Flexible Optical B.V.

Adaptive Optics • Optical Microsystems • Wavefront Sensors

Linear 39-channel micromachined membrane deformable mirror system:
technical passport

OKO Technologies,

OKO Technologies is the trade name of Flexible Optical BV

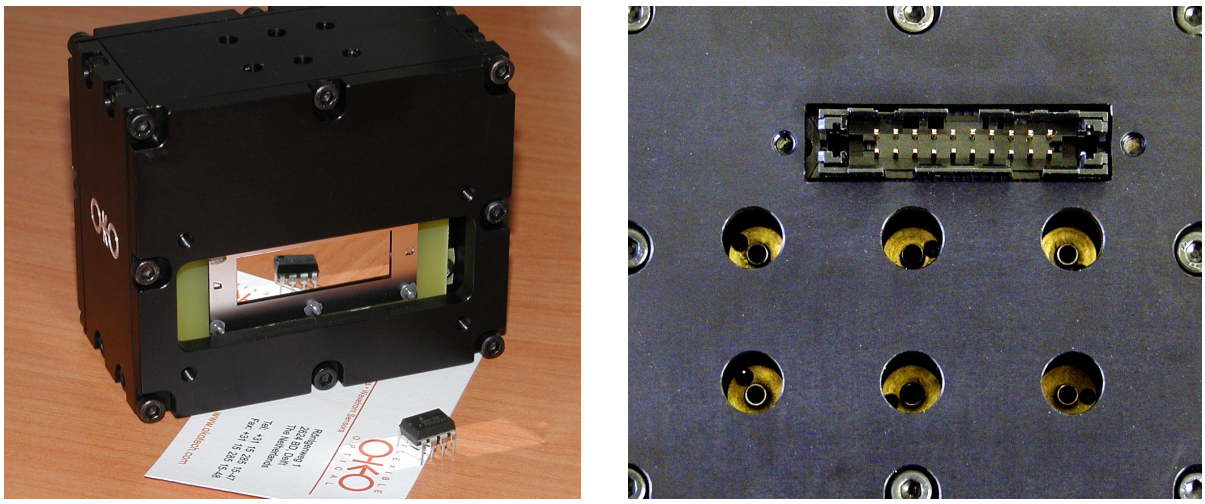
DM model: MDM39LIN
DM s/n: 23.03

1 Membrane mirrors

Silicon micromachined mirrors are fabricated by OKO Technologies using the technology of silicon bulk micromachining.

In the temporal domain, the device can be used to control the duration and the temporal shape of ultrafast pulses in femtosecond lasers and amplifiers. In the spatial domain, the device can be used as a normal deformable mirror to control the phase of extended in one dimension laser beams.

The mirror, shown in Fig. 1, consists of a silicon chip mounted over a PCB holder. The chip contains thin micromachined membrane, which is coated to form the mirror. The chip is mounted over 6 micrometric (see Fig. 1(b)) screws to adjust the mirror figure and the mirror-to-actuator distance.



(a) (b)

Figure 1: (a) Typical view of a linear 19-channel micromachined deformable mirror and (b) adjustment micrometric screws on the back side of the mirror. Please note that these mirrors can be fabricated with different package designs, so the mirror you have may look differently.

The printed circuit board substrate contains the control electrode structure and connectors. It also serves as the mirror package.

The scheme of the assembled mirror and the principle of biased control are illustrated in Fig. 2

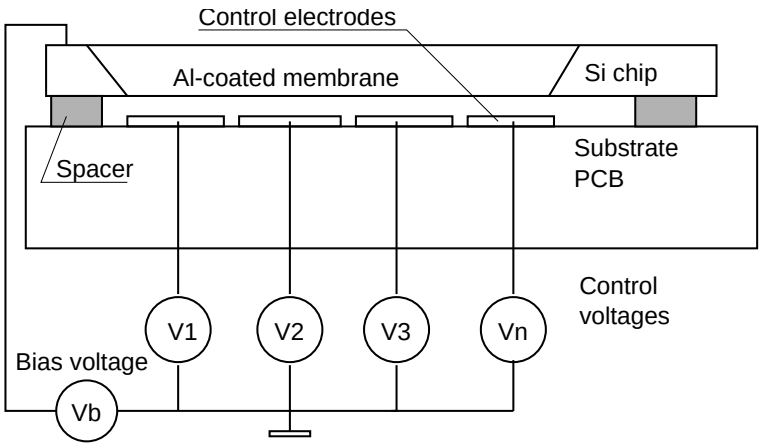


Figure 2: Schematic section of the 39-ch linear micromachined deformable mirror.

2 Technical data

See Table 1 for technical parameters of the mirror before shipping.

Small surface defects are possible. They do not influence the quality of the mirror.

3 Actuator structure

The membrane is mounted over the printed actuator structure, shown in Fig. 3. The gap between actuators is 8 mils (0.2032 mm).

4 Control amplifier unit

The mirror is controlled by a high-voltage amplifier unit (20-channel unit for 19-channel mirror and 40-channel unit for 38-channel mirror). To use the unit, you must connect it to the mirror, to a DAC USB unit (or PCI boards) and to the wall outlet (85 to 250V AC, 50 to 60 Hz). Connect the mirror with a supplied flat ribbon cables to the 20-pin connectors on the front side, and the driver boards or the USB unit to the 26-pin connectors.

In case of OEM version of the system, the mirror is controlled by one (two) high-voltage amplifier board(s). Each board contains 20 non-inverting DC amplifiers with gain 35, 59, or 79 depending on the board type, and should be connected to a high-voltage ($\leq$395 V) power supply and to a stabilized $\pm$15V DC supply. Connect the ground, +15V and -15V to the pins marked G,+ and –. Connect positive high-voltage stabilized DC supply to the pin marked V_high, connect negative high voltage terminal to the ground (see Fig. 6). **The high voltage supply should not exceed 395 V DC.** Use the flat ribbon cable supplied to connect the driver board to the mirror socket.

Table 1: Technical parameters of the mirror.

Parameter	Value
Deformable mirror model	MDM39LIN
Deformable mirror s/n	23.03
Aperture shape	rectangle 11x39mm
Number of electrodes	39
Control voltages V_c	0. . . 283 V
Mirror coating	Al
Initial RMS deviation from plane/cylinder	less than 1 μm
Main initial aberration	defocus/cylinder/adjustable
Frequency range	0 . . . 500Hz
response time 250 μs to overshot settle time 500 μs	
Maximum deflection of the mirror center	10 μm (32 fringes)
Maximum optical load	not available
Surface defects	up to 20 dust particles, up to 2 coating defects with area of 1mm^2 each, total scattering less than 0.5%
Supplied with DAC s/n	D40V2q25
DAC type	USB-DAC-40 version 2

5 Digital boards

The output voltage of the channel N [N=0...23] of the 8-bit 24-channel DAC board is controlled by sending control byte V [0...255] to the output port BA+N*4. Please see the separate board description for detailed installation guide.

The pinout of the board and the pinouts of the board cable and the cable coming from the high voltage board are shown in Fig. 8. The board connector pinout is given for the board make connector. The cable pinouts are given for the cable female connectors viewed from the front side.

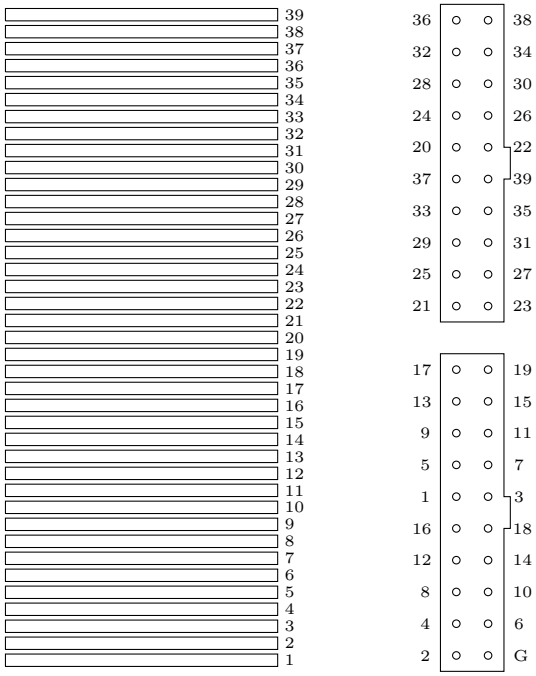


Figure 3: Actuator structure and connector pin-out, view from the back side of the mirror

6 DAC Unit

A single "DAC-40-USB" unit can control up to 40 channels. Please see the separate unit description for detailed installation guide.

The pinout of the DAC unit and the pinouts of the board cable and the cable coming from the high voltage board are shown in Fig. 8. The DAC unit connector pinout is given for one of its male connectors. The cable pinouts are given for the cable female connectors viewed from the front side.

7 Optical quality

The mirror was tested interferometrically before shipping. The null-interferometric patterns of the deformed mirror surface, and the response to bias voltage and to control voltage applied to the central electrodes are shown in Fig. 9.

Figure 4: 40 channel high-voltage amplifier unit.

Figure 5: Front and back panels of 40 channel high-voltage amplifier unit.

8 First run of the system

- **Read this document through before performing any practical steps. Follow the instructions exactly.**
- All following operations refer to:
  - either *DAC-40-USB unit* connected to a computer running Windows - we used XP SP2 for final tests
  - or *digital boards* installed in a computer running Linux - we used RH 7.2 for final tests.
- *For digital boards.* Insert digital board into computer slot. Install the board and get the address from the system. For Linux look at /proc/pci, for Windows check the device manager. Compile the example software and check all board channels.
- *For DAC-40-USB unit.* Connect the DAC USB unit to the computer USB port. Install the software (refer to the DAC USB unit guide). Jumpers of the USB unit are already preset to the correct position (every connector provides 19-channel output and ground). Run the example programs supplied with the CD to test the DAC USB unit functionality.

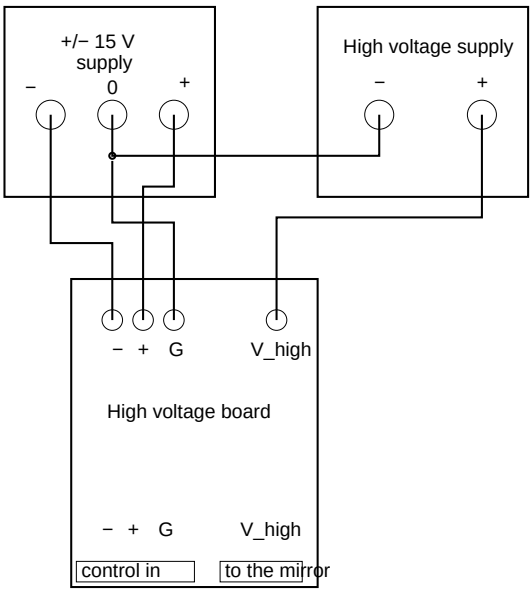


Figure 6: Power supply wiring for OEM version of the system. Position of the connectors can be different; refer to the board manual and/or marking on the board.

- Switch the computer off. Connect band cables to the connector(s) in the mirror holder. Connect the amplifier unit to the DAC USB unit. At this stage the system is fully assembled but the adaptive mirror is not used yet. Switch on the amplifier unit. Test the output voltages in the mirror socket. These voltages must be in the range 0...2V. Turn the computer on. At this stage the voltages in mirror socket may have values between 0V and 283 V. Run the test programs. Control all channels. Switch off the amplifier unit and computer.
- *For OEM version.* Switch the computer off. Connect the amplifier board to the mirror driver board. Connect the driver board to the low and high voltage power supplies. At this stage the system is fully assembled but the adaptive mirror is not used yet. Switch on the power supplies in the order: +15V, -15V, +V_high. Do not use V_high higher than 120V for the first test. The current (positive supply to ground) should not exceed 0.125A for one board (zero output of all 20 amplifiers). The high voltage current should not exceed 0.05A for V_high=150V. Test the output voltages in the amplifier board output. These voltages must be in the range 0...1V. Turn the computer on. While turned on, the boards are initialized to random output voltages. At this stage the voltages in mirror socket may have values between 0V and V_high. Using supplied example drivers, set the board to zero and to maximum voltage. Control output.
- Connect the cable to the mirror. Place the mirror into interferometer or a setup with a wavefront sensor. Fix the cables to the optical table. You may also test the mirror by reflecting a good collimated beam from the mirror surface and observing the near

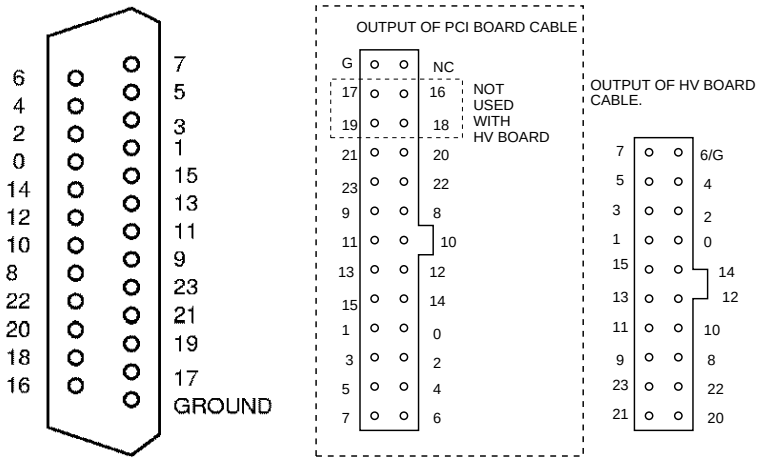


Figure 7: Pinouts of the digital board and cables. The numbers correspond to the addresses of the pin with respect to the base address of the board.

field intensity distribution. At this stage you do not have to feed any supply voltages to the control boards but the power supplies must be grounded appropriately.

- Check the initial mirror figure. Align if necessary.
- Switch on all supply voltages (*For OEM version* in the order +15V, -15V, V_high. Do not use V_high higher than V_max.) The mirror figure should not change after drivers are switched on. If the mirror figure changes, check all connections and the boards for damage. In some cases the problem is caused by incident short circuits at the bandcable termination.
- Switch on the computer. After the system is loaded, the mirror figure represents strongly distorted concave surface. Reset all voltages to zero and observe zero surface.
- You may start to use the mirror if all channels work. Use templates supplied to write your own control programs under Linux and Windows.

9 Remarks

Drivers supplied will work under Windows and Linux. In the Windows drivers you need to adjust the addresses. Use Linux drivers as a template.

In the first days of operation, the mirror figure can drift due to relaxation of internal stresses. The mirror can be re-aligned.

OKO Technologies is not responsible for the result of alignment procedure and provides no warranty!

To align:

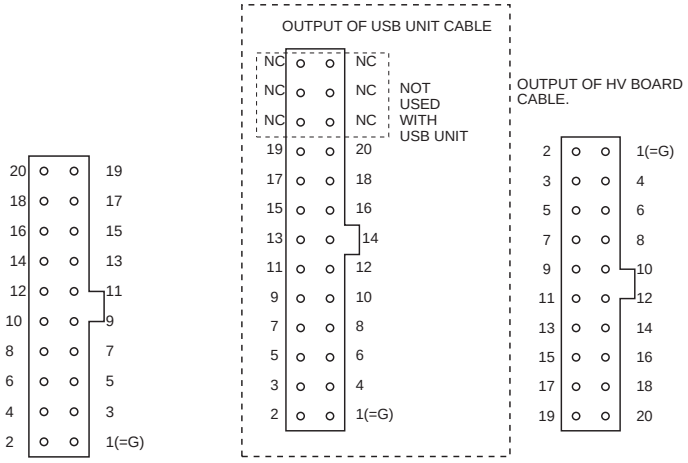


Figure 8: Pinouts of the first connector of the "DAC-40-USB" unit and cables. The numbers correspond to the numeration of "DAC-40-USB" output channels. Second connector is connected in a similar way.

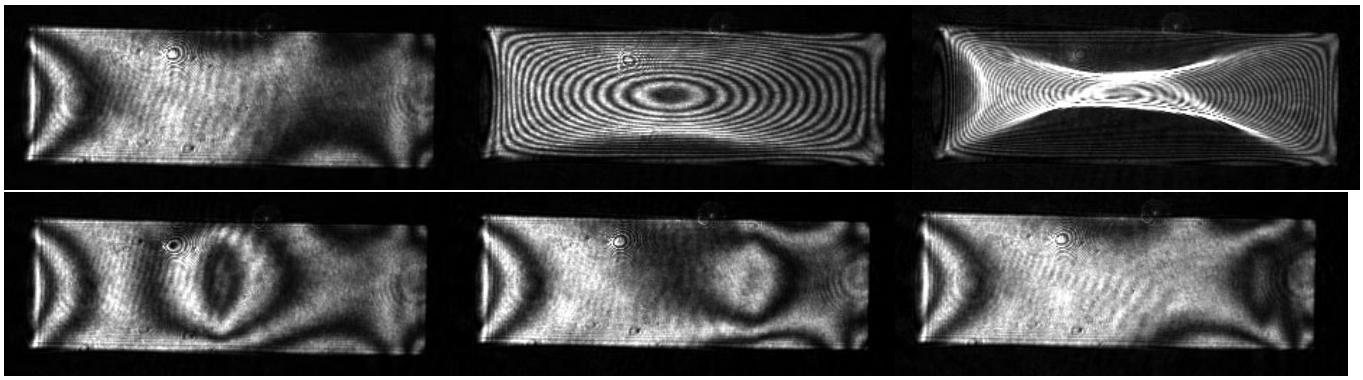


Figure 9: The response to control voltage 0, 229V and 325V applied to all actuators; 325V to a single actuator (left to right, top to bottom).

1. put the mirror into interferometer and fix it solidly.
2. Using 0.9mm hex key release the screw latches.
3. Set all actuator voltages to zero and align the mirror to observe zero interferometric pattern.
4. By slight clockwise turns of alignment screws adjust the mirror figure. Do not turn the screws more than 15 degrees of arc counterclockwise! By doing that you may land the membrane onto the actuator structure and destroy the mirror. Use hex key with a very long handle to improve the sensitivity of alignment. In general you will need extremely gentle movement (about one degree of arc) of the screws. Be careful - the screws can be tight.
5. Apply maximum voltage to all actuators and check the deformation is symmetrical

with respect to the mirror center. If not - realign the membrane to make it parallel to the actuator structure.

6. Repeat 5...6 until the satisfaction is reached or until the membrane is broken.
7. Fix the screw latches.

In case you use custom amplifiers, make sure that the control voltage does not exceed V_max on any mirror actuator. Higher voltage applied even for one millisecond, will destroy the device!

Use high-quality stabilized filtered high-voltage supply. Some high-voltage supplies generate short high-voltage spikes at the output, these deviations can destroy the mirror, driver electronics and even the control computer.

Do not touch or clean the membrane.
Do not ever think about touching or cleaning the membrane.

10 Warranty

The equipment is covered by a one-year factory-defect warranty.

If the mirror is damaged during shipping, it will be replaced by a similar device within two months. A photo of the damaged device should be sent to Flexible Optical B.V. (OKO Technologies) within 3 days after the damaged device is received.

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11 Contact person

All questions about the technology, quality and applications of adaptive mirror should be addressed to:
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2288 GG Rijswijk ZH,
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Date:

Signature:

(Dr. Seva Patlan,
Senior Researcher)