Cerabyte - Ceramic-on-Glass for Fast Access, High-Performance, Permanent Data Storage

Executive summary

Cerabyte is developing **Ceramic Nano Memory**, a laser-written, optically read storage technology designed for **high-throughput, random-access, permanent data storage** with exceptional environmental resilience and long projected lifetime. The approach combines a **dark ceramic nanolayer** on **ultra-thin, flexible glass substrates** with a **laser-matrix** and **image-sensor** process to enable **fast, low-energy parallel write and high-speed readout** using mature optical components and scalable manufacturing processes.

Cerabyte's media architecture uses **surface-based recording** on thin substrates that can be **stacked in cartridges** to achieve high volumetric density without the read-performance penalties associated with writing deep into the volume of a thick medium. The company targets **media acquisition costs significantly below mainstream media by the end of this decade**, leveraging existing display-glass manufacturing capacity (cited at **~700 million m^2/year**) and industrial thin-film coating processes.

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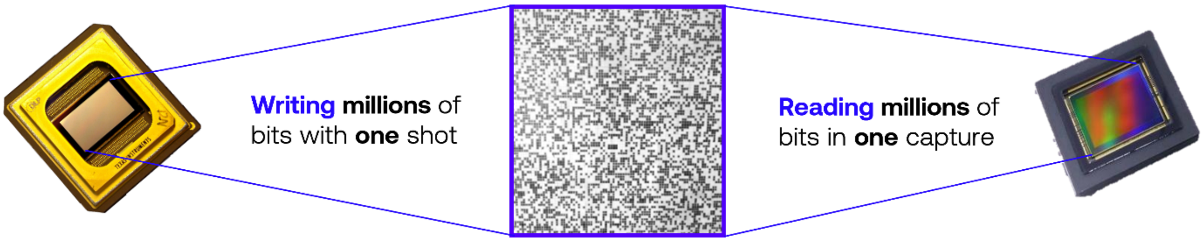
1. Company and technology overview

Cerabyte, founded in **2022**, is developing a new class of storage media based on a **highly durable ceramic nanolayer** deposited on a **flexible, ultra-thin glass substrate**. The media design is intended to support:

- **Ultra-fast writing** through efficient modification of the ceramic coating
- **High-speed readout** enabled by strong optical contrast (high signal-to-noise ratio)
- **Random access** via sheet separation and precision positioning
- **Extreme environmental durability** with strong resistance to temperature extremes and radiation exposure
- **Scalable manufacturing economics** by leveraging established glass and coating supply chains

Company website (reference): https://www.cerabyte.com



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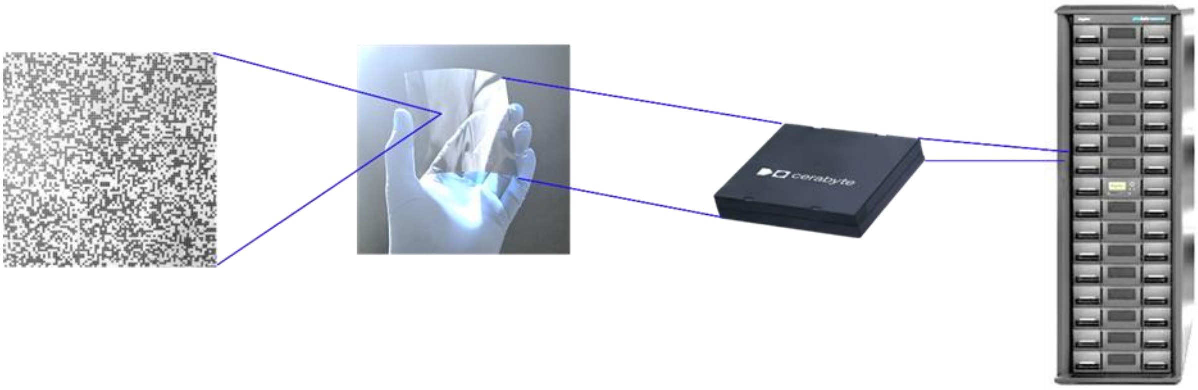
2. Media architecture: ceramic-on-glass sheets

Cerabyte's data carrier consists of **ceramic-on-glass sheets** built as follows:

- **Substrate:** ~**100 µm** thick **ultra-thin flexible glass**
- **Format:** glass cut into **9,4 cm × 9,4 cm** sheets
- **Recording layer:** a **~15 nm** dark ceramic nanolayer (approximately **100–150 atomic layers**)
- **Coating configuration:** ceramic deposited on **both sides** of the substrate

This structure forms a robust optical recording medium optimized for rapid write/read operations and reliable handling in automated library environments.



Manufacturing scalability and cost trajectory

Cerabyte's approach is designed to leverage **existing display-glass production capacity** and high-throughput industrial coating methods. By using processes and supply chains already proven at scale (e.g., for display glass and thin-film deposition), the company anticipates achieving **substantially reduced media acquisition cost** relative to current mainstream archival media **by the end of this decade**.

Cerabyte's patented media coating: four key functions

2.1 Faster, low-energy writing

The dark ceramic coating (~**100 atoms thick**) is designed to strongly absorb the writing laser energy, enabling efficient bit formation (stated at **~0.1 nJ/bit**) with **~10–100× less energy** than writing directly onto or into uncoated glass. **Impact: 10–100** lower CAPEX, higher throughput, reduced TCO and cost per TB.

2.2 Anti-adherent surface for reliable random access

Uncoated glass sheets typically strongly adhere to each other when stacked, complicating separation. The coating functions as a **surface lubricant**, enabling practical **sheet separation** and therefore **random access** in stacked formats.

2.3 Protection that increases resilience

Direct writing on or into uncoated glass creates nanocracks which significantly reduce robustness during handling. The **ceramic coating is harder than steel and protects** the surface while maintaining the inherent resilience of the glass substrate, enhancing durability.

2.4 High signal-to-noise ratio (SNR) for fast readout

The dark ceramic coating provides excellent optical contrast, yielding a **high SNR** and enabling fast, deterministic readout at high frame rates.

The ceramic material is described as **inert** and commonly used in applications such as **cookware, surgical tools,** and medical implants.

Ceramic-on-Glass achieves higher contrast with much lower energy

Ceramic-on-Glass	Borosilicate Glass	Fused Silica

Ceramic-on-Glass		Borosilicate Glass		Fused Silica	
Read-Contrast	**100%**	Read-Contrast	59%	Read-Contrast	50%
Write-Energy	**100%**	Write-Energy	**895 %**	Write Energy	**1105%**

10x lower writing cost ($/TB) due to lower laser pulse energy per bit

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3. Writing process: massive parallel laser modification

Cerabyte writes data by permanently patterning the ceramic nanolayer using **laser pulses** combined with **Digital Micromirror Devices (DMDs)** — a widely deployed technology in **video projectors, head-up displays, and 3D printers.**

Parallel bit writing mechanism

- The laser and DMD form a **matrix of beams** (a projected bit pattern).
- Each pulse **modifies** selected regions of the ceramic nanolayer, creating a permanent recorded pattern.
- The system targets up to **~2 million bits per pulse** written in parallel.
- Operation at **kHz-class repetition rates** enables high aggregate throughput.

Targeted write performance

Based on the described parallelism and repetition rates, Cerabyte projects future write speeds of **1-2 GB/s** at **<3 W average optical power**, stated as **~3–4× faster** than LTO tape or HDD technology.

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4. Reading process: high-speed imaging and GPU decoding

Readout uses the same microscope-class optical path, coupled with high-speed illumination and an ultra-fast image sensor:

- **Optics:** microscope objective / imaging optics aligned to the media surface
- **Sensor:** high-resolution image sensor at **≥500 frames per second**
- **Decoding:** parallel processing on **GPUs (Graphics Processing Units)** to convert image frames into digital data streams

Targeted read performance

With high-speed capture and parallel decoding, Cerabyte targets **1-2 GB/s** read performance, intended to significantly outperform HDD-class readout in cold-storage use cases.

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5. Random access via precision scanning and autofocus

Both writing and reading are performed by scanning across the substrate using:

- **High-speed XY stages** to position the optical head over the targeted address
- A **piezo-driven autofocus** system to maintain focus over the sheet surface

This architecture is designed to provide **true random access**, enabling the retrieval of specific data regions without sequential scanning of an entire medium.

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6. Cartridge concept and library integration

Stacked-sheet cartridges for high volumetric density

Multiple **9,4 cm × 9,4 cm** sheets are **stacked into individual cartridges** to reduce volumetric footprint while preserving random access. Cerabyte adopts the **external form factor of standard magnetic LTO tape cartridges**, enabling integration into established data center library mechanics.

Random-access retrieval vs. sequential tape

While using a tape-like cartridge form factor, Cerabyte's concept is a **random-access media retrieval regime**. Media can be selected, accessed, and positioned with **much shorter time-to-first-byte** than sequential LTO tape workflows.

Remote write architecture in a commercial library unit

Cerabyte's system concept includes a commercially available library platform that:

1. Locates and retrieves the addressed cartridge
2. Unloads the cartridge
3. Unstacks and separates the sheets
4. Positions the targeted sheet in the optical write/read unit

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7. Durability and data integrity under extreme conditions

Cerabyte reports accelerated aging tests across a temperature range from **-273 °C to 500 °C**, indicating a **potential storage lifetime in the millennia range**. In addition, the data is described as remaining intact when exposed to:

- **Electromagnetic pulses**
- **UV radiation**
- **Gamma radiation**

These properties are positioned to support cold storage deployments where long retention, offline integrity, and environmental robustness are primary design requirements.

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8. Development status and performance roadmap

Cerabyte describes a staged system roadmap from prototype demonstration to pilot and multi-rack deployments:

2026-27 Pilot system

- Remote testing availability: Q4 **2026**
- Target performance: **~100 MB/s** write/read
- Target capacity: **~1–5 PB per rack**

2028-30 Data center system

- Target performance: **~250 MB/s to 1 GB/s** write/read
- Target capacity: **~20–40 PB per rack**, scaling upward over time
- **Goal:** capacities and economics attractive for data centers **by the end of the decade**

2031-33 Cloud system

- Target performance: **~ 1 GB/s to 2 GB/s** write/read
- Target capacity: **~80–160 PB per rack**, scaling upward over time
- **Goal:** capacities and economics attractive for hyperscalers
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	Generation 1	Generation 2	Generation 3
Capacity per rack	1 - 5 PB	20 - 40 PB	80 - 160 PB
Speed per drive	100 - 250 MB/s	250 - 1000 MB/s	1000 - 2000 MB/s
Access time	< 30 sec	< 10 sec	< 5 sec

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9. Intellectual property position

Cerabyte´s roadmap is supported by a comprehensive international IP portfolio covering:

- Storage media
- Write/read devices
- High-density matrix formats

The portfolio coverage spans approximately:

- **80% of global GDP**
- **85% of global data storage infrastructure**
- **67% of smartphone penetration**
- **49% of global population**

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10. Data density strategy: surface recording instead of volumetric layers

Cerabyte positions its media design around a central trade-off between **data density** and **read performance**:

SNR as a driver of read speed and complexity

- **High SNR** enables deterministic (simpler, faster) decoding.
- **Low SNR** often forces heavier computing (e.g., ML/AI-based enhancement) and stronger error correction to ensure reliable reads.

Volumetric density vs. read performance

Writing hundreds of layers into the volume of a thick medium can increase density, but it can also degrade read performance due to:

- signal weakening through many layers,
- tighter tolerance requirements for read/write alignment, and
- increased sensitivity to scattering and optical distortion.

Cerabyte approach: stacked thin substrates

Rather than reading through many embedded layers, Cerabyte writes to the **surface** of a thin ceramic coating on an glass substrates and achieves volumetric density by **stacking many ultra-thin sheets** inside a cartridge. Because individual sheets are designed to be separable, the system reads from a single surface without looking through hundreds of layers — preserving SNR and enabling fast readout.