

# FEATURING

## Grating Light Valve Display Device MEMS—A New Electronic Device that Combines Both Electronic and No-electronic Devices

- **MEMS\*<sup>1</sup> is a precision device technology that combines mechanical motion and electrical circuits in precision electro-mechanical systems.**
- **The GLV\*<sup>2</sup> light modulator device uses a grating.**
- **Diffraction phenomenon\*<sup>3</sup>**

\*1 MEMS: Micro Electro-Mechanical Systems

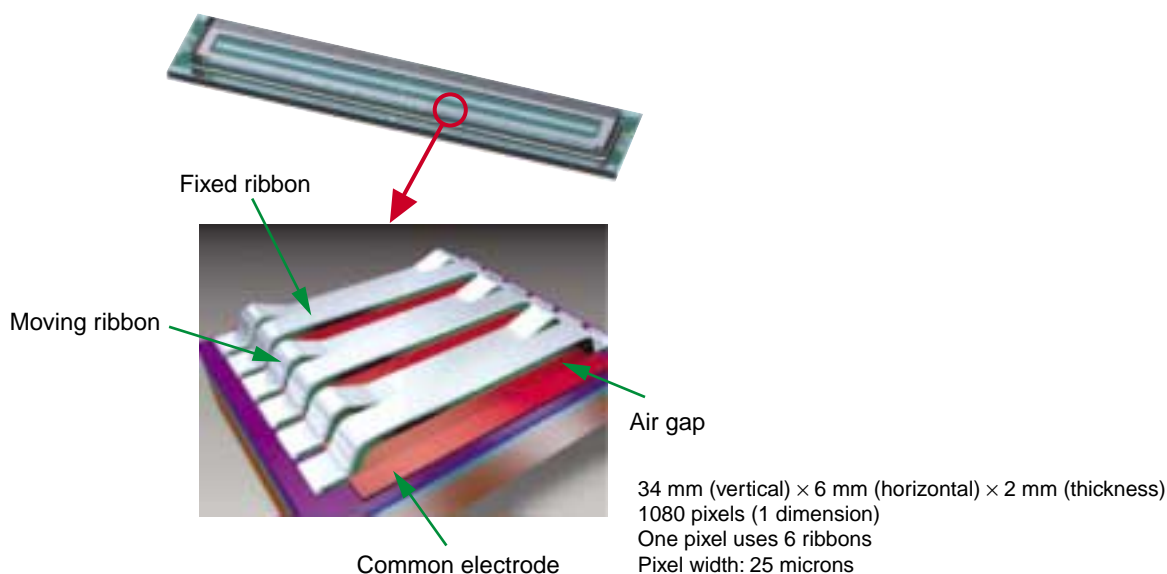
\*2 GLV: Grating Light Valve

\*3 Diffraction phenomenon: Diffraction of light is a phenomenon that the direction in which light is traveling is bent when light passes through an object that has regularly spaced bumps and depressions. The reason that CDs reflect multiple colors is that the precisely manufactured track structure.

On June 11, 2002, Sony announced the technological development of a new grating light valve (GLV) display device. A GLV display device is a one-dimensional reflective display device in which a ribbon-shaped optical grating is formed in a row on a silicon substrate. A GLV display device creates a full HDTV image by shining RGB laser lights (R, G, and B are the primary colors) on the GLV micro-ribbon array, modifying the amount of diffraction, and then using a scanning mirror to scan the one-dimensional image over the required two dimensions. Sony is aiming to apply this device in practical use as the projector imaging element for large-screen displays. One of the main features of this device is its ability to adjust the amount of diffracted lights used by grating step control implemented by MEMS technology. Sony has begun developing MEMS devices, which feature the previously unknown added value of combining mechanical functionality with semiconductor devices. In this article, we introduce the GLV device, which is a MEMS device, and the GLV projector, which uses that device.

### What Is MEMS?

MEMS stands for micro electro-mechanical systems, and refers to precision devices that combine mechanical functionality with electrical circuits. This technology is targeted at devices that range in size from millimeters down to microns, and involve precision mechanical components that can be manufactured using semiconductor manufacturing technologies. A diverse range of application areas has been proposed, and applications developed for these devices include a wide range of sensor, fluid mechanics, optics, RF, storage, and biotechnology applications. Sony sees these as precision devices that fuse mechanical functionality with electrical circuits and is proceeding with the development of device and process technologies as a technology that provides new added value in semiconductor devices without being constrained by Moore's Law.

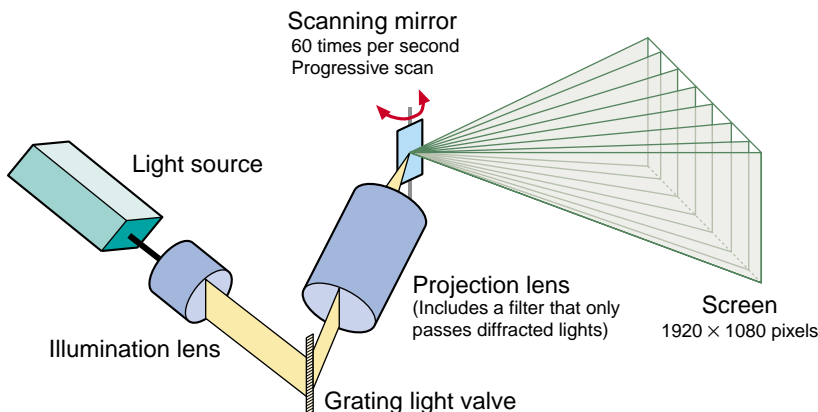


■ Figure 1 GLV Photograph and Pixel Structure Overview

In MEMS devices, a three-dimensional spatial structure is formed on the substrate and mechanical blocks are formed within that structure. A system is then created by fabricating electrical circuits that drive those mechanical blocks on the same substrate. While MEMS devices are created with design and process technologies based on semiconductor technologies, Sony is working on new and improved design technologies for three-dimensional device structures and their operation, process technologies unique to MEMS devices, and device evaluation technologies.

### The GLV Device

In July 2000, Sony concluded a technology licensing contract concerning the "grating light valve" technology with Silicon Light Machines (Head office: CA, USA) and acquired the rights to exclusively develop, manufacture, and market general-purpose display products using that technology. Since then, Sony has been working towards the practical application of this device in display systems, and has been exclusively proceeding with the development of GLV devices themselves and the development of light sources and peripheral technologies. The GLV device will form the core of projector products, and is an optical engine component that modulates reflected lights. (See figure 1.)



The projector forms a 2-dimensional image by scanning a 1-dimensional image.

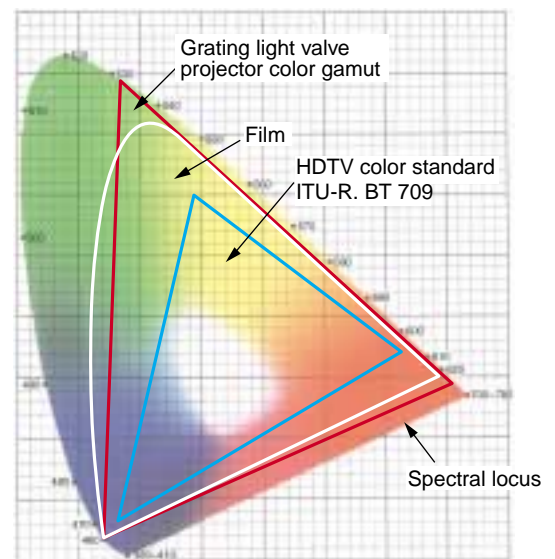
■ Figure 2 The Grating Light Valve Projector

### Grating Light Valve Laser Projector

The grating light valve laser projector differs from other techniques that use a two-dimensional device structure in that it is a projector display that uses a single row of precision ribbons to project a large-screen image. (See figure 2.) Red, green, and blue laser lights are projected in a slit form on individual GLV devices that correspond to each of those colors, and a one-dimensional array of 1080 pixels is scanned in the horizontal direction by a moving mirror to form a two-dimensional image. Currently, Sony has succeeded in creating a full HDTV progressive scan 1920 (horizontal) × 1080 (vertical) pixel image by scanning with an equivalent to 1920 pixels in the horizontal direction. By using RGB laser lights with high color purity as the light source, this projector

achieves a color gamut twice as wide as that provided by CRT displays (comparing areas in CIE 1931 chromaticity diagrams). (See figure 3.)

The GLV device is designed so that its ribbon elements can operate with mechanical vibration frequencies up to 1 MHz. Logically, this performance is not only adequate for full HDTV operating at a 60 Hz refresh rate in progressive scan mode, but also allows expansion to handle up to an equivalent of 4000 pixels in the horizontal direction or even higher progressive scan refresh rates up to, for example 90 Hz. Thus this performance indicates that the device can support projector systems with even more advanced specifications. (See figure 4.) This projector is a high resolution, high contrast, wide viewing angle system that is aimed at the professional and high-end home system markets.



CIE 1931 chromaticity diagram (xy chromaticity diagram)

The xy chromaticity diagram expresses, on a 2-dimensional surface, the chromaticity coordinates determined by the tristimulus values XYZ in the XYZ color space based on the CIE color matching functions  $x(\lambda)$ ,  $y(\lambda)$ , and  $z(\lambda)$  adopted in 1931 by the Commission Internationale de l'Eclairage (CIE). This allows colors to be expressed quantitatively in terms of values on the x and y axes.

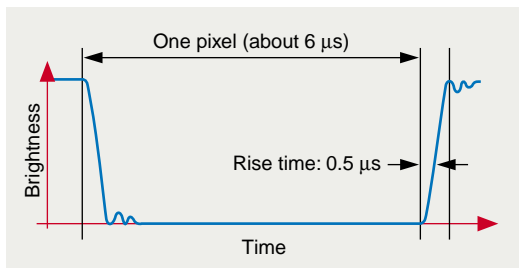
■ Figure 3 Projector Color Gamut

## GLV Device Operating Principles

In the GLV device Sony has just developed, a single pixel is formed from six beams, called ribbons, held in a cavity structure. Optical diffraction devices for 1080 pixels, the same number as the number of vertical pixels in an HDTV image, (for a total of 6480 ribbons) are formed on the GLV device. In addition to their role as reflective mirrors, these ribbons, which are formed from Al/SiN layered film, also function as the drive electrode. The ribbons are driven by applying a voltage between the ribbon electrode and the bottom electrode. When

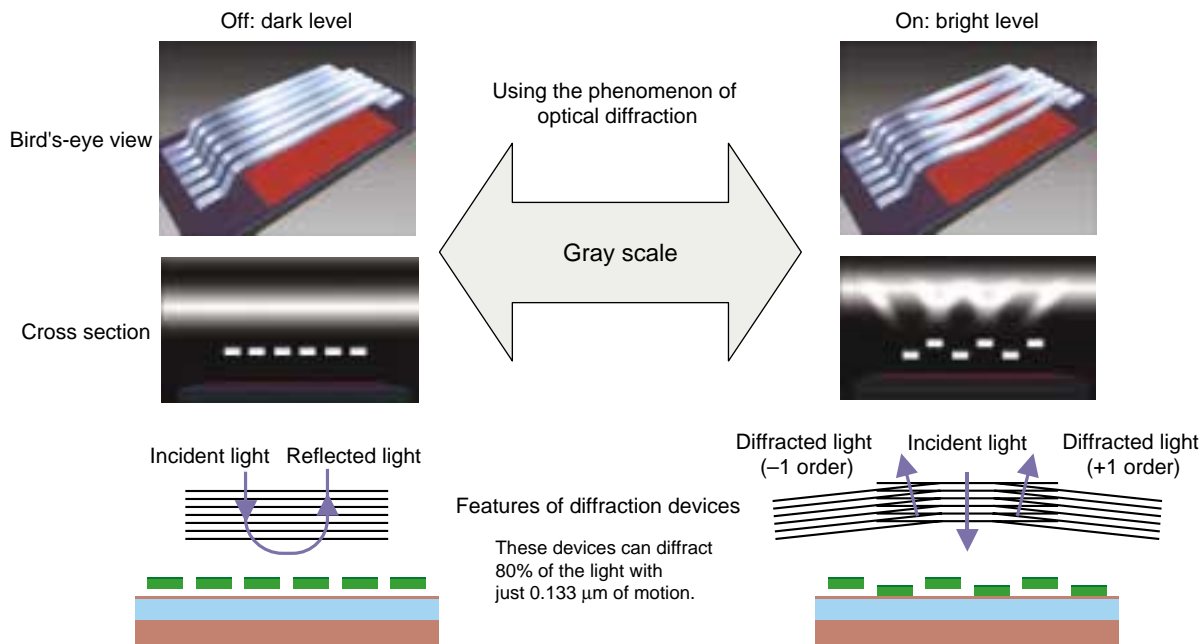
no voltage is applied, all of the ribbons will be aligned in a plane and thus form a mirror surface. Thus they will reflect the three color RGB laser lights. When the pixel is operated, a voltage is applied to every other ribbon creating steps between adjacent ribbons and thus forming a grating. This grating creates diffracted lights which have an angle relative to the incident laser light. (See figure 5.) The reflected lights from the GLV device are blocked, and only the diffracted lights are collected. When a condensing filter is placed in front of the element, it becomes possible to extract the diffracted lights from the device as the bright or dark sections in an image. (See figure 6.) Furthermore, it is possible to

modulate the intensity of the diffracted lights according to the depth of the grating. The state where no voltage is applied and all the ribbons are at the same height corresponds to black, and the point where the height of alternate ribbons is  $\lambda/4$  is the point where the modulated light has the maximum intensity. The depth of the steps between the ribbons is controlled in an analog manner by the applied voltage. A moving image is displayed on the screen by horizontally scanning the one-dimensional image created by applying a voltage modulated by the video signal to the electrodes. The operating principles of the GLV device allow it to achieve smooth multi-level images with contrast ratios in excess of 3000:1 on average. Thus this device can reproduce images with a feeling of depth and superb image quality down to the finest parts of the image.



The GLV technology has an operational performance of 1 MHz, and surpasses the display speed required for HDTV.

■ Figure 4 Response Characteristics



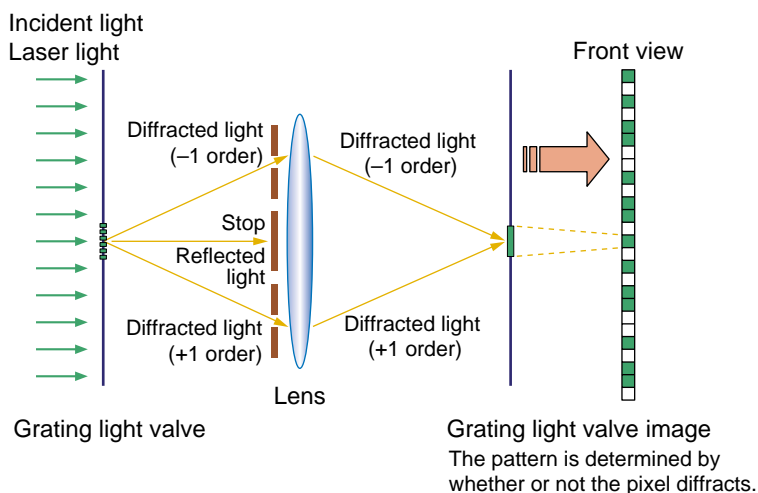
■ Figure 5 Operating Principles (Bright screen and dark screen operating principles)

## GLV Device/Module

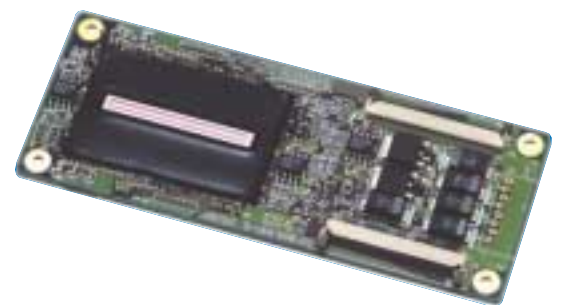
In the development of the optical device component fabrication process, the problem of flattening the surface of the ribbons at the nanometer level became a key point. Sony is currently proceeding with the development of a unified module that combines a GLV device with the required driver ICs. Photograph 1 shows a prototype GLV module. The driver ICs that drive the GLV device are mounted in the area around the device and sealed in resin, and the module has a size of 100(W) × 40(D) × 5(H) mm. The size of the module decides the size of the whole optical engine, and the module is one factor that influences performance. Also, Sony is currently working on improving the performance of the device/module even further, and improving the resolution and functionality of the device/module as a display system with the creation of a practical system in the near future in mind.

## Future Developments

MEMS is a technology that provides new functionality that previously could not be provided by semiconductor devices, in particular, the functionality of having moving parts on an IC chip or substrate. There are now strong hopes for the application of this functionality as a new platform technology to I/O components and all types of sensors. As the S in MEMS, which stands for “systems”, indicates, this technology is expected to contribute to the creation of new system solutions. You can count on Sony to continue to create exciting developments in MEMS technology.



■ Figure 6 Design of an Optical System to Collect Diffracted Lights



100 × 40 × 5 (W × D × H) mm  
 Display resolution: Equivalent to 1920 × 1080 pixels (full HDTV equivalent)  
 Scanning method: 60 frames, progressive scan  
 Contrast: Over 3000:1

■ Photograph 1 GLV Module