SSDs - What You Need to Know

Ben Britt, March 2015

- WHAT are SSDs - relatively new tech based on flash memory technology- definitions

- WHY do you want - advantages vs. drawbacks; SDDs vs. HDDs

- HOW to choose, install, configure

- Future considerations - ?

Disclaimer - Any and all information here is to be used at your own risk
Always have verified back-ups before adding/changing a drive

Current Drive Types

- HDD - Hard Disk Drive - 30+ years old technology: traditional hard disk - rotational magnetic medium; speed varies with surface velocity; serial data transfer

- SSD - Solid State Drive - originally developed for digital camera storage w/limited write/erase cycles of large files; now used NAND technology is < 10 years old; parallel data transfer

- SSHD - Solid State Hybrid Drive: a single device consisting of small SSD section and a much larger HDD section, the SDD section is usually 8-24 GB.

- Apple's Fusion Drive: a logical drive setup using two devices: a 128 GB SSD and a 1TB or 3TB HDD seen as *one* drive to MacOS.

What are SSDs

A. SSD = Solid State Drive - storage implementation based on flash memory technology which has limited writes/rewrites

B. May be used instead of or in conjunction with a hard disk drive.

C. Semiconductor technology (NAND) - no moving parts - has limited long term endurance

D. Parallel (Multiple-Pathway) access - very fast

SSDs consist of 4 major items

A. Drive interface - SATA, PATA, mSATA, etc.
   - the physical connection to the computer

B. Controller Chip - SandForce, Marvell, MEX, etc.
   - the brain of the SSD

C. NAND, V-NAND, NOR media
   - the place of storage

D. Firmware
   - the info and instructions for the controller

   all items work together to give a SSD its performance and durability

SSDs (vs HDDs) for Mac
Advantages vs. Drawbacks

+ Advantage - high access speeds - reading and writing up to 100x of HDDs
+ Advantage - no moving parts - silent operation and greater shock resistance
+ Advantage - lower operational power consumption - better battery life and cooler operation
+ Advantage - lighter weight

More expensive (500 GB - $.07/GB HDD vs $.46/GB SDD) - Drawback -
OSX tweaks necessary for peak performance - Drawback -
Firmware and other updates require Windows in most cases - Drawback -
Technology still advancing, obsolescence issues - Drawback -
Shorter long term storage life - Drawback -

Some Terms

Internal SSD items

NAND FLASH - common storage media of SSDs: flash architecture made up of pages, typically 512 or 2,048 or 4,096 bytes in size, Different types: SLC - Single Layer, MLC - Multi Layer, TLC - Triple Layer
CONTROLLER CHIP - separate chip containing the firmware that controls storage in NAND
WEAR LEVELING - technique for prolonging the service life of NAND
GARBAGE COLLECTION - Process where the SSD clears out space of invalid data, making it available for writing new data. Analogous to the same named process in RAM.
WRITE AMPLIFICATION - undesirable phenomenon where the actual amount of physical information written is a multiple of the logical amount intended to be written by the operating system.
SATA - Serial ATA, Common interface for disks

SSD Config consideration items

Atime - File status tag updated when a file is merely read
TRIM - Process where the operating system notifies the SSD which data is no longer valid; drive then invokes background garbage collection to keep blocks ready for writing
HIBERNATION - powering down a computer while retaining its state producing a sleep image on disk
SLEEP - low power mode, memory kept active in RAM
LOCAL SNAPSHOT - kept on internal disk to compliment regular Time Machine backups

SSD Configuration Overview

SSDs are much faster but work differently than HDDs, requiring additional considerations:

A. Status flags on files

B. Time Machine Local Snapshots

C. Sleep and Hibernation variations

D. TRIM - for efficient garbage collection, file writing, longevity

E. Additional items
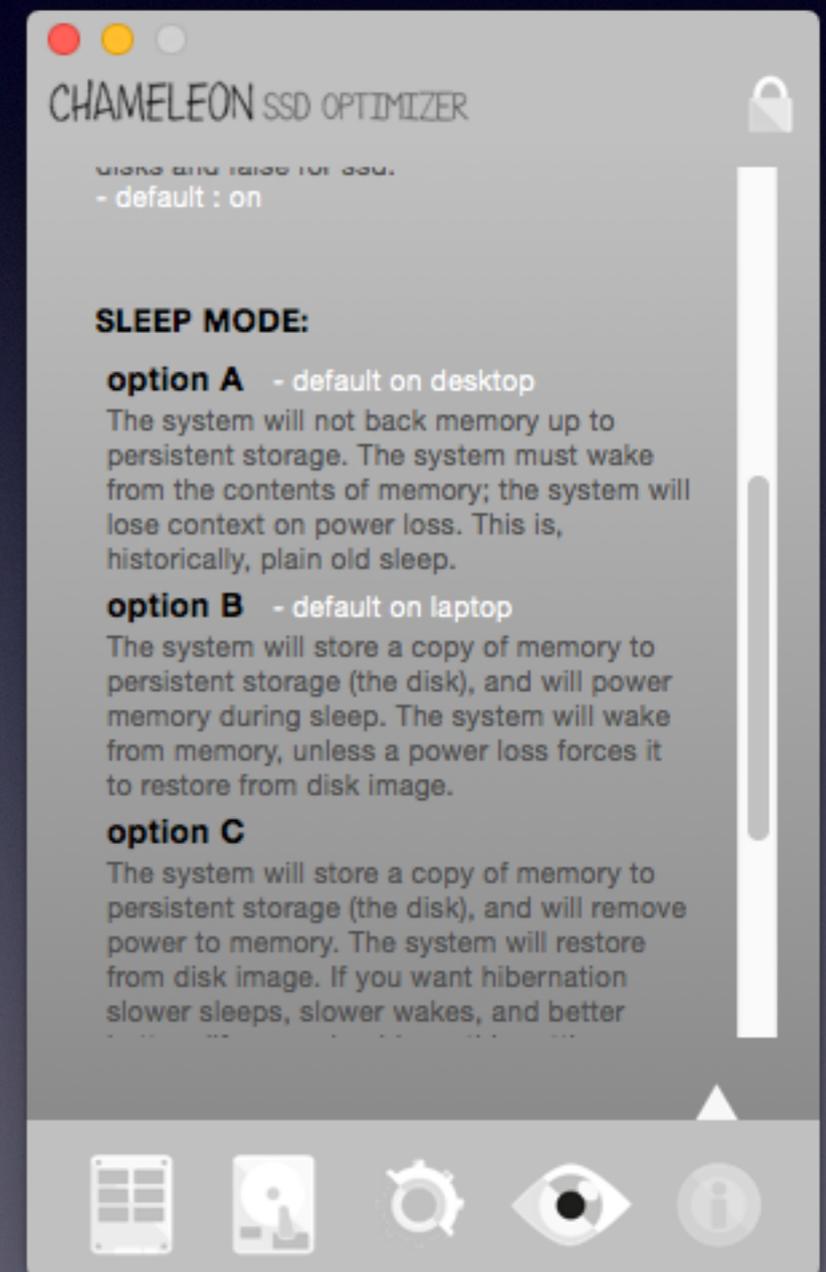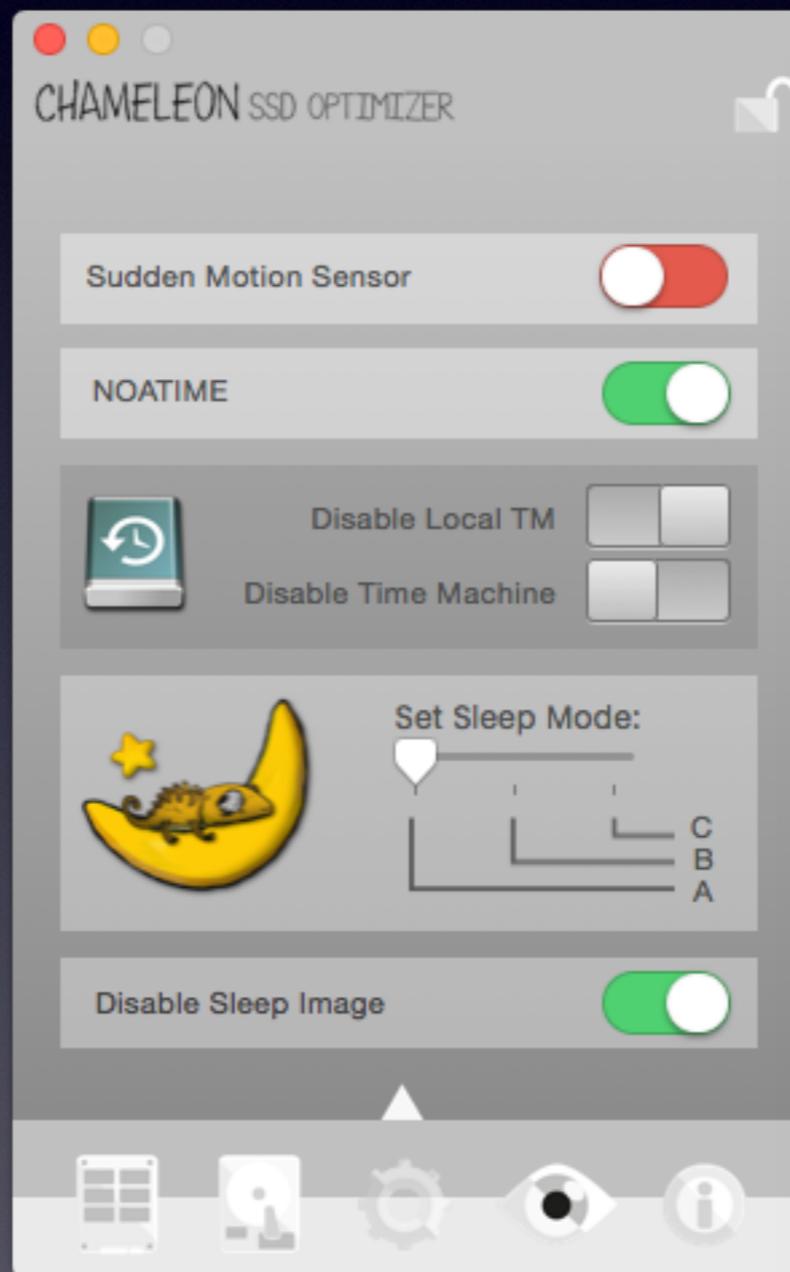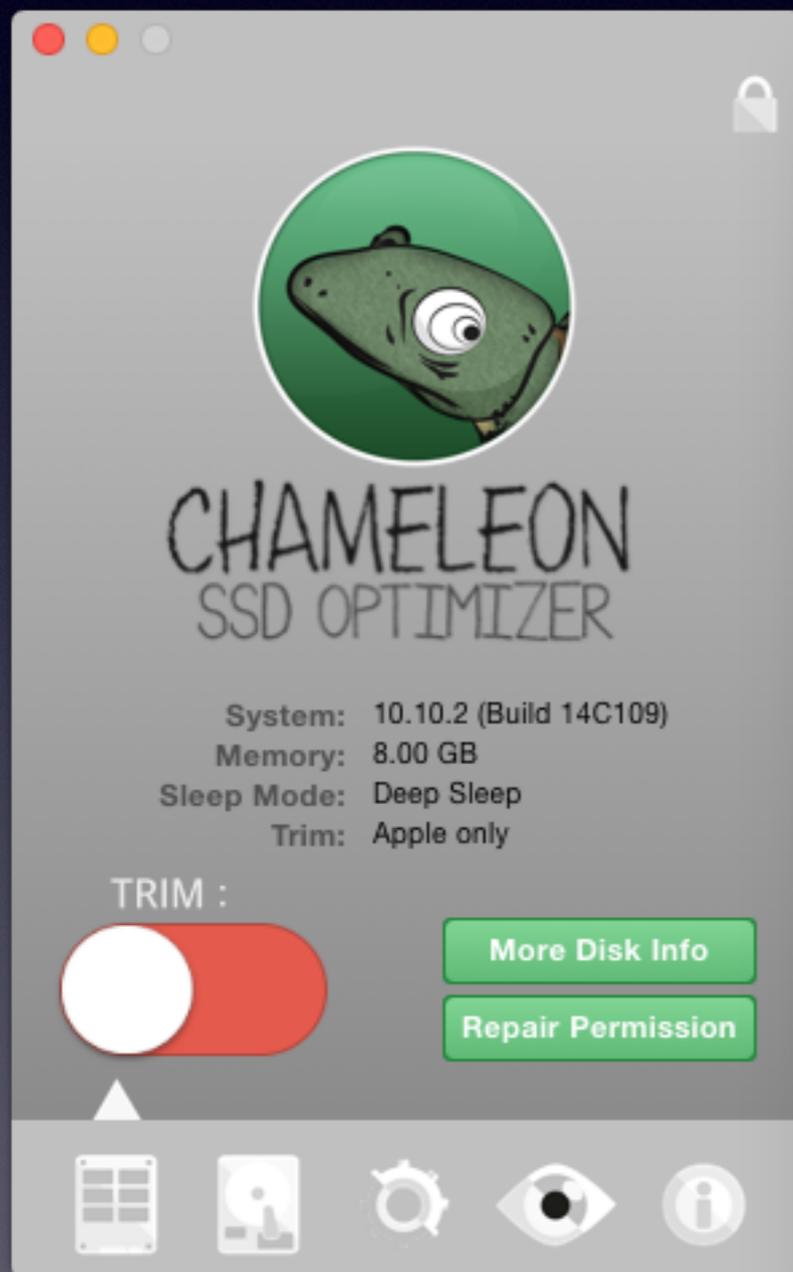
F. Mixing SDDs and HDDs

TRIM Enabler

TRIM Enabler http://www.cindori.org

$Free/basic; $10/with extended capability

Chameleon SSD Optimizer
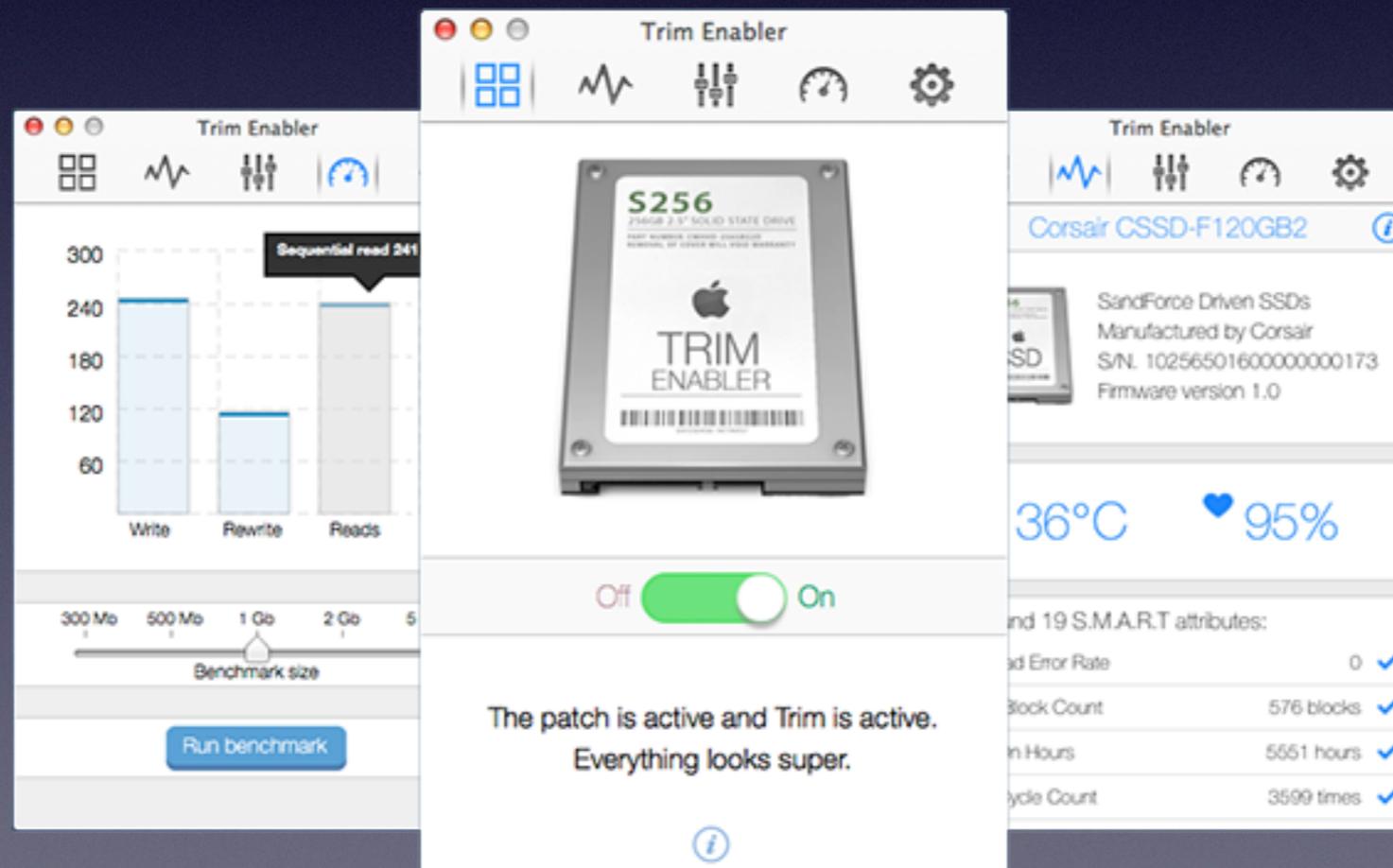
http://chameleon.alessandroboschini.it/index.php
$Free

Set Noatime status flag
turn off unneeded writes to drive

MacOS (like other unix-based systems) by default records last access time for every file; i.e. every time you read a file, a write is made on the filesystem to record this action. There is little point in doing it and no side effects if you disable that by mounting the root filesystem with noatime flag set.

A. TRIM Enabler advanced features

B. Chameleon SSD Optimizer

C. Using Terminal Commands is not recommended - difficult to execute since different OSX variants require different command strategies

Disable <u>Time Machine Local Snapshots</u>
To save space and prevent extra disk writes

A. Use TRIM Enabler advanced features

B. Use Chameleon SSD Optimizer

C. Use Terminal Commands

    1. MacOS has no GUI switch to turn these local backups off, but it can easily be done on the command line. Just start Terminal.app and execute the following command:
   Code: sudo tmutil disablelocal

    2. Once you do this, the TM Preferences panel will immediately reflect it – the text will change from "Time Machine keeps local snapshots as space permits, and:" to "Time Machine keeps:". To turn it back on, you can simply run the following in the Terminal:
   Code: sudo tmutil enablelocal

    3. Also note, this feature gets turned on automatically whenever you turn off and on the Time Machine – so don't forget to turn the local backups back off again whenever you do that.

Hibernation [laptops only] 1

Another feature of Mac OS turned on by default on laptops is, that it saves all the memory to disk when entering sleep mode. This is to ensure your laptop does not lose your work if it runs out of battery while "sleeping". The more RAM you have, the more gigabytes it writes to the disk every time you close the lid/put it to sleep. If you have 8GB of RAM, that means your MacBook writes up to 24 GB of hibernation data to your SSD every day. You can turn this off – it will not only make your SSD's life longer, but also significantly speed up the time it takes for your laptop to enter the sleep mode:

A. Use TRIM Enabler advanced features

B. Use Chameleon SSD Optimizer

C. Use Terminal Commands -
   Code: ***sudo pmset -a hibernatemode 0***

      1. hibernate mode = 0 - RAM only

      2. hibernate mode = 3 - laptop defaults - RAM & disk sleep image

      3. hibernate mode = 25 - sleep image on disk only

Hibernation [sleep image] 2

A. Review Hibernation Terminal Commands -

    A. Code: **sudo pmset -a hibernatemode 0**

        A. hibernate mode = 0 - RAM only - desktop defaults

        B. hibernate mode = 3 - RAM & disk sleep image - laptop defaults

        C. hibernate mode = 25 - sleep image on disk only - best battery life

    B. *Once you turn off hibernation, you can also remove the sleep image file that will free up several GB of disk space (depending on how much RAM you have):
Code: **sudo rm /Private/var/vm/sleepimage**

    C. *Then create a blank zero-byte file so OS X cannot rewrite the file:
Code: **sudo touch /Private/var/vm/sleepimage**

    D. *Last, make the file immutable:
Code: **sudo chflags uchg /Private/var/vm/sleepimage**

Enable <u>TRIM</u>
For efficient garbage collection, writes, drive longevity

- Definition - A **Trim command** (commonly typeset as **TRIM**) allows an operating system to inform a solid-state drive (SSD) which blocks of data are no longer considered in use and can be wiped internally. A command from the operating system tells the SSD which blocks can be cleared to write to. On the SSD level it is the ability to clear that obsolete data in the background so that blocks are write-ready. This becomes more important when the drive becomes full, has many small files written, and effects both the write efficiency and longevity of the drive.

- Apple branded SSDs have TRIM enabled by default, but 3rd party SSDs are not recognized by MacOS in this regard, so that a patch needs to be applied in the SSD driver so many 3rd party SSDs to effect background garbage collection. However some SSDs (with SandForce controllers) have efficient garbage collection in their firmware, so there is some controversy about the value of TRIM in those cases.

- TRIM is most important if your drive is getting full or you do a lot of file deletion and writing.

- OS 10.10.x, *Yosemite*, now requires KEXT signing and has made using TRIM Enabler or Chameleon problematic. Both of them need to disable global KEXT signing before they work. see http://www.cindori.org/trim-enabler-and-yosemite/

To TRIM or not to TRIM . . . that is the question

SSDs & HDDs together

- Can be used together in a single Mac

- Best practice for SSD is to install OSX and most applications and only one user for solely admin use.

- Use HDD for bulk of files and other real users - use advanced options in Users & Groups to change default home folder location(s)

- Can use smaller SSD if done properly

Buying Recommendations

- If you want to buy now, get an entry level SSD (Crucial BX100, Samsung 850 EVO, OWC Mercury Electra) - technology is changing fast - wait if you can - buy now if your hard drive is dying - if on a budget

- Buy a "Pro" level SSD (Samsung 850 Pro, OWC Mercury Extreme Pro, Sandisk Extreme Pro) if you think you might keep your newer model Mac for a while or give it heavy use; video editing, design, frequent writes or save as, etc - most have 5-10 year warranties

- Try to get a SSD with a **SandForce** controller especially if you use OSX 10.10 *Yosemite.* Currently proven to have very efficient garbage collection lessening the need for TRIM. However technology is changing fast and a new controllers are coming later this year - wait if you can.

- Samsung SSDs have great specs, and are used in Fusion Drives; but are very TRIM dependent; so beware; maybe not the best stand-alone for OS 10.10 Yosemite.

- Beware of current SSHDs; they try to use the SSD portion for the most used files but are not able to handle well multiple users, partitions, large video files; for only ho-hum better performance than regular HDDs, sometimes not even as good.

Recommended Configurations

A. Noatime set, as this has no real downside.

B. Local time machine snapshots disabled to eliminate its constant writing to the SSD.

C. Sleep Mode=0 is best for limiting writing; Mode=25 is best for battery life; Mode=3, default for laptops; disable sleep image for sleep mode 0; all have advantages & drawbacks.

D. TRIM activation - controversial with Yosemite, but helps any SSD; beware of downsides and caveats!

E. Set home folders to HDD in mixed drive systems

Let Apple know that we all want 3rd party SSD support in Yosemite.
Go to https://www.apple.com/feedback/macosx.html and let them know - maybe they'll change the hex entries in their SSD KEXT so TRIM will work with all SSDs as it can and should. After all Apple signed on to the TRIM standard.

Some Future Tech

- PMC — Arizona State University (ASU) have developed "programmable metallization cell" memory, which they say will boost the performance, capacity and battery life of consumer electronics; using nanowires from copper atoms to record binary data

- MRAM — Freescale/IBM developing "Magnetoresistive Random Access Memory" has much faster write speeds than Flash and has an unlimited endurance

- Nanowires/rods — Brown University researchers developed a way to control the shape of iron-platinum and cobalt-platinum nanorods; narrow nanorods could pack densely alongside each other, with their magnetic information oriented in only two stable and opposite directions

- Nanostructured glass — Researchers from the University of Southampton used nanostructured glass to demonstrate recording and retrieval processes of five dimensional digital data using a super fast laser that can write up to 360 TB of data on a single CD sized media and withstand a temperature of 1000 degrees Celsius. Jokingly referred to as the "Superman memory crystal" the glass memory has some very unique properties just like the crystals seen on the Superman movies.

- HAMR — TDK is developing the next generation of hard drive technology called Heat-Assisted Magnetic Recording. This new technology introduces a tiny laser into the head of the hard drive for the first time. The aim of the laser is to allow the drive to write bits of data closer together without the risk of accidental polarity change by warming up a very precise spot on the hard drive platter where the specific cell is.

- RRAM — Micron is developing Resistive Random Access Memory as a NAND replacement

Useful SSD Links

- http://www.macworld.com/category/storage/

- http://www.tomshardware.com/forum/270102-32-useful-articles-part

- http://www.storagereview.com/reviews/consumer/ssd

- http://eshop.macsales.com/shop/SSD/OWC

- http://www.anandtech.com/tag/storage

- http://www.lostcircuits.com/mambo//index.php?option=com_content&task=view&id=72&Itemid=1

- http://ssdboss.com