Logitech® Darkfield Laser Tracking: The World Is Your Mouse Pad
An Innovation Brief

The portable computer. For several years now, laptops have been the form factor of choice for consumers, and one of the predominant reasons for their ascendancy is the ease with which we can take and use them anywhere. And the computer mouse is often the most useful accessory in making this mobile world more comfortable and productive.

Many people enjoy the advantages of the mouse over the tricky touch pad. But, from hotels to coffee shops, conference rooms to the living room, you and your mouse are bound to encounter a broad range of surfaces. Although tracking technology has advanced significantly in the last two decades – from ball mice, to optical, to laser – some surfaces have remained a challenge. Without a mouse pad, today's mice couldn't track on extremely smooth or transparent surfaces – such as lacquered tabletops and glass.

Beginning in 2005, Logitech – the world's leading manufacturer of computer mice – embarked on a multiyear research and development project to create a mouse that could overcome these limitations. After considering many options – including Doppler radar, UV imaging and interferometry techniques – Logitech® Darkfield Laser Tracking was developed.

Darkfield Laser Tracking provides precise cursor control on virtually any surface – even glass[1]. Darkfield is derived from the principles of dark field microscopy, which is used in laboratories around the world to detect the most difficult-to-see particles.

Debuting in the Logitech® Anywhere Mouse MX™ and the Logitech® Performance Mouse MX™, Logitech Darkfield Laser Tracking is the only current tracking technology on the market that works on glass[2].

Breaking the glass barrier

Why is the ability to track on glass important? DarkField Laser Tracking is a significant technological breakthrough in the field of optical engineering for mice. And glass is common in more homes, businesses and hotels than one would think. In fact, a Logitech study[3] found that 40 percent of respondents have a glass table. And 47 percent of them use their notebook computer on it at least once a week.

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[1] 4 mm minimum thickness
[2] As of its introduction on August 19, 2009
[3] Survey fielded in November 2008 with 1239 mouse owners and mouse purchase intenders in the United States, France and Germany

But more importantly, the ability to track on glass sets a new standard for where you can confidently use your computer mouse. With glass now a viable surface to track on, you can certainly use the mouse anywhere else, including the glossy surface of your polished desk and the granite counter in your kitchen.

Getting to glass

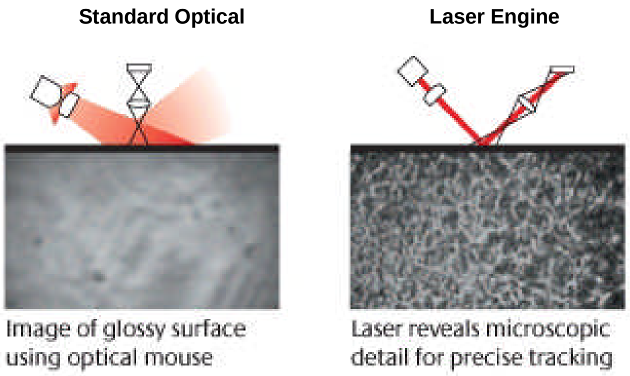
Since its inception in the 1960s, the computer mouse's primary function has been to assist in the manipulation of on-screen information, primarily through precise control of the cursor. The first commercial mice, available in the early 1980s, relayed the positional location of the cursor through the movement of a mechanical ball, which rolled on the surface beneath the mouse, and an electrical system that transmitted those movements to the computer. The ball mouse offered significant advantages in on-screen control and – though it wasn't the first graphical user interface (GUI) on the market – with the introduction of the iconic Apple® GUI in the 1980s, the ball mouse (and the accompanying mouse pad) became an indispensable computer peripheral.

While the ball mouse provided an efficient way to control and access the computer, it had its disadvantages, as well. The ball would often collect dust; in fact, one often had to remove the ball from the mouse chassis and clean it with a damp cloth. A few pieces of dust could cause the tracking to become unreliable.

Advances in computer mouse technology proceeded over the next two decades as companies such as Logitech and Microsoft developed mice that paired optical systems and sensors for more precision – resulting in optical and laser tracking technologies.

Standard optical and laser mice consist of a light source that illuminates the surface beneath the mouse, a lens that captures the scattered light and a tiny image sensor. The sensor, working with an onboard processor, processes the generated image, looking for minute differences that it can use to determine the direction and speed of motion.

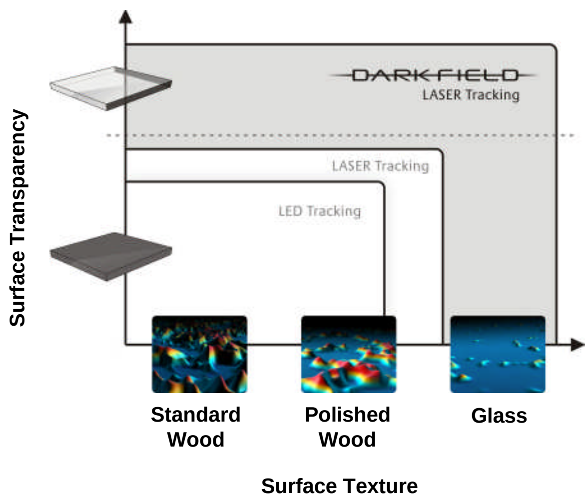
Diagram 2: Illustration of how optical and laser tracking work



The more irregularities a surface exhibits, the easier it is for the sensor to identify reference points that it can use to accurately measure motion. Because laser light illuminates surfaces in far greater detail than LED light, traditional laser mice are superior to standard optical mice at tracking on smooth, glossy surfaces such as ceramic tile, metal and polished wood. See Diagram 2 for an illustration of this difference.

However, extremely smooth, glossy surfaces with minimal irregularities – such as clear glass – are a challenge for even regular laser mice. One of the primary reasons glass is such a challenge for mice is because it is a very unusual material. Technically, glass is a transparent, inorganic solid material. But it has an atomic structure that is more disordered than typical solids, which makes it easier for light to pass through and makes for an almost completely smooth surface. Because most glass is practically flat and has almost no imperfections, it's difficult for a mouse sensor to find enough details to use as reference points for tracking. However, no piece of glass is perfectly flat in a real environment; microscopic scratches can be found in the glass itself and, as anyone who's ever owned a glass table knows, dust and other particles often rest on the surface. And for the purposes of tracking with a mouse, Logitech needed to find a way to track these small objects, rather than the surface itself.

Diagram 3: Tracking capabilities based on surface transparency and texture



An illuminating look at Darkfield

Optics is the study of how light behaves. For many scientists, the microscope is the most practical application of an understanding of optics. Essentially, a microscope magnifies small objects so that they are visible to the human eye.

Optical microscopes use a lens, or a stack of lenses, to magnify the details that sit, usually on a small glass slide, above a mirror or light source. The light shines up from the surface into the lens, and scientists can then view the small objects through the eyepiece. Traditional microscopes – that use standard, or bright field, illumination – direct the light into the objective lens. But sometimes the tiny objects underneath the microscope lack contrast under normal illumination. For example, biologists often see this challenge when viewing small organisms in a liquid habitat; the contrast between the fluid and the organisms is not great enough for the microscope to detect.

To help scientists see objects that are very tiny and not sufficiently contrasted in the surface environment, dark field illumination was invented. Instead of collecting and focusing the light from points directly beneath the surface of the lens, dark field illumination blocks out the central area of light and only allows rays of light to enter the lens from an angle. If there are no objects beneath the microscope, the entire field will appear dark. But when the light hits a particle, it scatters the light into the lens at an angle. The resulting image has a dark background with bright objects on it, similar to a starry sky, and this is where the technique gets its name.

To achieve dark field illumination, Logitech mice with Darkfield Laser Tracking use two lasers to more effectively collect microscopic details of the tracking surface. When the mouse is used on a regular surface – such as a formica table or a piece of paper – the texture of the surface provides plenty of detail for the lasers to track and requires only one of the lasers to be used. But for high-gloss surfaces that don't have enough details, such as a glass tabletop, the mouse sensor views the surface itself as black and, instead, tracks the dust and other residuals that appear on the surface. In this case, two lasers are used. Diagram 4 (below) shows a visual representation of how dark field illumination works on both an opaque and a transparent surface.

Diagram 4: How dark field illumination works on an opaque and transparent surface (only one laser is represented)

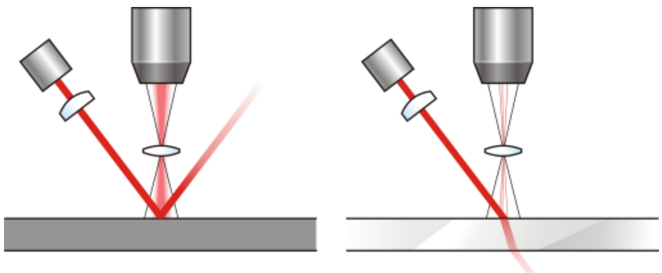
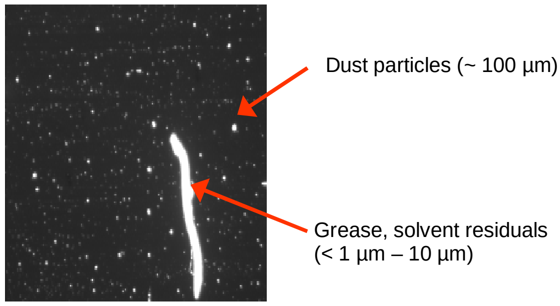


Diagram 5: Typical dark field image of a glass sample with residuals



Just as a scientist would use a dark field microscope in a lab, a Logitech mouse with Darkfield Laser Tracking illuminates the surface beneath the mouse at an angle, and collects and focuses that light back into the lens. Any small particles, such as dust or micro-scratches, are cast against a black background. Similar to the way that our eye sees the clear night sky, the mouse's sensor sees the clean areas of glass as a dark background with bright dots – the dust. Then, the sensor interprets the movement of these dots to track exactly where you've moved the mouse. Diagram 5, above, provides a visual of this concept.

Because of its ability to detect the tiniest of particles, Darkfield Laser Tracking allows your mouse to track virtually anywhere. But because it requires some micro-details to work, it won't work on a surface that's perfectly clean and smooth. However, outside of scientific laboratories, such a surface is extremely rare.