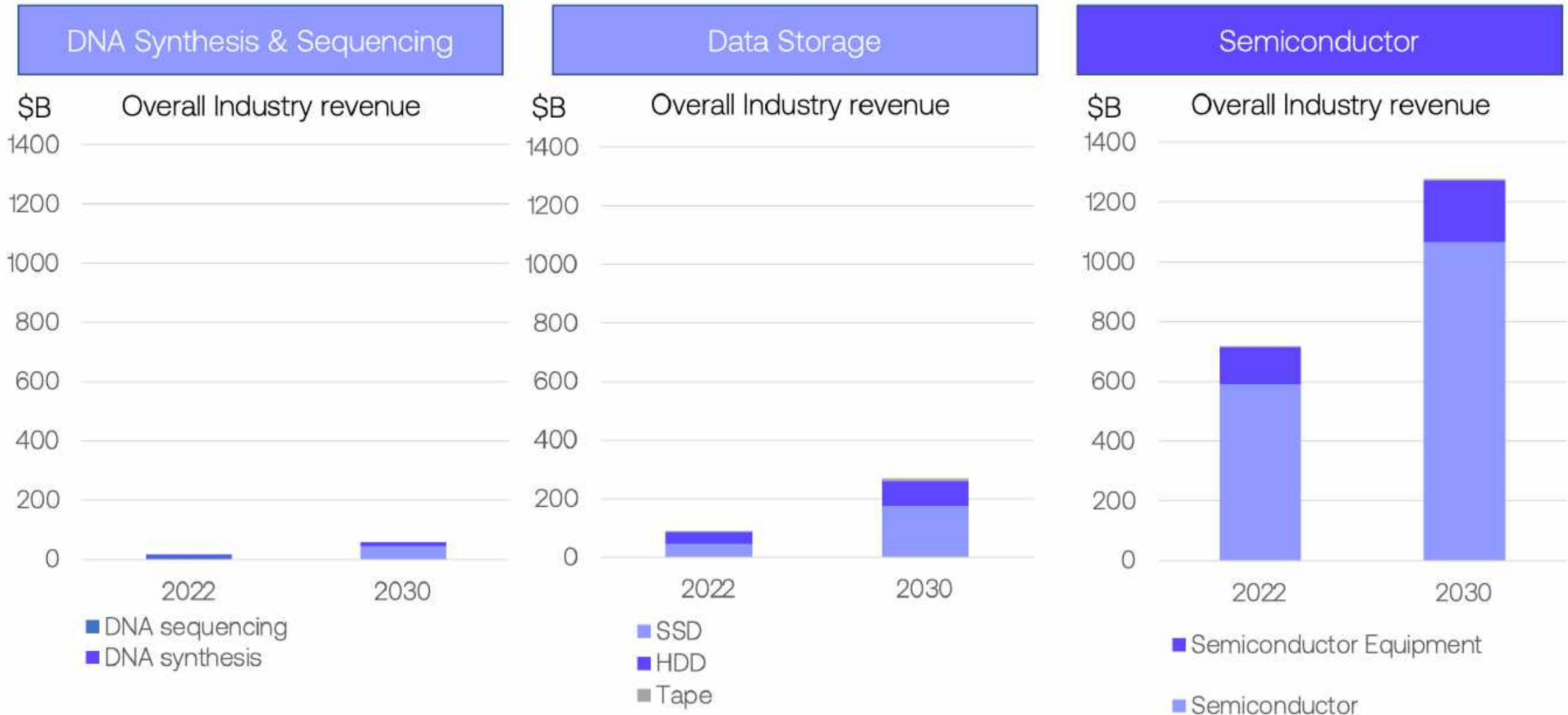
Multi-beam electron gun tubes have been sold in millions as

Color TV-sets

AI-fiction: Frustrated astronaut watching mars landing on color tv-set in living room of 1970s.



Semiconductor industry best positioned to drive innovation





Fifth Principle

Leverage
Existing Scale



Watch video <https://vimeo.com/859016937/1e6029f31d>

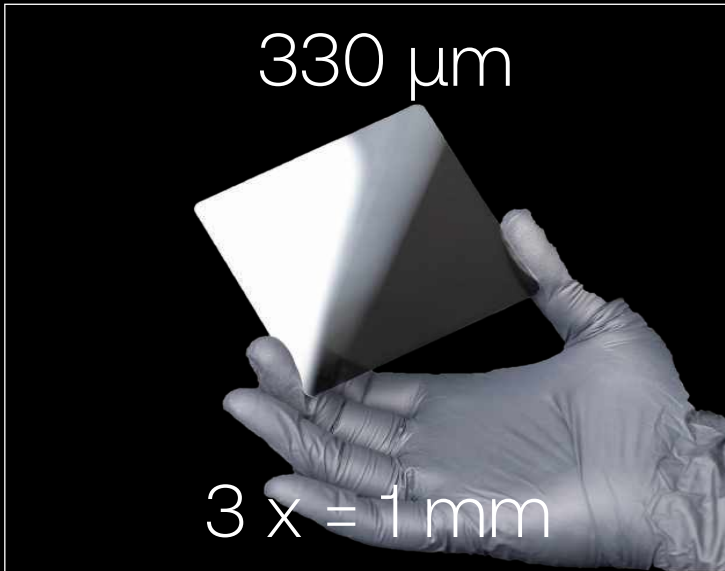
Billions of
Data Media
with only
One Plant

Further scaling options



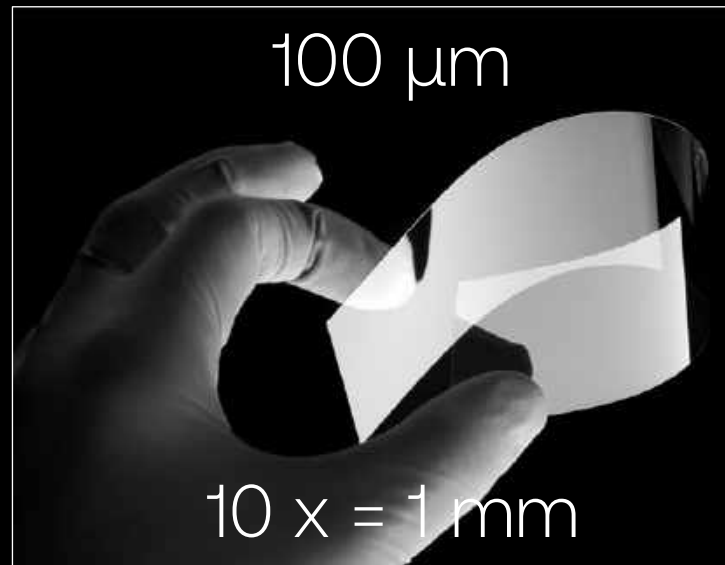
Substrate type extends field of application & volume density

Thin display glass



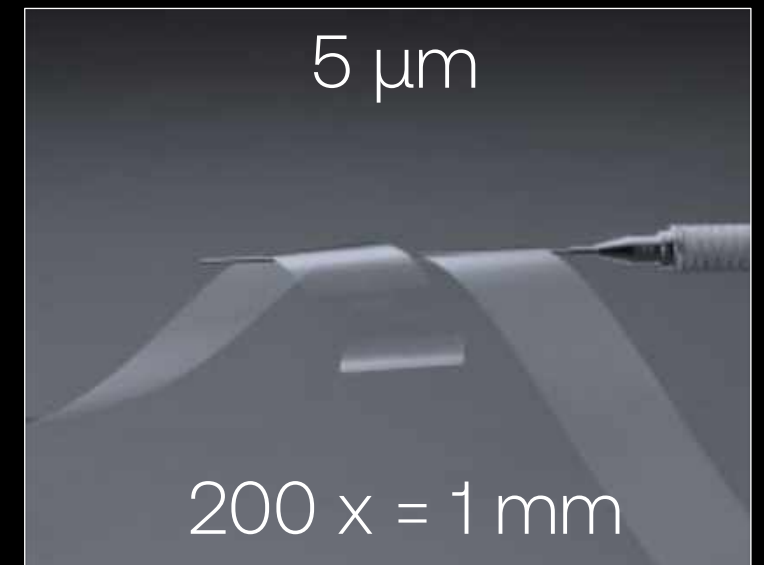
CeraDemo

Flexible ultra-thin glass



CeraMemo

Ribbon glass



CeraTape

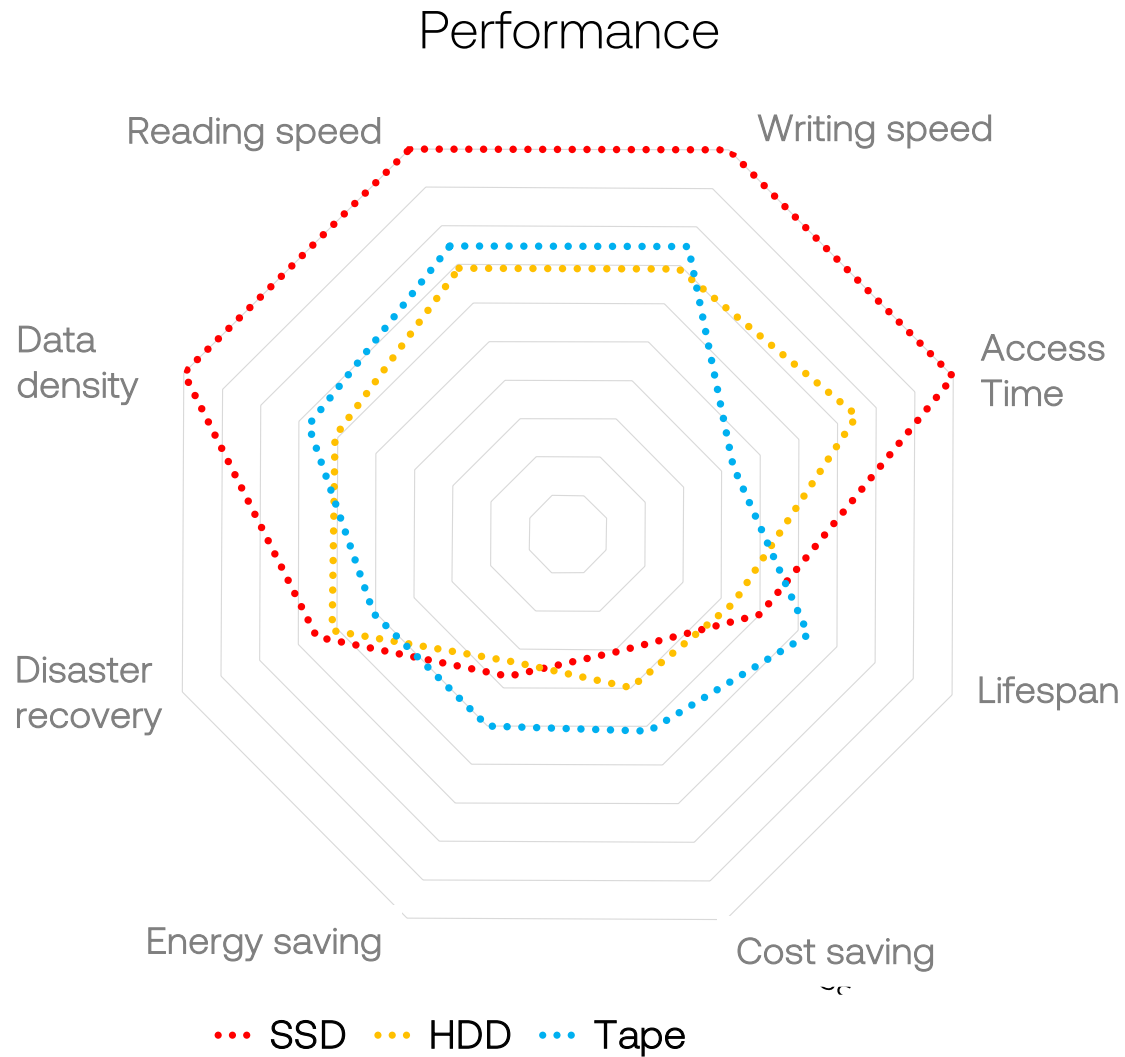
Sixth Principle

The image features a vibrant sunset background with a gradient from blue at the top to orange and yellow at the bottom. In the foreground, several hands are silhouetted against the light, holding and interlocking four gears of various sizes. The gears are arranged in a line, with the hands positioned at the top and bottom of each gear, suggesting a collaborative effort in assembling or maintaining a system.

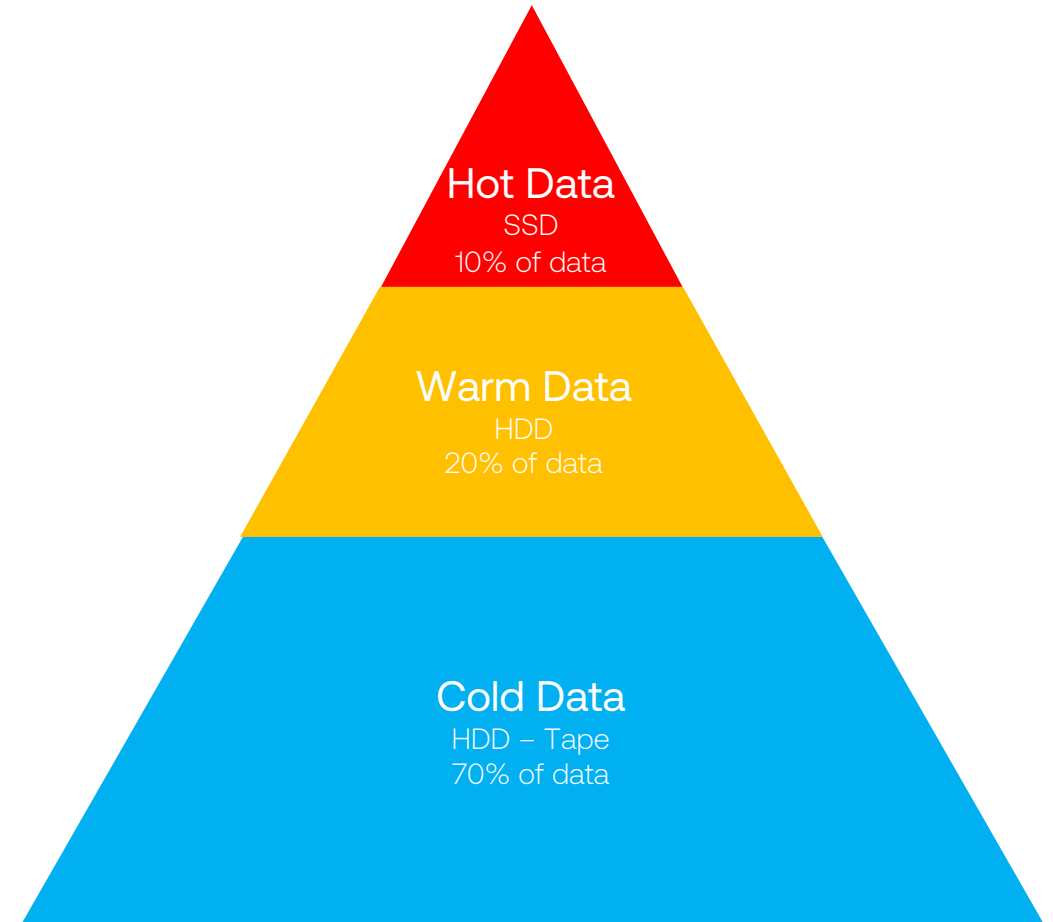
Complementing
Existing Technologies



SSDs and HDDs are expensive to operate and need replacement every 5-7 years

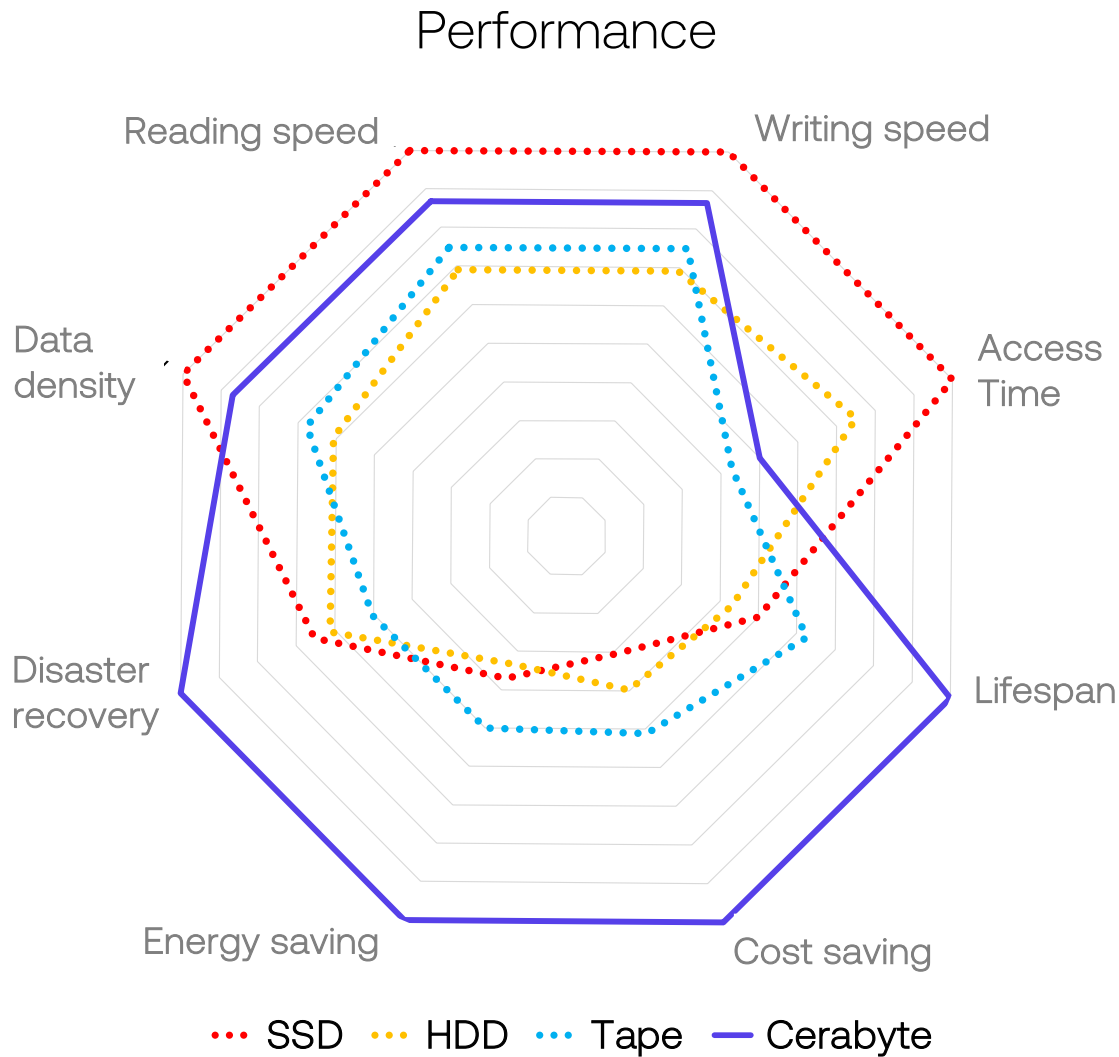


Addressable Segment

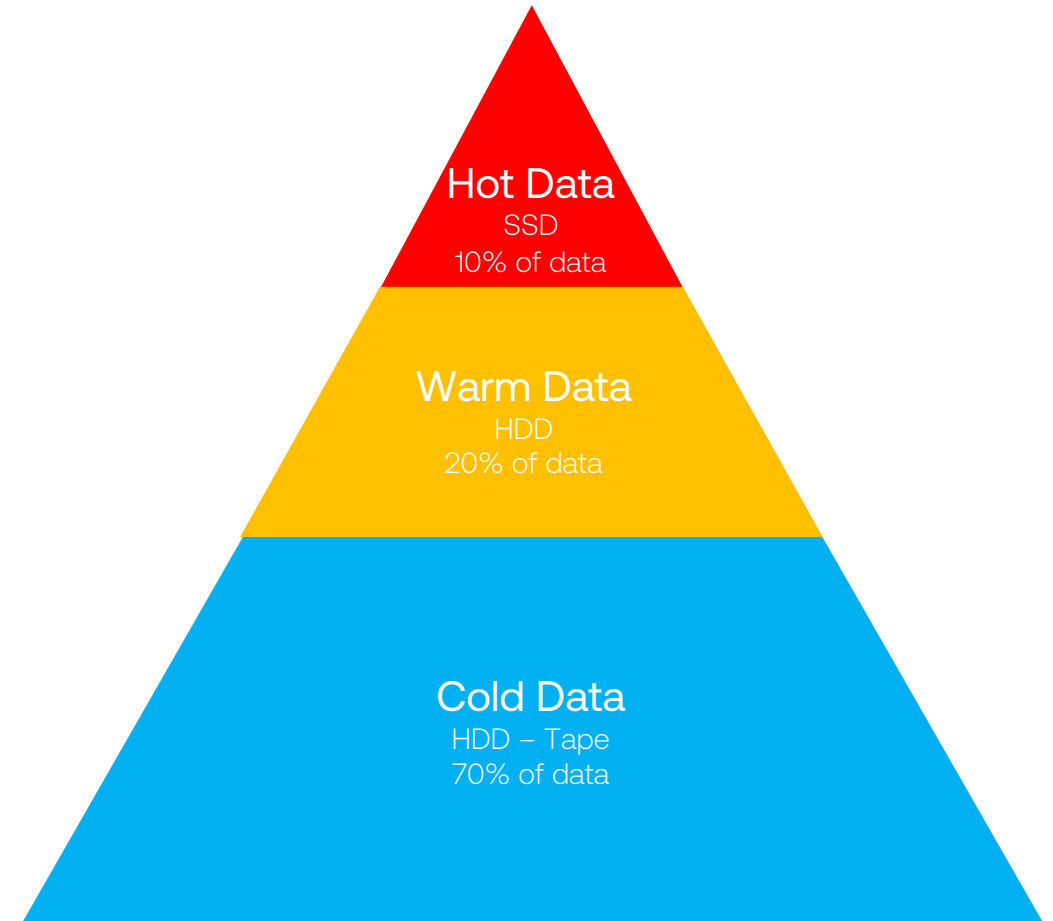




Cerabyte outperforms all storage media on lifespan, resilience, energy & cost saving

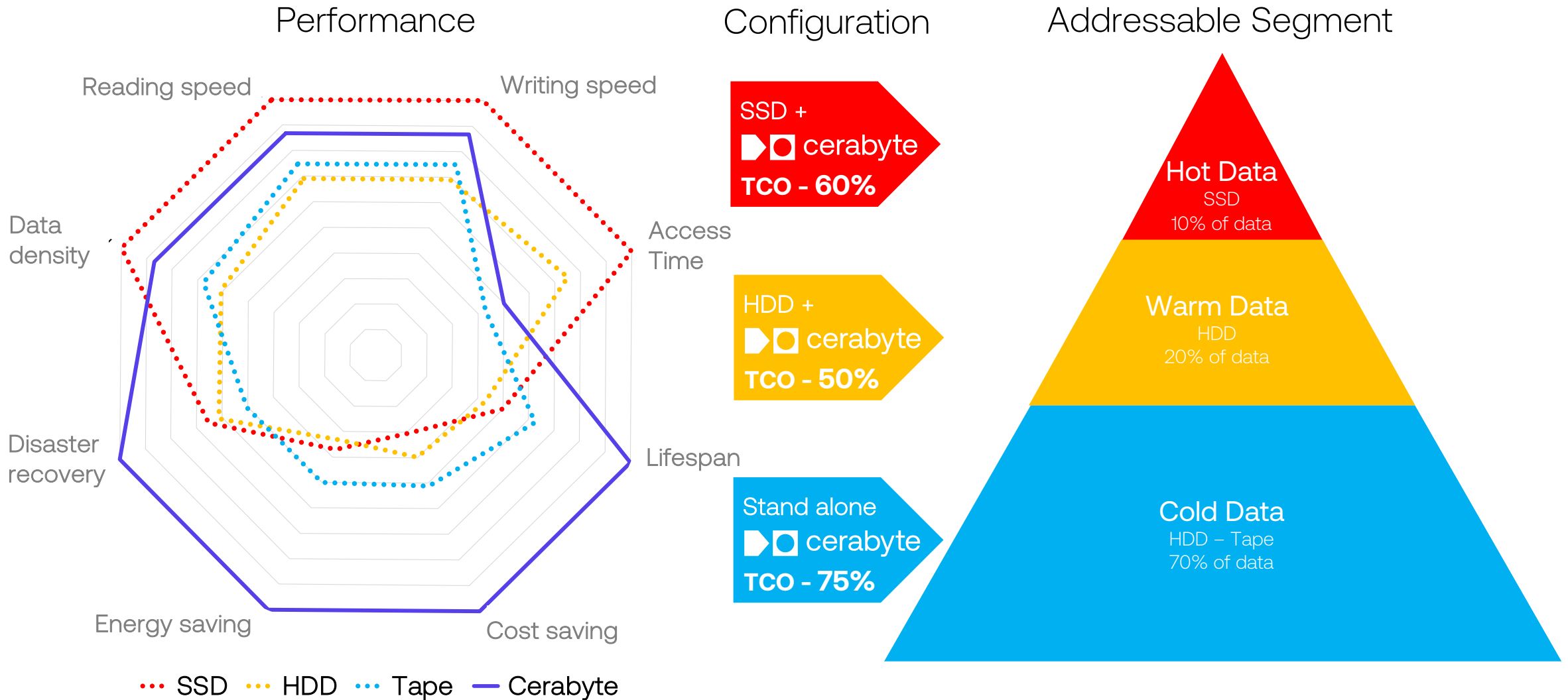


Addressable Segment





Cerabyte complements SSD & HDD reducing TCO for warm & cold data storage

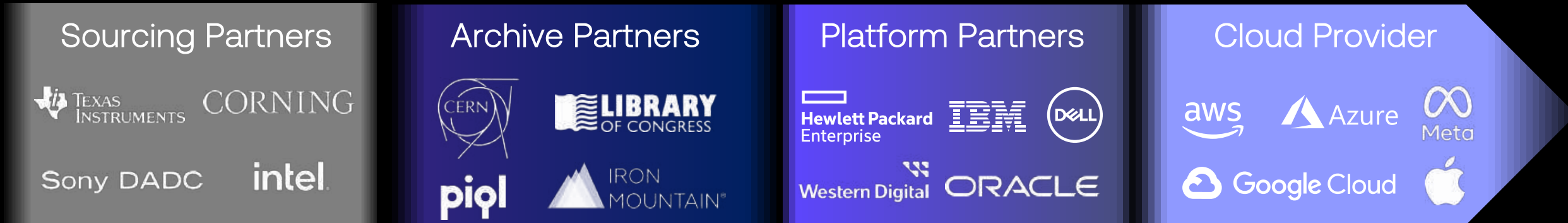


Seventh Principle

Build Global
Eco - System

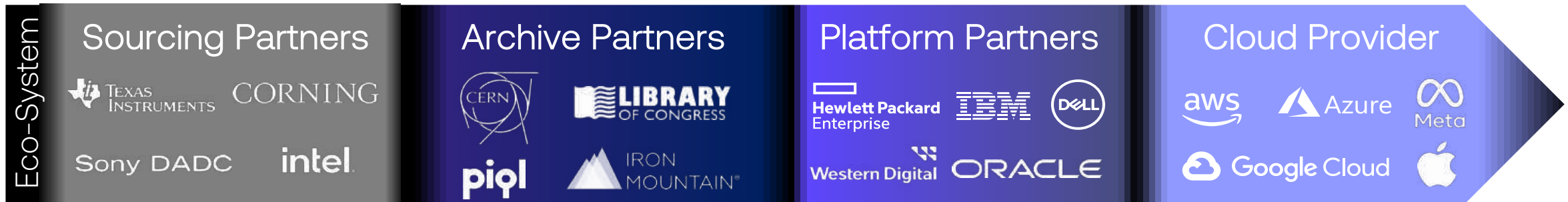


Initial positive response from all approached potential partners

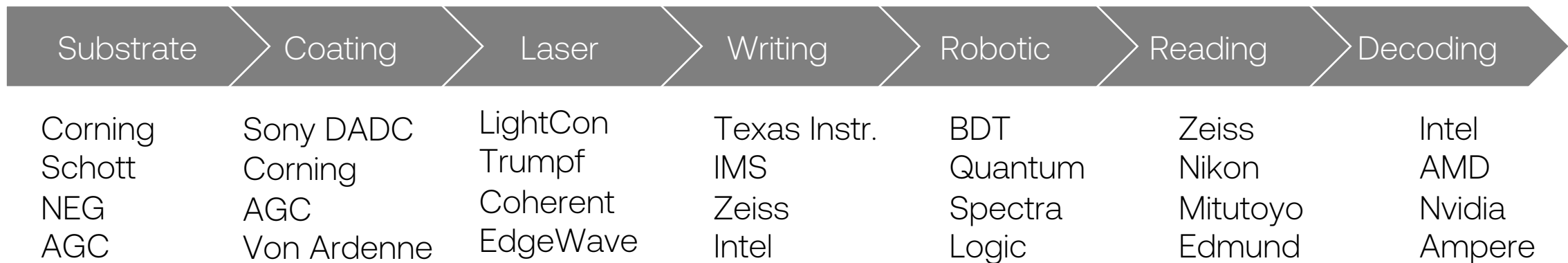




Proposal: New "Cold data storage eco-system" would enable multi-sourcing supply chain through potential partner network



Multi-sourcing supply chain





Cerabyte is seeking test & product development partners



Pilot Projects



Production Ramp-up



Volume Production



High-volume Production

Cerabyte Management Team



Two generations creating a new standard for cold data storage



Store all data forever



Christian Pflaum, CEO & Founder
christian.pflaum@cerabyte.com

Ceramic Data Solution Holding GmbH
Rundfunkplatz 2 - Munich - Germany