



ATI Catalyst®
Graphics Drivers and WDDM
Leading the way to Windows Vista™



Graphics Drivers: Leading the way to Windows Vista™ ... 3

Graphics Drivers before Windows Vista.....	5
Preparation for the Windows Vista Graphics Driver Model	6
GPU Recover	6
Enhanced Memory Management	7
Graphics Drivers in Windows Vista.....	7
Graphics Drivers in Windows Vista.....	8
Graphics Driver Enhancements for Windows Vista	10
Security Leadership	10
Parallel Engine Support	11
Conclusion	12
Summary table of ATI's Windows Vista driver benefits:	12

Graphics Drivers:

Leading the way to Windows Vista™

Within the next several months Microsoft will release the next version of its Windows Operating System, Windows Vista™. Microsoft's Windows Vista represents the most significant change to Windows since the release of Windows 95. Microsoft Vista features offers a substantial number of new and exiting features; a greatly simplified user experience, security enhancements, a revolutionary new desktop search engine to help user find files quickly, a new version of Internet Explorer, a new version of Windows Media Center, and most substantially a premium user experience called Windows Aero, that features a fully 3D accelerated windows desktop.* Windows Aero as seen in **Figure 1** will use 3D effects to deliver many exciting features, such as transparent window borders, real-time taskbar previews, 3D window management tool, called Windows Flip 3D, and dynamic lighting effects. These Windows Aero features will deliver a premium PC experience, helping users navigate and use windows more quickly as well as provide a more visually appealing and fun user experience. The importance of 3D graphics acceleration under Vista is not limited to the Windows Aero user experience. 3D graphics will also play a substantial role in the acceleration of HD video, driving new 3D user-interfaces (created using the Windows Presentation Foundation) and supporting the latest versions of DirectX. For more detail on the critical role the GPU will play in Vista please see ATI's white paper entitled "Windows Vista: a GPU Centric OS". With 3D graphics playing such a fundamental role in Windows Vista, a significant amount of collaborative work has taken place between Microsoft and graphics hardware companies such as ATI to develop a new graphics driver model for Windows Vista.



Figure 1: Windows Vista 3D accelerated Desktop

* Windows Vista is the first Windows operating system that has a user experience that can gracefully scale to the hardware capabilities of the computer on which it is installed. All computers that at least meet the minimal hardware requirements will see the Windows Vista Basic user interface and be able to have an entry level Vista user experience.

A critical piece of the many 3D accelerated features found in Vista is its new graphics driver model, **Windows Display Driver Model (WDDM)**. Vista's new graphics driver model offers a number of significant improvements over the previous driver model that existed under Windows XP (called the XP Driver Model or just **XPDM**). The improvements found in the **WDDM** include significantly improved stability, security, and most importantly helps to enable the many 3D accelerated feature found in Windows Vista.

At a high level, a graphics driver can be thought of as the interface between the physical graphics accelerator, the operating system, and the applications that use the graphics resources. Previous to Windows Vista graphics drivers had two major components, one for 3D graphics, and one for 2D graphics (to draw the Windows Desktop). Under Windows Vista there is no longer a need for a 2D graphics driver as the Windows desktop is now 3D accelerated.

As shown in **Figure 2**, applications do not interact directly with the Graphics driver. Applications communicate indirectly through an API or Application Programming Interface. There are two major APIs that applications use when they want to render 3D accelerated graphics – Direct3D and OpenGL. The Direct3D API is defined by Microsoft, and the OpenGL API is defined by a consortium of industry experts. Both Direct3D and OpenGL APIs provide a standardized set of controls that any graphics application can use in conjunction with a graphics accelerator that is capable of supporting all the features of the API.

The Direct3D API is part of a larger API from Microsoft called DirectX (the latest version available today is DirectX 9). One other DirectX API that is becoming very important in the graphics world is DXVA (or DirectX Video Acceleration). DXVA uses the power of the graphics processor to help play High Definition video content on the PC.

A third API, used for drawing the 2D windows desktop found in Windows XP is the GDI or Graphics Device Interface. Within Windows XP the GDI was accelerated by the GPU through the 2D display driver. The GDI is no longer accelerated by the GPU under Vista, as the Windows desktop is now drawn using the Direct3D API.

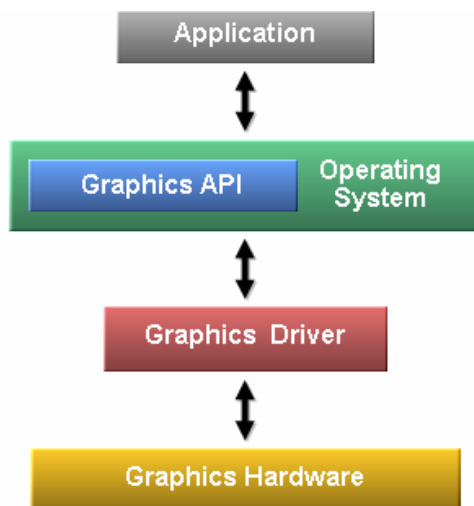


Figure 2: The path between an application and graphics hardware

Graphics Drivers before Windows Vista

Graphics drivers in the Microsoft PC world are composed of two major components, the Kernel space and the User space.

The kernel space interacts directly with the graphics hardware (accessing the graphics processor and graphics memory) and is effectively treated as part of the operating system. One of the pitfalls of the kernel space is that an error in a kernel drive can also cause an error in the operating system, and possibly lead to a PC system crash.

The user space exists at the application level and does not have direct access to graphics hardware or memory, and is isolated from the operating system. As a result the user space is far more stable and secure when compared to the kernel space.

The Windows XP driver model, as shown in **Figure 3** makes little use of the driver user space, and most of the graphics driver (Direct3D driver for 3D graphics, and Display driver for 2D graphics) resides in kernel space. Only the OpenGL component of the driver resides in user space. As a result errors encountered in a Windows XP graphics driver can lead to PC system hangs.

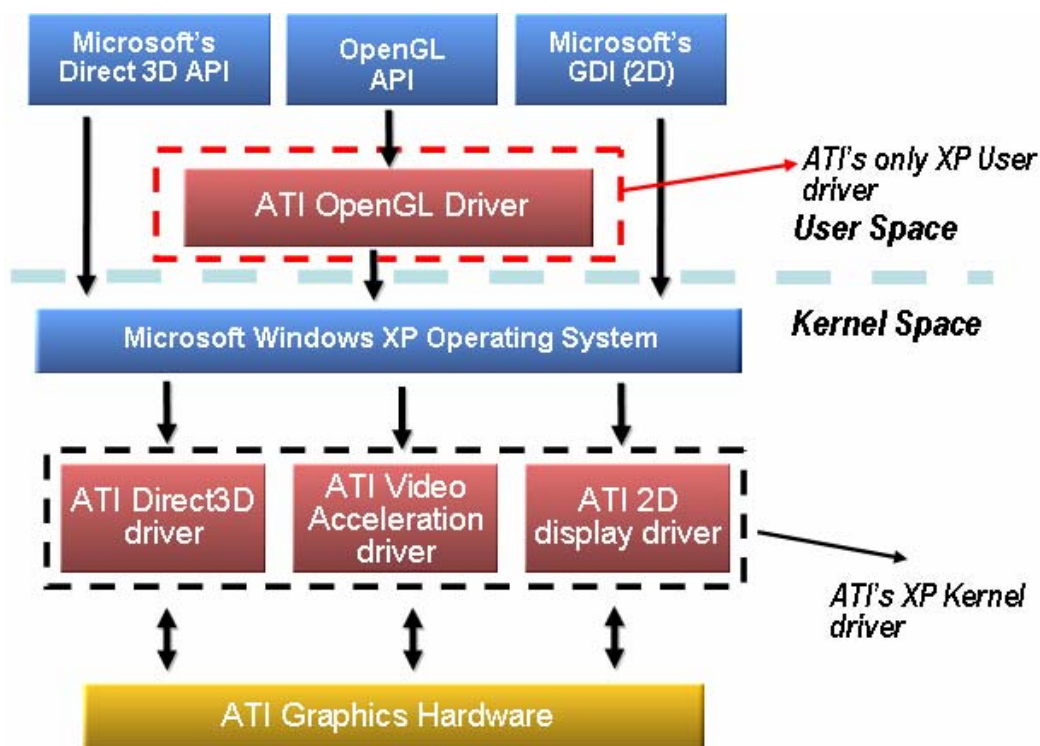


Figure 3: Driver model under Windows XP

Preparation for the Windows Vista Graphics Driver Model

In the lifespan of the Windows XP driver model ATI Technologies Inc. developed two key technologies, GPU recover and VCAM, both of which greatly enhance ATI's Windows XP driver. Microsoft has incorporated very similar technologies in the Vista operating system, ensuring maximized ATI graphics driver compatibility and performance.

GPU Recover

GPU recover was introduced by ATI Technologies Inc. October 2003, and represented the first step towards a more stable Windows environment. GPU recover detects when the graphics accelerator encounters an issue and recovers by resetting the graphics processor, so that users do not have to reboot their system.

The Windows Vista operating system has taken over the responsibility of detecting a graphics hardware error, but still relies on the ATI graphics driver to gracefully recover from a kernel space error as shown in **Figure 4**.

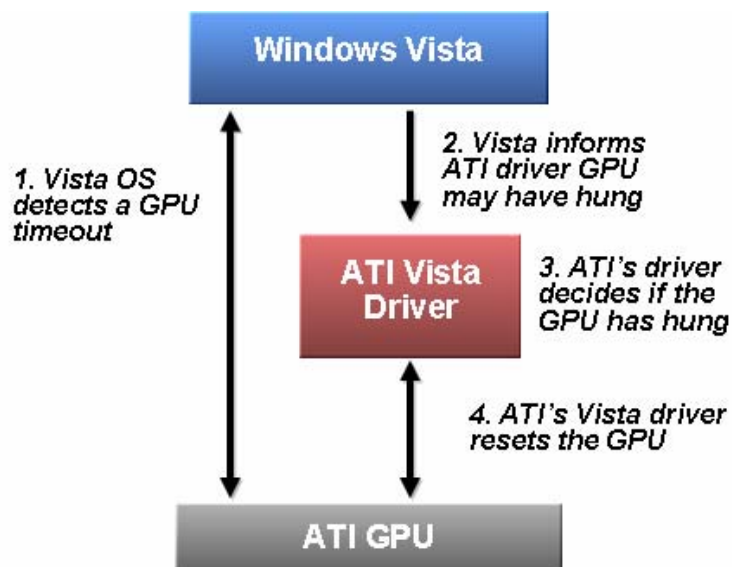


Figure 4: How GPU Recover and Windows Vista give users a crash-free, stable experience

Enhanced Memory Management

VCAM or Virtual Command and Memory Management is a memory manager developed by ATI for the Direct3D and OpenGL components of the ATI Windows XP driver to more efficiently address and use graphics accelerator memory as shown in **Figure 5**. One of the new changes within Microsoft's Vista is that graphics memory management has been moved from the graphics driver to the operating system. As a result the graphics driver must interact quite closely with Vista's memory manager. Microsoft's Vista memory manager operates very similarly to VCAM, enabling ATI's Vista graphics driver to seamlessly interact with it. As a result ATI's Vista graphics driver performs with maximum efficiency thanks to previous optimization done for ATI's VCAM driver component.

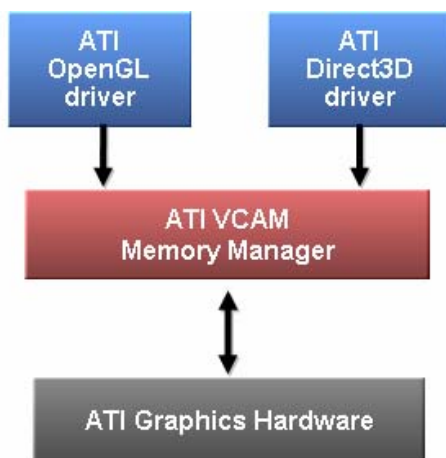


Figure 5: VCAM – helped ATI maximize memory management efficiency and performance for Vista's WDDM

Graphics Drivers in Windows Vista

The biggest change in the **WDDM** is that much of the graphics driver has been moved from kernel space to user space. The major goal of this change is to isolate the graphics driver and its activities as much as possible from the operating system (and other applications).

The **WDDM** has two major components, but with slightly different names - the User Mode Driver (**UMD**) and the Kernel Mode Driver (**KMD**). See **Figure 6** for a high level diagram of the ATI Windows Vista driver model.

The ATI Windows Vista graphics driver consists of multiple User Mode Drivers (**UMDs**); Direct3D and OpenGL for 3D graphics and DXVA for video functionality. Support for 2D in the graphics driver is no longer needed as the Windows Vista desktop is drawn using the Direct3D API. The **UMDs** are completely isolated from the kernel mode driver and the graphics hardware. The Windows Vista operating system loads a separate copy of the **UMD** for each application. In the unlikely event that an application or its **UMD** does something illegal and causes an error, only that single application will close, leaving the Windows Vista operating system unscathed, allowing the user to continue working.

The Kernel Mode Driver (**KMD**) is the interface between the graphics driver and the graphics hardware. The most important change in the **WDDM** is that the kernel mode driver framework is not as closely linked to the operating system as it is in the **XPDM**. This means that there is a far less chance of the operating system encountering an issue, in the unlikely event of a **KMD** error.

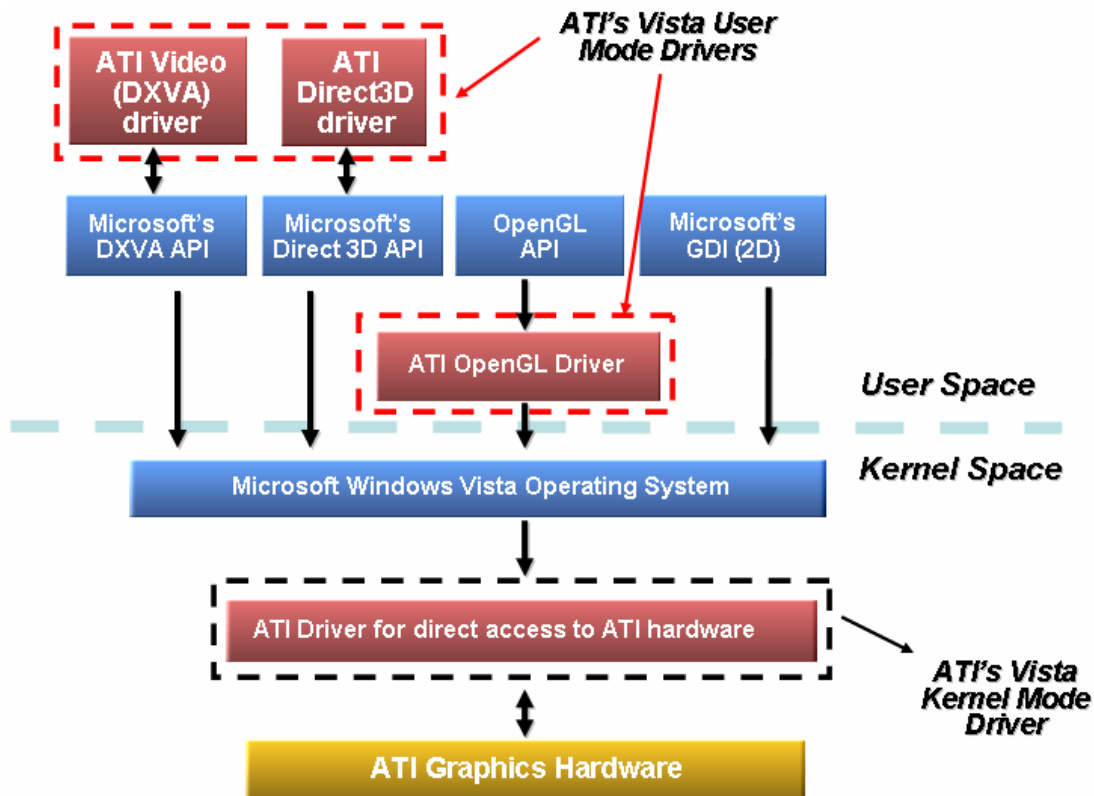


Figure 6: Windows Driver Display Model under Windows Vista

One of the most immediately noticeable benefits of the **WDDM** is its substantial role in enabling Windows Vista's premium 3D user experience, Windows Aero. Windows Aero requires a **WDDM** graphics driver be installed along with a DirectX 9 graphics accelerator. Windows Aero can be thought of as any other 3D application you may be familiar with, such as a 3D game. The Desktop Windows Manager or **DWM** as shown in **Figure 7** is responsible for actually drawing, or more correctly compositing the desktop, including the windows and applications. One of the benefits of having a 3D accelerated desktop is that each window (whether it be an application, Internet Explorer, or just Notepad) is treated simply as an independent surface, allowing the user to move windows around and on top of each other without having to repaint any of the underlying windows. Under Windows XP the entire desktop and all of its windows are treated as a single 2D surface. Moving around windows in this environment requires the repainting of any window or desktop area that may be underneath the moving window, resulting in windows that suffer from a stuttered effect and appear to drag streams of pixels with them.

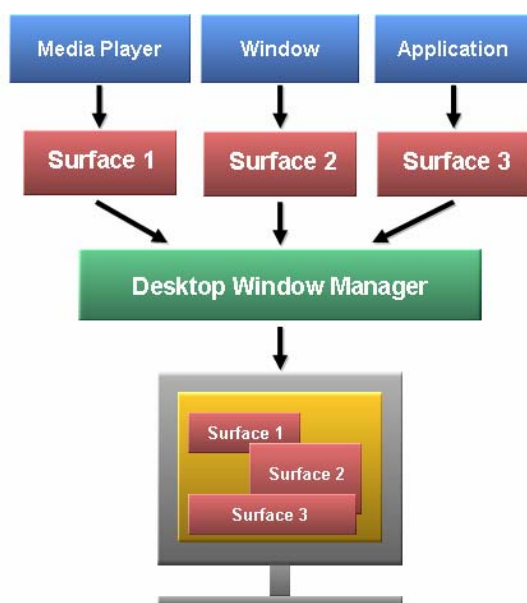


Figure 7: How Vista draws its 3D accelerated desktop

A significant benefit of the **WDDM** is that the operating system no longer needs to be restarted after the installation of a driver. This means that end users will no longer need to reboot their system after installing the latest graphics driver.

The **WDDM** also enhances the overall efficiency of the graphics accelerator. The **WDDM** prioritizes and manages the workload of the GPU, by scheduling the workflow of GPU in the most efficient manner possible. This enables the **WDDM** to manage graphics accelerator resources across single or even multiple applications, ensuring the highest performance possible for every 3D accelerated application.

As noted earlier, the **XPDM** mostly lies in the driver kernel space which has rather strict memory requirements. This memory limitation sometimes makes it impossible for applications to start as there simply isn't enough memory available to them. The user space does not suffer from these constraints, and as a result the **WDDM** (as most of the **WDDM** components lie in the user space) provides a much more robust driver environment for both operating system and applications.

Graphics Driver Enhancements for Windows Vista

ATI's close working relationship with Microsoft on the development of the **WDDM** not only helped ATI create a highly efficient and stable Vista graphics driver, it also enabled the development of new innovative features that significantly enhance the **WDDM** structure as well as the overall Vista experience

Security Leadership

Driver and PC system security will play a very important role in the playback of next generation HD content, including HD-DVD and Blu-ray discs. Unless the PC system (including graphics hardware and software) is highly secure and protected from 3rd party attacks, viewing next generation HD content will not be possible.

ATI's Windows Vista graphics driver ensures that any application using ATI graphics hardware will be fully protected from 3rd party application attacks. This will be enforced by blocking applications from directly accessing ATI graphics hardware. Applications allowed to interact with ATI graphics hardware will only be given protected access to graphics memory as seen in **Figure 8**. Security measures such as these will ensure that users of ATI graphics can view next generation HD content on their Vista PCs.

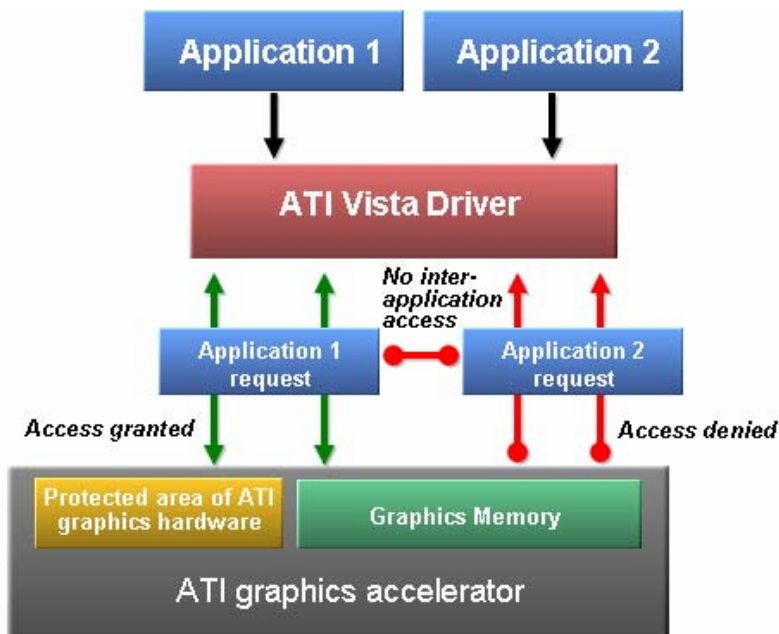


Figure 8: ATI's highly secure WDDM driver

Parallel Engine Support

Parallel engine support is a new feature found in Vista's **WDDM** that was developed by ATI Technologies Inc. The concept behind parallel engine support is actually quite simple, the **WDDM** views graphics hardware as a set of separate engines. To maximize graphics performance it is important that these engines work in parallel, as seen in **Figure 9**.

Parallel engine support can provide substantial performance improvements when playing HD Video on an ATI graphics accelerator. Previous to parallel engine support, graphics hardware had to wait for each frame of video to be displayed on the users monitor before it could start working on the next frame. Using parallel engine support the hardware can now continuously work on drawing new frames, and store the finished frames in memory, without worry whether the frame has been displayed yet. As a result the user will experience smooth video playback, as each fully completed frame will be shown on the display when it's required.

Multi-GPU solutions such as ATI's Crossfire™ will also see a significant benefit from parallel engine support. With an extra graphics accelerator there are twice as many engines that can be used in parallel, offering even greater efficiency and performance. The Windows Vista operating system will include native support for multiple graphics accelerators through a technology called Linked Adapter. Linked Adapter will treat multiple graphics accelerators as a single resource (GPU and memory), and working together with parallel engine support, schedule the most efficient workload possible across the graphics processors and graphics memory pool to maximize performance.

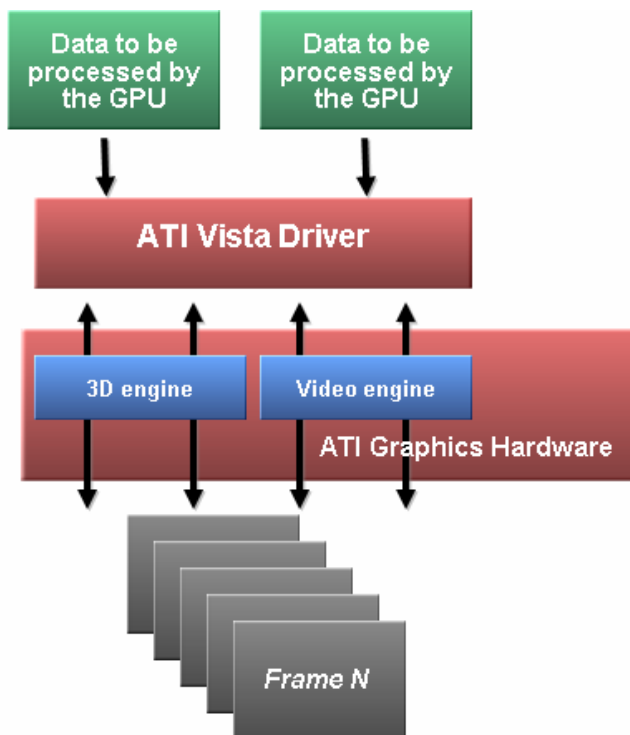


Figure 9: ATI's parallel engine support

Conclusion

ATI's new Windows Vista driver model will substantially increase the performance, stability and visual look-and-feel of the entire Windows Vista experience. ATI has not only spent substantial effort preparing for the **WDDM** through the development of features such as GPU recover and VCAM, but ATI has also played a key role in the development of new key **WDDM** features that enhance Windows Vista security and make better use of ATI graphics hardware.

ATI's Windows Vista's graphics driver is fully supported on all of its DirectX 9 graphics solutions across the Desktop, Integrated, Mobile and Workstation business units.

Summary table of ATI's Windows Vista driver benefits:

Feature	Benefit for users
1. New driver model – Windows Display Driver Model (WDDM)	3D accelerated Windows desktop
	Software installations no longer require a system reboot
	Highly stable Windows Vista environment
	Increased application performance (for single and multiple application cases)
2. GPU recover	Seamless recovery from rare driver errors due to illegal application behavior
3. Enhanced memory management	Driver optimizations based on ATI Technologies Inc. VCAM memory manager maximize Windows Vista performance and efficiency
4. Security leadership	ATI's highly secure software and hardware environment will ensure users can watch security protected next generation HD-DVDs and Blu-ray discs on their Windows Vista systems
5. Parallel Engine Support	An ATI sponsored feature that ensures graphics accelerator resources are used with maximum efficiency – significantly benefiting Video playback and multi-graphics accelerator systems

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