EN

LUNAR MISSION ONE

Data Archive Storage Material

Nuffield Foundation

Introduction

Lunar mission 1 aims to send a capsule to the moon documenting human history so far, as well as holding some pieces of human DNA. Furthermore, the mission hopes to hold a data archive on the moon for 1 billion years or more, in the hopes that in the future it will be read by other humans or possibly even other intelligent lifeforms from other planets and galaxies in the universe.
The mission will be both privately funded and government funded. The projected launch year is 2024, and will feature research from across the globe and from all ages, from engineers and scientists who do full time research and development to students studying a relevant subject. (Such as Physics or Computer Science)

Lunar Mission 1 Potential Storage Solutions:

Storage medium:	**Advantages:**	**Problems:**	**Lifespan (Years)**	**Density (Terabits/cm^2)**	**Problems on the moon:**
Magnetic Hard Drive	Inexpensive ($40 per Terabyte) Reliable	Delicate in power surges or if dropped	7-8 unused, 2-3; constant power	0.52	Temperatures above 0K Cause corruption of data (Movement of particles) Induction of current from moons EM Field could corrupt data Disk crash from dust on moon
Solid State Drive/ USB	No moving parts, stores data using electronics. Fast Read/write times Robust	Expensive per Terabyte compared to a HDD Lower capacity (Than HDD)	7-9 years, Also depends upon read/ write cycles	0.908	Stores charge, induction of current from moons EM field could corrupt data
Optical Drive	Relatively Low cost	Relatively Short Lifespan	2-5 (DVD up to 30 in correct condition)	3.6×10^{-4}	Radiation could corrupt data (Create dark/ unreadable spots on disk)
5D data	High density Basically unlimited lifespan (13.8 billion years at temperature 190^{O}C Very robust	Slow write speeds (1.5Kilobits per second)	A long time, Over 13.8 billion years at RTP	3.84×10^{7}	Al impurities in glass absorb radiation Very slow read/write time Not in mainstream usage
Holographic storage	High data density achievable through multiplexing High freedom of space usage Hologram doesn't deteriorate	See Optical Disc	100 (According to current lab tests)	0.00337	Small Chance of Internal degradation Not in mainstream usage

Zeki Shaw

Storage Challenges

Storage mediums utilized on earth use electromagnetic binary storage of data. Data will always corrupt at anything above absolute 0 (0 Kelvin) due to the storage of thermal energy within the storage medium which means that the particles within the medium are constant random motion and so data will be changed after time. This means that are back ups are needed otherwise sections of data on most storage mediums could co-alesce to create an alteration of data or polarity changes could occur within a sector.

Furthermore, the mission needs 10 Terabytes of data to be available, preferably a lot more to be held in a 5 litre volume (0.005m^3). The table shows that only 5D data technology could do this, however with 5D data technology it would take 21.3 years to write 1TB of data, and so is unsuitable for the mission.

Radiation 100 metres down into the moons surface also needs to be considered - at 100metres depth all 3 types of nuclear radiation - Alpha Beta and Gamma are present meaning ionizing energy could be hitting the data archive and degrading and corrupting the data it holds. Gamma radiation is the least ionizing (shown on figure 1.1) but the most penetrating (shown on figure 1.2) over the course of a billion years the slightly ionizing radiation could cause serious damage to the data within the archive.

Radiation type	**Comparative Speed/ Actual Speed**	**Ionizing ability**	**Relative Atomic mass**
Alpha	Slow/$1.5 \times 10^{7} ms^{-1}$	Strong	4
Beta	Fast/ $1.8 \times 10^{8} ms^{-1}$	Moderate	1/2000
Gamma Rays (Waves)	Fastest/$3 \times 10^{8} ms^{-1}$	Very Weak	0

Figure 1.1—Summary of radiation types

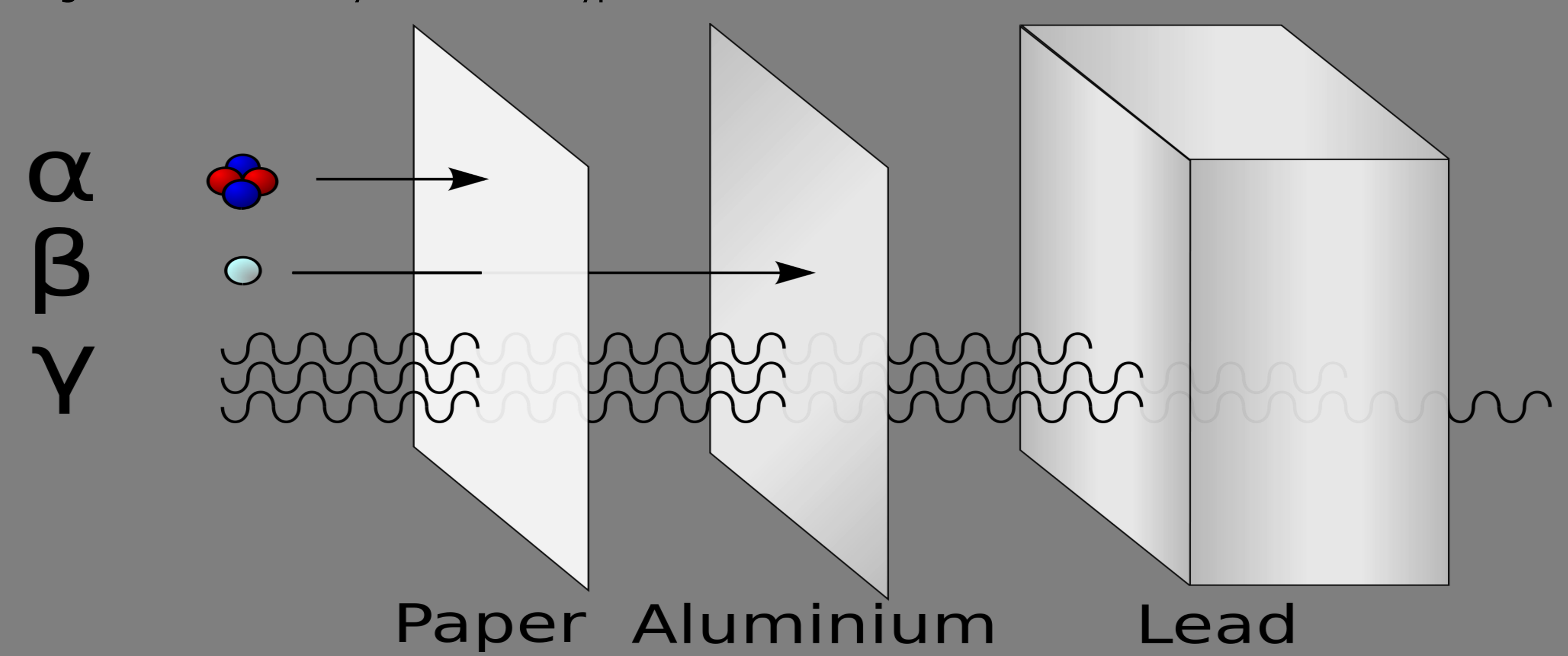

Figure 1 .2 - Penetrative effects of the 3 types of nuclear radiation

Proposed Solution

Inspired by the voyager golden record mission, a solution to radiation, write speed and data corruption/degradation is electron beam lithography – Using high powered beams of electrons to engrave patterns on materials - upon a synthetic diamond.

The engravings can be used to write '1's and '0's (binary) at sizes of 5nanometres with spacings of 10 nanometers between them.

(1nanometre = 1 millionth of a millimeter).

The diamond could be written upon as a disk, allowing 16-39.2 gigabytes of data to be stored within the capsule, or by writing on many substrates a maximum of 1.25 Exabytes (1 million terabytes) of data could be contained in the archive.

If used today the binary would be copied into a computer system and decoded to display the data. By using engraved diamond for lunar mission 1, a computer system and instructions for reading the data would also need to be with the archive.

Diamond is the perfect material to be used for holding data upon it on the moon. This is because it is unaffected by all types radiation, it is incredibly strong (highest hardness of any bulk material), and a diamond is unreactive, and won't even react with strong alkali or acidic solutions.

Conclusion

Electron beam lithography upon diamond can achieve the highest data storage (125 Petabytes) for the archive as well as providing a solution that would mean data is held upon one of the most physically strong and unreactive materials on earth. Whilst diamond is often thought of as being an expensive raw material, synthetic diamond can be made for only £100. Whilst this would still make it the most expensive storage solution for the archive, it achieves the highest data density without having to wait 100 years and means that no data degradation would occur within the archive.

References

https://commons.wikimedia.org/wiki/File:Alfa_beta_gamma_radiation_penetration.svg
nedds.co.uk
www.jwnc.gla.ac.uk/electronbeamlithography.html
http://em.wikipedia.org/wiki/electron-beam_lithography