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PRESS RELEASE
For immediate publication

11/20/14

Mirrorcle announces availability of MEMS-based Laser Q-switch modules

Mirrorcle Technologies' gimbal-less MEMS mirrors are now available with high reflectivity (HR) dielectric coatings for use in compact, short-pulse, Q-switched lasers, the California-based manufacturer of patented beam-steering micromirrors announced today. The company developed a low-cost MEMS-based laser intracavity Q-switch solution that replaces complex and costly components previously needed for active Q-switching, e.g. acousto-optic, electro-optic or passive Q-switches. These more traditional methods' inherent disadvantages include their relative bulkiness, the need for bulky electronic drivers, their high power consumption, and significant optical losses. Passive Q-switching, while simpler, is relatively inefficient and does not allow for adjustment of pulse energy. At the heart of the newly-developed highly efficient Q-switch module lies a micro-electro-mechanical system ("MEMS") mirror that acts as a high-reflectance (HR) end mirror in a laser resonant cavity which can be "modulated" on demand. The MEMS module features single-axis mirror tilt capability, and can be controlled to align with the laser cavity or to tilt away from alignment. The mirror can therefore be commanded to slew very quickly from misaligned position through aligned position, and back to a misaligned position. When the mirror passes through the aligned position, laser cavity resonance is momentarily achieved, and a very high peak-power laser Q-switched pulse is generated. Note that since the mirror rotates along one axis, the MEMS Q-switch requires precise alignment in only a single axis, namely the cross-axis to the slew direction of the mirror. This MEMS-based solution is more cost-efficient because devices can easily be batch-fabricated utilizing established semiconductor manufacturing processes, yielding hundreds of devices on a single silicon wafer.

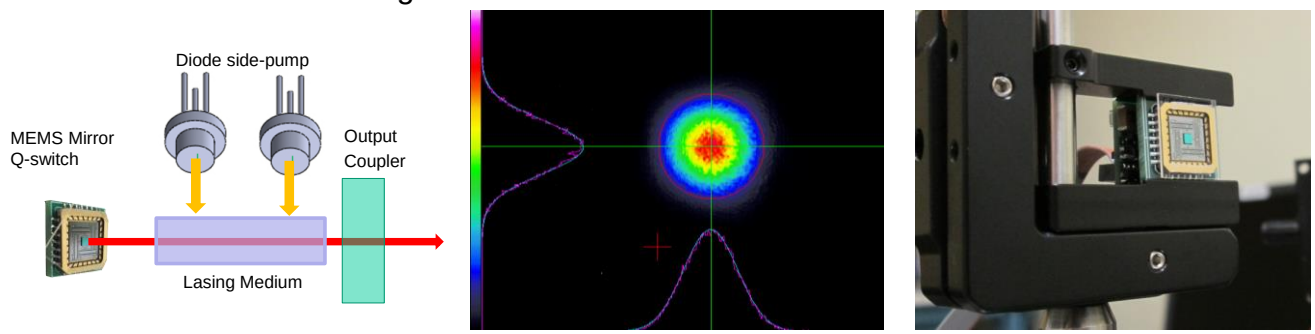

Figure 1. (left) Diagram of a Q-switched laser using a MEMS mirror Q-switch in a side-pump configuration. MEMS mirror acts as the high reflector and the on-demand Q-switch. (middle) Resulting beam-profile of a prototype laser at customer site (NVESD, US Army) shows a high quality pulse emission. (right) A complete Q-switch module optical bench top tests.

Government-supported development for highly mobile low-cost laser rangefinders

Mirrorcle Technologies MEMS mirrors, known for their capability for arbitrary tip-tilt (two-axes) positioning, were sought by multiple industrial customers for possible use in Q-switched laser cavities. However, initial tests at customer sites revealed that metal-coated MEMS mirrors

could not withstand the high intra-cavity optical power levels. With the subsequent financial support of the US Army’s Night Vision and Electronic Sensors Directorate (NVESD), Mirrorcle has developed a dielectric coating solution that would solve this challenging problem. NVESD’s researchers have been working on realizing a highly mobile, light-weight, reliable, low power-consuming laser Q-switch solution for use in e.g. US-Army rifle-mounted laser range finders (LRF). ”Size, weight, power, and cost (SWaP C) are the primary considerations in development of the MEMS-based laser Q-switch,” said John Nettleton, Project Leader - Lasers at US ARMY NVESD. “Mirrorcle Technologies was successful in ensuring that all requirements could be met; e.g. size, weight, and volume. In collaboration with NVESD, Mirrorcle also overcame technical issues such as mirror coating damage, mirror coating reflectivity, mirror rotation speed, and mirror flatness to ensure that the MEMS device would operate successfully in a Q-switched laser cavity.”

On-demand, high-speed, high-efficiency laser pulse generation

The MEMS-based approach is a significant improvement compared to other active mechanical Q-switch technology, e.g. spinning mirrors whose frequency is generally invariably set to approximate the allowable pump time of the respective lasing material. Fundamentally, MTI’s MEMS-based approach is also a mechanical Q-switch, with the advantage of offering full control of the switching sequence with on-demand pulse emission, by the push of a button. Once the operator decides to emit a laser pulse (in hand-held laser range finding) by depressing a button, the Q-switch module is enabled which moves the MEMS mirror into a position misaligned to the lasing cavity, thereby allowing optical pumping of the Er-Yb doped glass gain medium to build up as much energy as possible for a subsequent laser pulse. Then, after a programmable amount of time (e.g. ~25 ms), the mirror quickly moves to a new angle, and during that movement briefly aligns with the cavity optical axis to establish a high quality factor (or “high-Q”) resonant condition which allows the medium to release its energy coherently. The result is a single, very high peak power laser pulse with a duration on the order of tens of nanoseconds and energy in the range of several milli-Joules (e.g. a US Army NVESD laser prototype typically achieves 3.4mJ, 17ns pulses, with 2.5mrad divergence, see Figure 1). The Q-switch module is subsequently disabled back into standby mode for ultra-low power consumption.

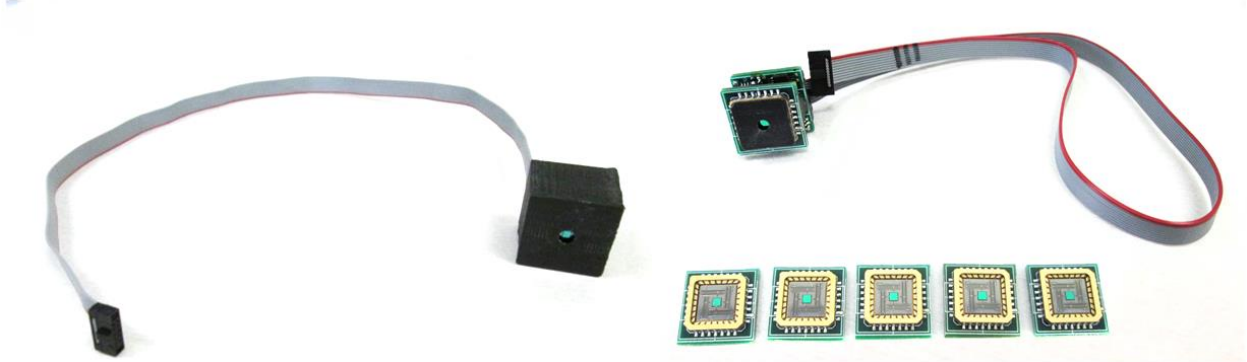

Figure 2. Mirrorcle Technologies MEMS mirror based Q-switch modules with HR coatings for 1535nm lasers. Prototypes presently ship in a protective housing shown on the left, with the overall dimensions of 17mm x 17mm x 15mm, or without the housing as shown on the right with outside dimensions of 15mm x 15mm x 14mm.

MEMS device with high reflectivity optical mirror allows for efficient on-demand Q-switching

In order to meet the specific requirements for Q-switching, the Mirrorcle team had to modify and advance certain features of its established dual-axis MEMS mirror technology. The main obstacles lay in realizing very high slew rates with mirrors that have excellent optical quality and high reflectance at a certain wavelength, while at the same time meeting challenging laser damage threshold requirements. An outside vendor was selected for the specialized coatings of thin, flat reflectors. These coatings are dielectric, high-reflectance (HR) type, optimized for >99.5% reflectance at the 1535nm wavelength, which is the center wavelength of the Er-Yb doped glass lasing medium. Prior to this, standard MEMS devices by Mirrorcle had exclusively been available with high-purity aluminum (Al) or gold (Au) coatings, both of which are very suitable for creating very low mass mirrors that offer extremely good flatness and little surface roughness. However, the damage thresholds of both gold and aluminum are too low for many Q-switching applications, necessitating multi-layer dielectric coatings. Because these dielectric coatings are significantly thicker than metal films and because they can deform thin substrates due to material stresses, thicker substrates had to be utilized to ensure final mirror flatness greater than 5m radius of curvature (RoC). This was the most challenging aspect of the implementation because it directly affects speed capability and robustness in high shock environments. Final HR-coated mirror substrates with the greenish hue seen in Figure 1 are now assembled on top of highly robust and fast single-axis MEMS actuators, to form the complete device. These actuators have a 7.26x7.26mm footprint and are assembled in ~12mm x 12mm ceramic Leadless Chip Carrier (LCC) packages. (what does LCCs stand for?) “The Mirrorcle MEMS rotating-mirror Q-switch is a cost-competitive solution for the implementation of compact lasers for high performance range-finders, and other applications requiring short laser pulses,” Nettleton added.

Compact control electronics and driving algorithms for on-demand Q-switch operation

One key challenge in terms of driving mechanical Q-switches is timing, to allow a laser pulse to emit at maximum peak power, taking full advantage of the respective lasing gain medium’s potential. Mirrorcle’s MEMS-based Q-switch with on-demand switching capability and a suitable high timing precision driver are very versatile in their ability to adapt to allowable pump lengths for differing gain media and other cavity considerations. Mirrorcle designed and realized very compact, low power-consuming control electronics to enable on-demand laser pulse emissions. Slew speeds of mirrors’ angular motion for various designs tested during development reached from 260 rad/sec to 460 rad/sec. The Q-switch module driver is designed to consume practically zero power in the stand-by (off) state, and it consumes very little power during the actual Q-switching event upon users’ pulse request. The peak power consumption of about 50mW lasts for ~50ms, therefore consuming approximately 2.5 mJ for the complete operation. Consequently, nearly 2 million cycles of Mirrorcle’s Q-switch module could run on a single AAA battery.

MEMS-based Q-switches to benefit multiple industries and applications

Mirrorcle’s compact, low power-consuming Q-switch modules open many opportunities for a broad range of applications for defense, industrial, consumer sports, and many other industries. This translates to a compact, robust package and an extension of battery life for any mobile application such as e.g. rifle-mounted or handheld LRF. The use of this high-reflectance Q-switch in the laser also improves the overall optical efficiency and, therefore,

battery efficiency. Other military applications that can benefit from this new offering include scanned LIDAR, target designators, communications, environmental sensing and collision avoidance, all of which also have application equivalents in the civilian space. Examples include range finders for e.g. hunting or golfing, surveying, construction, geology, traffic control, boating, etc. One of the benefits for using Er-Yb doped glass as lasing medium is its center wavelength of 1535nm. Lasers with emission wavelengths longer than ~ 1.4um are often classified as ‘eye-safe’, because light in that range is mostly absorbed in the cornea and cannot reach the more sensitive retina. Further improvements to the currently available MEMS-based Q-switch modules are under development.

[1] Milanovic, V., Kasturi, A., Atwood, B., Su, Y, Limkrailassiri, K., Nettleton, J.E., Goldberg, L., Leach, J, Hough, N., “Compact MEMS mirror based Q-switch module for pulse-on-demand laser range finders,” (to be presented at) SPIE Photonics West, Paper 9375-15 (2015).

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About Mirrorcle Technologies, Inc.

Mirrorcle Technologies, Inc. (MTI), founded in 2005, is a California corporation that commercially provides products and services based on its proprietary optical microelectromechanical system (MEMS) technology. Since its founding, and supported by its continuous investment in R&D, MTI has been offering the world's fastest point-to-point (quasi-static) two-axis beam-steering mirrors, as well as resonating-type micromirror devices with rates up to HD video display. MTI is globally the only provider of tip-tilt MEMS actuators in combination with mirrors from submillimeter to several mm in diameter, offering customers a wide selection of specifications to optimize their paths to successful commercialization. In addition to a variety of existing designs and in-stock products, MTI also contracts to create specialty designs and fabricate custom units as well as full system solutions.

MTI maintains a laboratory at its headquarters and has year-round, 24-7 access to wafer-based CMOS and MEMS fabrication facilities. MEMS mirror fabrication, wafer-level and die-level testing, packaging and outgoing inspections are all performed in a clean-room environment. MTI established a manufacturing service cooperation with a leading MEMS wafer foundry in 2010, allowing streamlined volume production while maintaining highest quality standards.

As a privately held company, MTI is able to act efficiently, offering creative and highly responsive service to its customers. The motivated staff is dedicated to providing highest-quality products and support to facilitate customers’ product development and successful commercialization. It draws on several decades of staff’s combined experience in MEMS design, fabrication, and testing.

