Open Platform and Cable Free Technology

for the
Chrome S20 Series

A
S3 Graphics
White Paper

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **2** of **17***

Scope

This overview discusses S3 Graphics' MultiChrome, a scalable, multiple Graphics Processor (GPU) technology that enables low cost and high performance rendering with the Chrome S20 Series of PCI Express (PCIe) desktop graphics processors. This easy-to-use technology requires no proprietary motherboards or special cables or connectors.

Background

The use of multiple devices for the acceleration of graphics operations have been part of the graphics industry for many years. Many of the early high end workstation solutions used several chips – some responsible for triangle setup and others for actual rendering. These solutions were extremely expensive. Other solutions were intended for the PC market, but because of hardware, software, and market issues, they did not last long.

Some current PC solutions target the use of multiple PCI Express graphics cards to further accelerate graphics for games and applications. These solutions, require the use of proprietary GPU-to-GPU cables/connectors or only work on specific motherboards. This makes setup and use complex for the consumer, which translates into higher costs.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **3** of **17***

MultiChrome is S3 Graphics' advanced multi-graphics processor technology that combines 2 GPUs into a single high performance GPU. It enables simple-to-use, low cost, high performance scalable graphics acceleration without the need for any inter-board proprietary cables or connectors and without any restrictions requiring the use of proprietary motherboards or upgrades to higher performance power supplies.

MultiChrome Features

The advantages of MultiChrome are many, including:

❖ **Open Platform** – works on any of the latest multi-GPU motherboards.

❖ **Cable/Connector Free** – does not require any proprietary GPU-to-GPU cables or any other connectors to achieve its high performance.

❖ **Low Power** – does not require any special high performance power supply or high power fan.

❖ **Ease of Use** –provides a simple, easy-to-use user interface. A system re-boot is not required when going from single to MultiChrome configurations and vice-versa.

❖ **Performance** – achieves performance increases of approximately 70%-80% in most PC games going from single card to MultiChrome configurations

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **4** of **17***

Typical Chrome S20 Series MultiChrome Configuration

The figure below shows a system with a typical S3 Graphics Chrome S20 Series MultiChrome setup. The example uses the latest dual-GFX (dual graphics) motherboard chipset on the market which allows for the installation of two Chrome S20 Series graphics cards into two physical x16 PCIe slots. The complete absence of any internal or external cables or connectors between the two graphics cards removes any sensitivity to relative slot spacing for thermal issues. The lack of restrictions on display connectivity makes MultiChrome simple to use.

Installation and setup of a MultiChrome configuration is simply a matter of inserting the two cards into any dual-GFX motherboard which has two compatible physical x16 PCIe slots. Note that some dual-GFX motherboards may require a system configuration setting to enable the second physical x16 PCIe slot. Instructions for such configuration are provided in the documentation accompanying the motherboard.

S3 Graphics advanced power management architecture, available with Chrome S20 Series GPUs, has produced one of the industry's leading power-efficient graphics solutions. The benefits of low power are doubled when used in MultiChrome setups: each Chrome S20 Series GPU operates well within the 75 Watt limit of power delivery to a single full length x16 PCIe slot, per the PCI Express specification. Even more importantly, a full performance MultiChrome setup does not automatically require an upgrade of the existing system power supply.
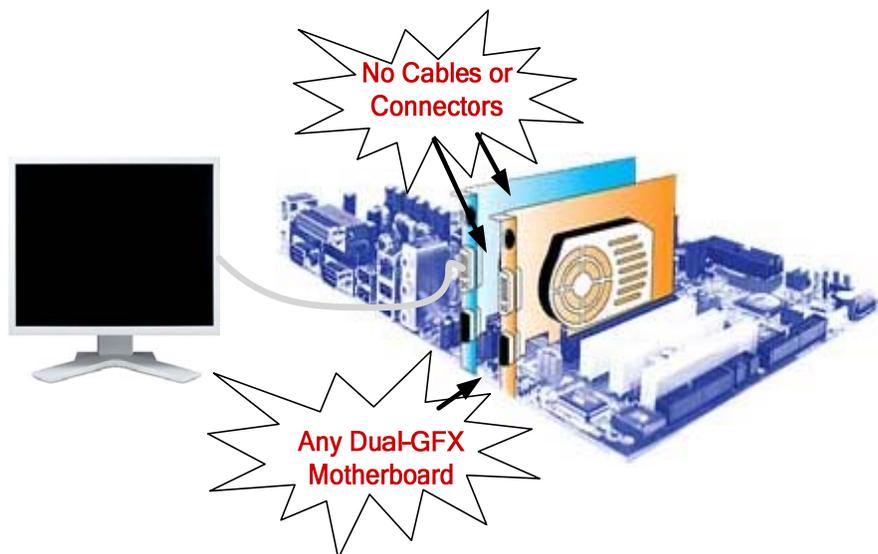

Figure 1. Typical MultiChrome Configuration

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **5** of **17***

Open Platform

One of the key advantages of S3 Graphics' MultiChrome is its cross-vendor motherboard compatibility. MultiChrome does not require any proprietary dual-GFX motherboard to be used. S3 Graphics' MultiChrome implementations have been tested and found compatible with a wide variety of dual-GFX motherboards currently available on the market. Some motherboards do not allow other dual graphics cards to operate on their motherboard, so those specific types of motherboards have not been found compatible. This is an issue with the motherboard and not the GPU card. S3 Graphics will continue compatibility testing with new motherboard models as they become available. S3 Graphics foresees no future compatibility issues with newer dual GFX motherboards as the MultiChrome technology already works on most leading edge dual GFX motherboards in the market.

Cable/Connector Free

Current competitive multi-GPU solutions require the use of a proprietary bridge connector or a complex external cable system with video loop-through and external capture/re-composition engines to achieve the performance level promised with their technology. Apart from the cost burden that these custom solutions impose on the retail graphics add-in board customer, these solutions further add complexity to installation, maintenance and setup.

The advanced cable/connector-free architecture introduced with S3 Graphics' MultiChrome technology is a refreshing change for anyone who has ever configured a multi-GPU system. MultiChrome technology leverages the high speed PCIe bandwidth using Peer-to-Peer transfers for fast inter-GPU communication to achieve the promised performance. It does not require any special cables or connectors.

Low Power

Multi-GPU solutions from other graphics vendors on the market today require an upgrade of the existing power supply because a more powerful and expensive power supply is needed to supply the extra power consumption needs of their multi-GPU solutions. The user also has to meddle with the two extra auxiliary power cables in an already crowded system to configure the multi-GPU cards correctly. MultiChrome technology, with its inherent low power consumption,

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 6 of 17

requires no additional auxiliary power connection to work at its highest performance level.

MultiChrome's thermal characteristics are much lower than the competitive solutions that exist today. MultiChrome users can achieve high performance at low cost in a quiet environment.

No Re-boot

MultiChrome technology allows users to select and de-select MultiChrome mode without having to re-boot the entire system. The mode of operation is activated through a simple menu in the S3Config3D display properties utility, as shown below. That is all the configuration needed. Constantly having to re-boot the system between multi-GPU and non-multi-GPU configurations certainly would be a great nuisance.
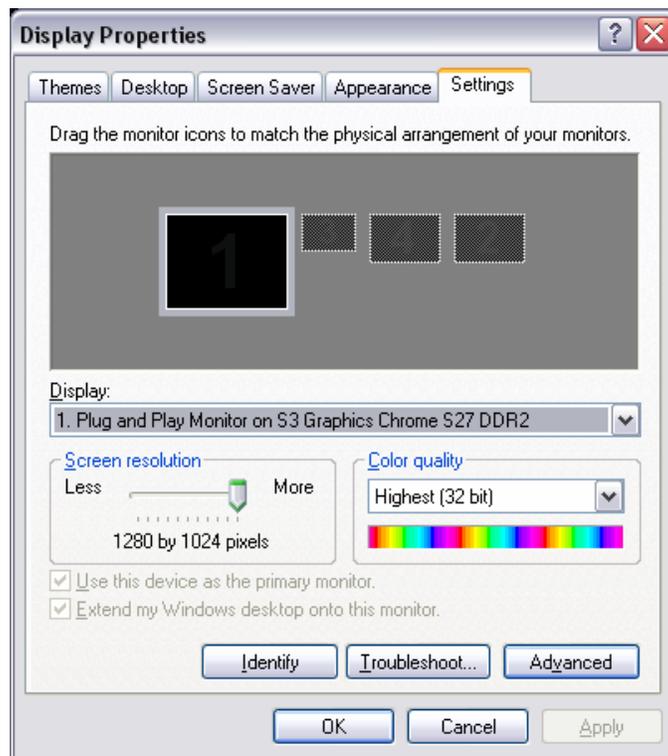
S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 7 of 17

Non-MultiChrome Mulitple Display Configuration

Two GPUs acting in MultiChrome mode work in concert as a single high performance GPU and take full advantage of MultiChrome technology for higher performance.

When MultiChrome is not selected, the user benefits in different ways from the advantages of having a dual graphics card configuration with their two independent multi-head GPUs, which provide a wide range of possible display connections. Re-configurations are available and can be applied without having to re-boot the entire system.

As an example, for a Chrome S27 low profile DDR2 card, 4 possible display outputs are available in non-MultiChrome mode, as there will be two GPU cards available, as shown in the Figure below.

MultiChrome Multi Graphics Rendering

Two multiple processor rendering modes as supported in MultiChrome to achieve high performance; Alternate Frame Rendering (AFR) and Split Frame Rendering (SFR). These are described briefly in this section. All MultiChrome rendering modes are not necessarily applicable for all applications. S3 Graphics MultiChrome-capable software automatically selects the most optimum mode for high performance.

Alternate Frame Rendering (AFR)

Alternate frame rendering (AFR) mode is usually preferred and is the most efficient way of using two identical graphics processors to achieve high performance as most video games/applications will benefit from this multi-GPU rendering mode. This rendering methodology can be applied to most video games and applications which have minimal or no inter-frame dependencies, as is the case in most video games and applications. In the system itself, this method can generate up to double the number of scenes within the same time slice, which can translate into higher performance.

To successfully accelerate or increase the frame rate, video games and applications often allow additional frames to be queued for rendering. In this case multiple GPUs can be used to render alternate frames in the queue, as shown in the Figure below.

| Frame 1 GPU-A | Frame 2 GPU-B | Frame 3 GPU-A | Frame 4 GPU-B | Frame 5 GPU-A | → |
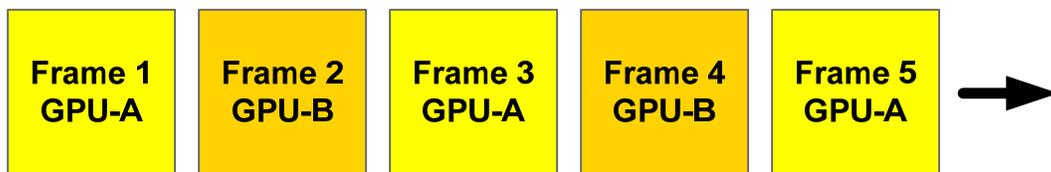
Figure 2. Alternate Frame Rendering (AFR) Sequence

Once each frame has been rendered the completed image has to be transferred to a location which can be used for display. The completed image representing that frame is transferred to the target GPU using a direct GPU-to-GPU transfer across the high speed PCIe bus and finally displayed on the screen. This method requires no custom GPU-to-GPU cables or connectors for communication to achieve its high performance.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 9 of 17

The timeline example for frame scene generation, rendering and final display can be seen in the Figure below.
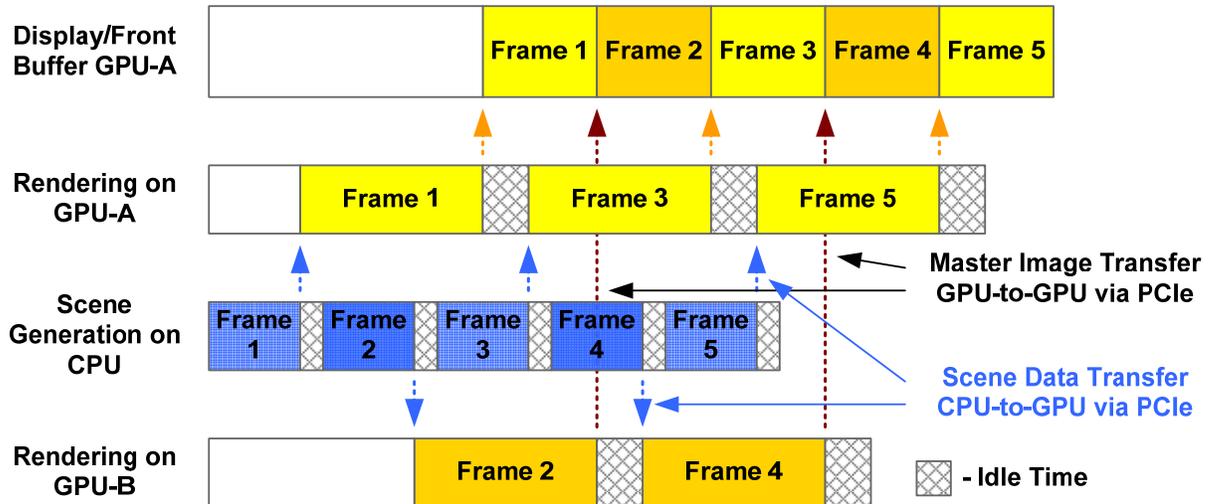
Figure 3. Alternate Frame Rendering (AFR) Activity Example Timeline

AFR is well suited for scenes where the current frame is not dependent upon the previous frame's information. AFR accelerates scenes that allow parallel frames to be rendered, which is the case for most PC video games and applications.

Split Frame Rendering (SFR)

Split frame rendering (SFR) mode leverages multiple GPUs to accelerate the rendering of each frame by splitting the frame into two parts: one for the 1st GPU and the other for the 2nd GPU, as shown in the Figure below. This mode has the advantage of actually reducing the time required to complete the rendering of each scene, thus reducing the latency between the point when the application closes the scene and the moment when the rendered image is visible on the attached display. Use of this mode is dependent upon whether or not the video game or application allows for this kind of rendering, which is not always the case. Sometimes, the added complexity of partitioning the rendering between multiple GPUs generally reduces the achievable boost in final frames per second, when compared to the frame rate possible with a single GPU configuration.
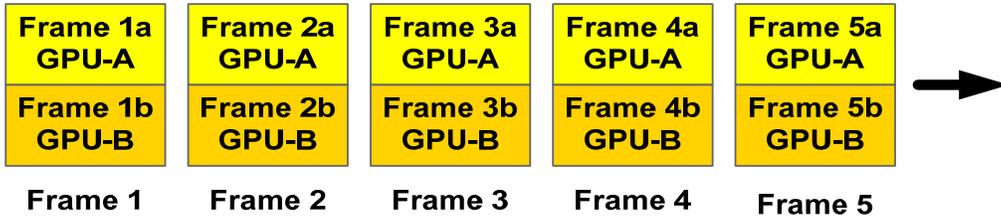
S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **10** of **17***

Figure 4. Load Balancing for Split Frame Rendering

With SFR, each GPU is responsible for rendering a designated slice of the complete final view. To achieve this, an additional clip rectangle is imposed on post transformation vertices. This clip rectangle is unique for each GPU and represents the slice of the screen which is the responsibility of that specific GPU.

The actual determination of which triangles and pixels are to be rendered by which GPU can only be done after transformation into screen space, which occurs as part of the vertex shader execution. Each GPU uses early rejection technology to reduce the number of non-visible triangles to process. Coupled with a high vertex shader processing rate, this technology minimizes the impact of redundant vertex shader processing across multi-GPUs. The increased amount of total vertices processed for each completely rendered frame means SFR mode provides a greater performance boost for those video games and applications which are generally more sensitive to pixel shader and fill rate performance, particularly at higher resolutions.
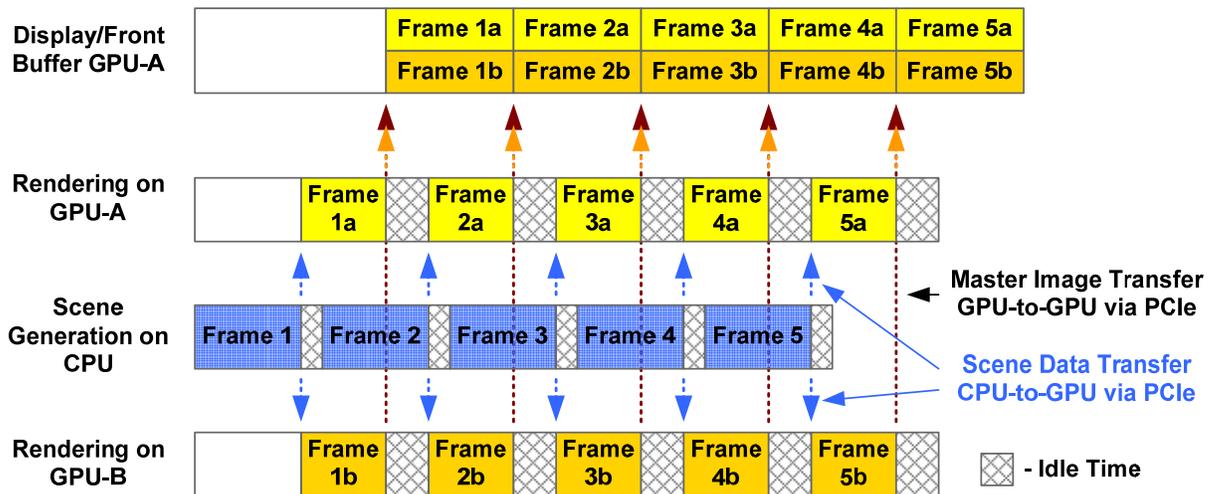

Figure 5. SFR Activity Example Timeline

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 11 of 17

SFR is well suited for scenes where the current frame is dependent upon the previous frame's information. Inter-frame dependency incorporates the practice of using a previously rendered frame as a texture in the frame currently being rendered. Such inter-frame dependencies automatically require that frames be rendered in a strict sequence, which prevents parallel rendering. Therefore, SFR mode does not always allow multiple GPU configurations to achieve high performance.

GPU Loading

The S3Config3D MultiChrome configuration menus have a Show GPU Load option. When selected, software displays a graph of the GPU load as an overlay over the MultiChrome rendered graphics. It is always on top of any 3D game/application running. Position and type of the GPU loading graph can be selected from drop-list options. An example of a GPU loading graph is visible on the screen shot below. It has the GPU loading horizontal bars for each GPU at the default medium setting and located in the upper right corner.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 12 of 17

Game Profiling

Generally speaking, most video games and applications have not been written in a manner which targets multiple GPU acceleration. As such, any given game or application could be dependent on operations which are inherently inappropriate for rendering in other environments. Thus, not all video games and applications show the same level of benefit when run in MultiChrome mode. Video games and applications that are more GPU bound will benefit the most with the addition of a second GPU. The second GPU will be fully utilized to share the load between the two GPUs. For video games and applications that are more CPU bound, the addition of a second GPU will not add much benefit, as the second GPU is not utilized by the video game or application.

Therefore, S3 Graphics MultiChrome-capable software allows video games and applications to take advantage of the performance advantages of multiple GPU technology whenever possible.

MultiChrome Performance Boost

The graph below illustrates some of the popular PC video game performance increases achieved when using a MultiChrome configuration compared to the performance when using a single board. Exact results are affected by many factors, including base system performance. Additionally, the relative achievable performance boost in real applications can vary from application to application.

The example results were run using two S3 Graphics Chrome S27 256MB/128bit DDR2 graphics adapter boards running at 650e/400m clocks with MultiChrome-capable 15.20.07 drivers and software. All the games were run in 1600x1200 @ 32bit color high quality mode. The system configuration includes an AMD Athlon 3800+ on a VIA K8T900 motherboard with 1.0GB (2 x 512MB) system memory.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 13 of 17

MultiChrome vs. Single
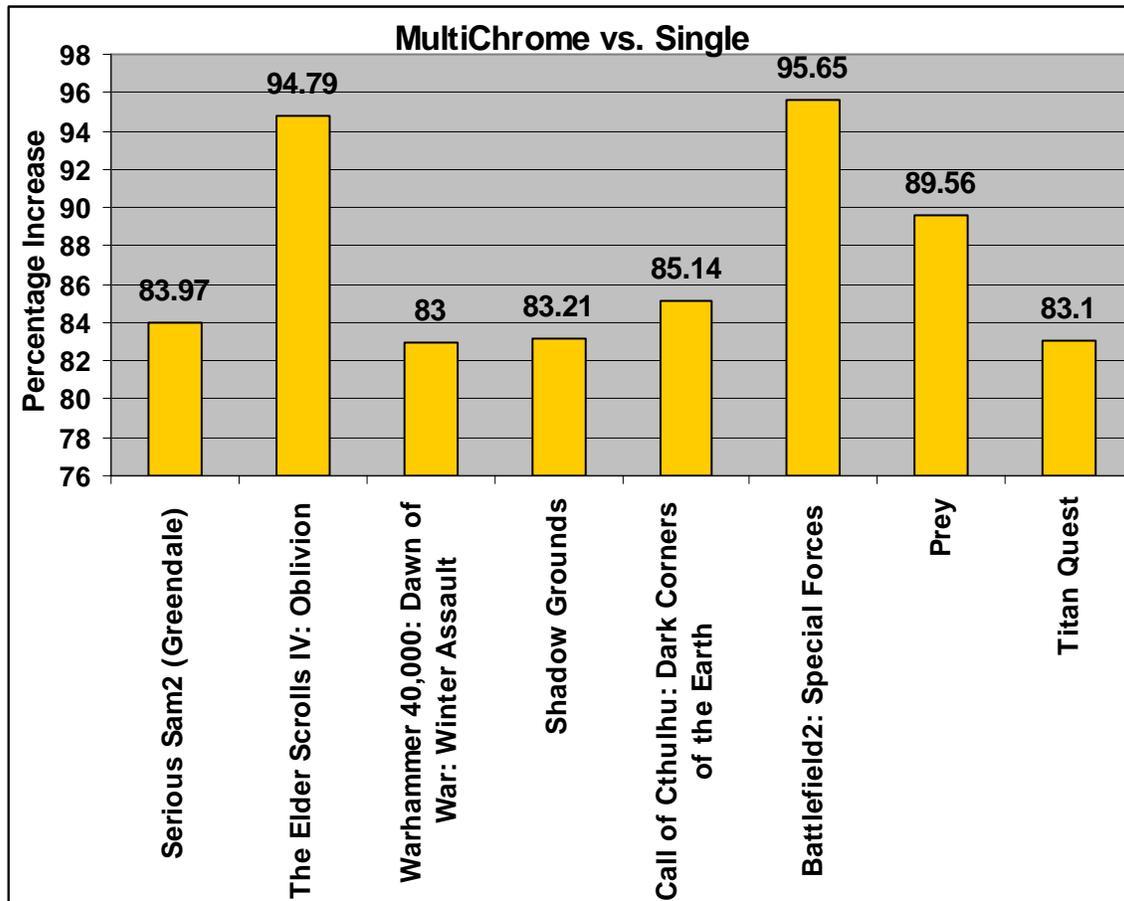
Figure 6: Game Performance Improvements

Some of the popular PC video game results shown in the preceding graph demonstrate performance improvements in the range of an 80% increase in speed (fps) for MultiChrome over single card operation. As discussed, the boost can vary from game to game, thus the above graph is an illustration only.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **14** of **17***

The following graph shows MultiChrome performance improvements on some of the most popular synthetic 3D benchmarks.

The runs were made using the same board and system configurations as for the preceding game results. 3DMark03 and 3DMark05 were both run at the default 1024x768 mode and 3DMark06 was run at the default 1280x1024 mode. All are run in the default mode with no AA and AF.
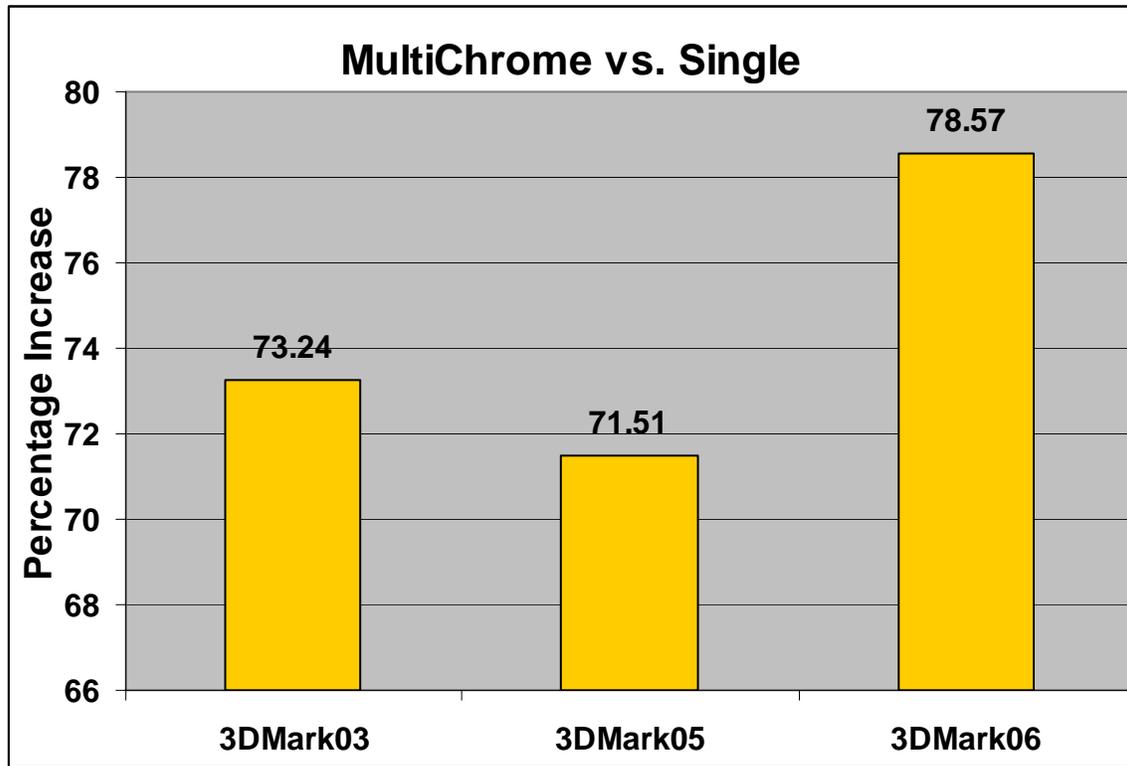
MultiChrome vs. Single

	3DMark03	3DMark05	3DMark06
Percentage Increase	73.24	71.51	78.57

Figure 7. Synthetic Benchmark Performance Improvements

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 15 of 17

System Considerations

For maximum acceleration with MultiChrome technology, use of matched pairs of graphics cards is recommended, where each add-in graphics board has the same Chrome S20 Series processor, the same clocks, and memory configuration.

Different GPUs, clocks, and memory configurations can be supported ‒ however, the MultiChrome configuration (as with other multi-GPU configurations) will default to the lowest common denominator of the two different graphics cards. Therefore, for maximum acceleration, use of two identical graphics boards is recommended.

For each card in the system, an identical version of a S3 Graphics MultiChrome-capable software driver must be installed.

All high performance Chrome S20 Series graphics boards feature a full length x16 PCIe connector, so any dual-GFX motherboard used in a MultiChrome system must have at least two physical x16 PCIe slots capable of physically accommodating the MultiChrome-capable x16 PCIe cards. As do other multi-GPU solutions, each Chrome S20 Series graphics card requires its own physical x16 PCIe slot.

Some dual slot motherboards available currently require configuration of the PCIe slots on the motherboard before any multiple graphics adapter solution, including MultiChrome, will work. With some motherboards, especially older ones, an adjustment setting may also be needed for a System BIOS configuration option, or a jumper setting or a PCIe selector card. Motherboard documentation provided by the vendor will identify which adjustments need to be made, if any, for that particular motherboard. Newer motherboards usually do not require such adjustments.

Media Playback Considerations

MultiChrome has no negative impact on media playback. During media playback, the Chrome S20 Series driver will automatically use whichever GPU is currently dedicated to the display of the target desktop or window. S3 Graphics software is capable of supporting media playback on one GPU while running a high performance 3D application on the other GPU in a non-MultiChrome configuration. Each GPU drives its own display and its own section of the Windows desktop.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
Page 16 of 17

Conclusion

MultiChrome, S3 Graphics' multiple graphics processor technology, enables the use of multiple Chrome S20 Series graphics cards in dual-x16 PCIe slot systems. MultiChrome technology provides an efficient methodology to greatly accelerate many video games and applications while combining a reasonable price point with ease of use functionality that is not offered by anyone else.

MultiChrome is an Open Platform and Cable Free Technology – which works with all major chipset vendor multi-PCie slot motherboards on the market – all without the need for extra communication connectors, cables, or upgraded power supplies. MultiChrome provides its Open Platform and Cable Free Technology at a low cost with ease of use functionality.

S3 Graphics
MultiChrome
for the Chrome 20 Series

WP013-A.4
1/2007
*Page **17** of **17***