Golden touch: Next-gen optical disk to solve data storage challenge

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Scientists from Australia and China have drawn on the durable power of gold to demonstrate a new type of high-capacity optical disk that can hold data securely for more than 600 years.

The technology could offer a more cost-efficient and sustainable solution to the global data storage problem while enabling the critical pivot from Big Data to Long Data, opening up new realms of scientific discovery.

The recent explosion of Big Data and cloud storage has led to a parallel explosion in power-hungry data centres. These centres not only use up colossal amounts of energy - consuming about 3 per cent of the world's electricity supply - but largely rely on hard disk drives that have limited capacity (up to 2TB per disk) and lifespans (up to two years).

Now scientists from RMIT University in Melbourne, Australia, and Wuhan Institute of Technology, China, have used gold nanomaterials to demonstrate a next-generation optical disk with up to 10TB capacity - a storage leap of 400 per cent - and a six-century lifespan.

The technology could radically improve the energy efficiency of data centres - using 1000 times less power than a hard disk centre - by requiring far less cooling and doing away with the energy-intensive task of data migration every two years. Optical disks are also inherently far more secure than hard disks.

Lead investigator, RMIT University's Distinguished Professor Min Gu, said the research paves the way for the development of optical data centres to address both the world's data storage challenge and support the coming Long Data revolution.

"All the data we're generating in the Big Data era - over 2.5 quintillion bytes a day - has to be stored somewhere, but our current storage technologies were developed in different times," Gu said.

"While optical technology can expand capacity, the most advanced optical disks developed so far have only 50-year lifespans.

"Our technique can create an optical disk with the largest capacity of any optical technology developed to date and our tests have shown it will last over half a millennium.

"While there is further work needed to optimise the technology - and we're keen to partner with industrial collaborators to drive the research forward - we know this technique is suitable for mass production of optical disks so the potential is staggering."

The world is shifting from Big Data towards Long Data, which enables new insights to be discovered through the mining of massive datasets that capture changes in the real world over decades and centuries.

Lead author, Senior Research Fellow Dr Qiming Zhang from RMIT's School of Science, said the new technology could expand horizons for research by helping to advance the rise of Long Data.

"Long Data offers an unprecedented opportunity for new discoveries in almost every field - from astrophysics to biology, social science to business - but we can't unlock that potential without addressing the storage challenge," Zhang said.

"For example, to study the mutation of just one human family tree, 8 terabytes of data is required to analyse the genomes across 10 generations. In astronomy, the Square Kilometre Array (SKA) radio telescope produces 576 petabytes of raw data per hour.

"Meanwhile the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative to 'map' the human brain is handling data measured in yottabytes, or one trillion terabytes.

"These enormous amounts of data have to last over generations to be meaningful. Developing storage devices with both high capacity and long

lifespan is essential, so we can realise the impact that research using Long Data can make in the world."

The novel technique behind the technology - developed over five years - combines gold nanomaterials with a hybrid glass material that has outstanding mechanical strength.

The research progresses earlier groundbreaking work by Gu and his team that smashed through the seemingly unbreakable optical limit of blu-ray and enabled data to be stored across the full spectrum of visible light rays.

How it works

The researchers have demonstrated optical long data memory in a novel nanoplasmonic hybrid glass matrix, different to the conventional materials used in optical discs.

Glass is a highly durable material that can last up to 1000 years and can be used to hold data, but has limited storage capacity because of its inflexibility.

The team combined glass with an organic material, halving its lifespan but radically increasing capacity.

To create the nanoplasmonic hybrid glass matrix, gold nanorods were incorporated into a hybrid glass composite, known as organic modified ceramic.

The researchers chose gold because like glass, it is robust and highly durable. Gold nanoparticles allow information to be recorded in five dimensions - the three dimensions in space plus colour and polarisation.

The technique relies on a sol-gel process, which uses chemical precursors to produce ceramics and glasses with better purity and homogeneity than conventional processes.

More information: "High-capacity optical long data memory based on enhanced Young's modulus in nanoplasmonic hybrid glass composites" *Nature Communications*, DOI: 10.1038/s41467-018-03589-y

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