

1 TITLE OF THE INVENTION:

Sensor Chip and Photoelectric Conversion Apparatus

Using the Same

5 BACKGROUND OF THE INVENTION:Field of the Invention

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The present invention relates to a sensor chip and a photoelectric conversion apparatus using the same and, more particularly, to a multichip photoelectric conversion apparatus using an array of a plurality of sensor chips.

Related Background Art

Conventionally, a photoelectric conversion apparatus (linear image sensor) in which light-receiving elements are arranged in a line has been widely used in an image reading apparatus such as a facsimile, a digital copying machine, and a scanner.

Since a sensor chip for use in a linear image sensor is generally made from a silicon wafer, the sensor length is limited by the wafer size. Therefore, it is difficult to manufacture a linear image sensor chip having a length identical to the width of an original to be read having a general size. For this reason, in order to use a single sensor chip, an imaging optical system is used to image an original to be read on the sensor chip in a reduced scale, thereby reading an image carried by the original. An apparatus

1 utilizing such a reduction imaging optical system,
however, requires a space for the optical system.
Therefore, it is difficult to make the apparatus
compact. In addition, it is difficult to obtain a
5 sufficient resolution.

For this reason, a so-called multichip image
sensor in which a plurality of linear image sensor
chips are linearly arranged has been put into practical
use.

10 Fig. 1 is a block diagram showing an arrangement
of a conventional multichip image sensor.

Referring to Fig. 1, n light-receiving elements
2-1-1 to 2-1-n are formed in a line in the x direction
on a sensor chip 1-1. A circuit 3-1 for sequentially
15 selecting outputs from the light-receiving elements
2-1-1 to 2-1-n is formed on the chip 1-1. An amplifier
4-1 for amplifying an output from the circuit 3-1 is
also formed on the chip 1-1. An output from the
amplifier 4-1 is output outside the chip from an output
20 line 5-1 generally via a signal extracting section.

The circuit 3-1 is driven by an external driver
via an input line 8-1.

Sensor chips 1-2 to 1-m have the same arrangement
as that of the sensor chip 1-1. In the sensor chips
1-2 to 1-m, therefore, the same reference numerals as
25 in the sensor chip 1-1 denote the same parts.

1 The sensor chips 1-1 to 1-m are arranged in a line
in the x direction. Therefore, a total of (n x m)
light-receiving elements are arranged in a line in the
x direction. Upon image reading, an original carrying
5 an image to be read and/or a photoelectric conversion
apparatus are conveyed in the y direction relative to
each other so that the original faces the
light-receiving elements.

 Outputs from all light-receiving elements of the
10 chip 1-1 are sequentially selected by the circuit 3-1
and externally output from the output line 5-1.
Outputs from all light-receiving elements of the chip
1-2 are then sequentially selected by a circuit 3-2 and
externally output from an output line 5-2.
15 Subsequently, signals from light-receiving elements are
similarly, sequentially read. As a result, outputs
from all light-receiving elements are time-serially
output.

 In the conventional multichip image sensor as
20 described above, since an output signal from each
sensor chip is independently extracted to an external
signal processor, the number of signal lines is
increased to complicate the wiring. In order to solve
this problem, a common signal line may be used to
25 extract signals to the external signal processor. If,
however, all sensor chips including those not
externally outputting signals from light-receiving

1 elements are connected to the output line, crosstalk
between signals easily occurs to reduce an S/N ratio of
a read signal.

In addition, in the above conventional multichip
5 image sensor, an amplifier is in an operative state
even while light-emitting elements of each chip do not
externally output signals. For this reason, if the
number of sensor chips is increased, unnecessary
consumption power is increased or heat is generated to
10 increase the chip temperature, thereby degrading the
sensor characteristics.

SUMMARY OF THE INVENTION:

The present invention has been made in
consideration of the above conventional techniques and
15 has as its object to provide a multichip photoelectric
conversion apparatus in which a common signal line is
used to extract signals from a plurality of sensor
chips to an external signal processor and which causes
almost no reduction in an S/N ratio of a read signal,
20 and a sensor chip for constituting the photoelectric
conversion apparatus.

It is another object of the present invention to
provide a photoelectric conversion apparatus in which
consumption power of a multichip photoelectric
25 conversion apparatus is reduced to prevent degradation
in sensor characteristics due to a temperature rise,

1 and a sensor chip for constituting the photoelectric
conversion apparatus.

It is still another object of the present
invention to provide a multichip photoelectric
5 conversion apparatus capable of increasing the
frequency of a clock signal to reduce a read time,
thereby performing high-speed read, without increasing
the cost by using an external complicated circuit.

It is still another object of the present
10 invention to provide a sensor chip which can be used in
a multichip photoelectric conversion apparatus in which
a plurality of sensor chips each having a plurality of
light-receiving elements are arranged, comprising
output signal lines for outputting signals outside the
15 sensor chip from light-receiving elements of the sensor
chip, a switch for connecting/disconnecting the output
signal lines, and a controller for closing the switch
only for a duration including a time interval in which
signals are output outside the sensor chip from the
20 light-receiving elements, and opening the switch for a
duration except for the duration.

It is still another object of the present
invention to provide a multichip photoelectric
conversion apparatus in which a plurality of sensor
25 chips each having a plurality of light-receiving
elements are arranged, comprising output signal lines,
connected to a common signal line, for outputting

1 signals outside the sensor chip from light-receiving
elements of the sensor chip, a switch, provided for
each of the sensor chips, for connecting/disconnecting
the output signal lines, and a controller, provided in
5 each of the sensor chips, for closing the switch only
for a duration including a time interval in which
signals are output outside the sensor chip from the
light-receiving elements, and opening the switch for a
duration except for the duration.

10 It is still another object of the present
invention to provide a sensor chip which can be used in
a multichip photoelectric conversion apparatus in which
a plurality of sensor chips each having a plurality of
light-receiving elements are arranged, comprising an
15 amplifier for amplifying output signals from
light-receiving elements of the sensor chip, and a
controller for enabling the amplifier only for a
duration including a time interval in which signals are
output outside the sensor chip from the light-receiving
20 elements, and disabling the amplifier for a duration
except for the duration.

It is still another object of the present
invention to provide a multichip photoelectric
conversion apparatus in which a plurality of sensor
25 chips each having a plurality of light-receiving
elements are arranged, comprising an amplifier,
provided for each of the sensor chips, for amplifying

1 output signals from the light-receiving elements, and a
controller, provided in each of the sensor chips, for
enabling the amplifier only for a duration including a
time interval in which signals are output outside the
5 sensor chip from the light-receiving elements, and
disabling the amplifier for a duration except for the
duration.

It is still another object of the present
invention to provide a sensor chip which can be used in
10 a multichip photoelectric conversion apparatus in which
a plurality of sensor chips each having a
light-receiving element are arranged, comprising means
for delaying a start signal for a light signal read
operation performed by the light-receiving element, and
15 means for outputting a signal used as a start signal
for the next sensor chip before the light signal read
operation is finished.

It is still another object of the present
invention to provide a sensor chip having a plurality
20 of light-receiving elements, comprising a circuit
connected to each of the plurality of light-receiving
elements, a signal extracting portion electrically
connected to an output signal line for extracting a
signal from the circuit outside the sensor chip, a
25 controller for connecting/disconnecting a signal output
from the circuit and from the signal extracting

1 portion, and a signal line for operating the
 controller.

 It is still another object of the present
 invention to provide a photoelectric conversion
5 apparatus comprising a plurality of sensor chips
 described above, the signal extracting portions of the
 sensor chips being connected to a common signal line.

 It is still another object of the present
 invention to provide a reading apparatus comprising a
10 photoelectric conversion apparatus described above, a
 signal processor for receiving an output signal from
 the photoelectric conversion apparatus, and a driver
 for driving the photoelectric conversion apparatus.

 It is still another object of the present
15 invention to provide a sensor chip having a plurality
 of light-receiving elements, comprising a circuit
 connected to each of the plurality of light-receiving
 elements, a signal extracting portion electrically
 connected to an output signal line for extracting an
20 output from the circuit outside the sensor chip, an
 amplifier for amplifying the output from the circuit, a
 controller for controlling an operation state of the
 amplifier, and a signal line for operating the
 controller.

25 It is still another object of the present
 invention to provide a photoelectric conversion

1 apparatus comprising a plurality of sensor chips
described above.

It is still another object of the present
invention to provide a reading apparatus comprising a
5 photoelectric conversion apparatus described above, a
signal processor for receiving an output signal from
the photoelectric conversion apparatus, and a driver
for driving the photoelectric conversion apparatus.

It is still another object of the present
10 invention to provide a method of reading a
photoelectric conversion apparatus having a plurality
of light-receiving elements, an amplifier for receiving
outputs from the light-receiving elements, and a
controller for controlling an operation state of the
15 amplifier, comprising the steps of enabling at least an
amplifier of an n th (n is an integer of 1 or more)
sensor chip to be read, and enabling an amplifier of an
($n+1$)th sensor chip by a signal output on the basis of
an operation of the n th sensor chip.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing an arrangement
of a conventional multichip image sensor;

Fig. 2 is a block diagram showing an arrangement
of an embodiment of a photoelectric conversion
25 apparatus according to the present invention;

Figs. 3A, 3B and 3C are circuit diagrams
showing detailed arrangements of an analog switch;

1 Fig. 4 is a timing chart for explaining an
operation of the embodiment shown in Fig. 2;

 Fig. 5 is a block diagram showing an arrangement
of another embodiment of a photoelectric conversion
5 apparatus according to the present invention;

 Fig. 6 is a timing chart for explaining an
operation of the embodiment shown in Fig. 5;

 Fig. 7 is a timing chart for explaining another
operation of the embodiment shown in Fig. 5;

10 Fig. 8 is a block diagram showing still another
embodiment of a photoelectric conversion apparatus
according to the present invention;

 Fig. 9 is a block diagram showing an arrangement
of a multichip image sensor;

15 Fig. 10 is a timing chart showing operation
waveforms of the sensor shown in Fig. 9;

 Fig. 11 is a block diagram showing an arrangement
of a multichip image sensor as still another embodiment
of an image sensor chip and a photoelectric conversion
20 apparatus using the same according to the present
invention; and

 Fig. 12 is a timing chart showing operation
waveforms of the embodiment shown in Fig. 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 The present invention provides a sensor chip and a
photoelectric conversion apparatus having the same

1 capable of solving the above problems and achieving the
above objects.

That is, according to the present invention, there
is provided a photoelectric conversion apparatus having
5 no crosstalk between signals upon signal read, and
capable of performing signal read at a high S/N ratio
and reducing consumption power to prevent degradation
in sensor characteristics due to heat, thereby enabling
high-speed reading, and a sensor chip for use in the
10 apparatus.

Preferred embodiments of the present invention
will be described in detail below with reference to the
accompanying drawings.

Fig. 2 is a block diagram showing an arrangement
15 of an embodiment of a photoelectric conversion
apparatus according to the present invention.

Referring to Fig. 2, a sensor chip 1-1 consists of
a semiconductor such as silicon. N light-receiving
elements 2-1-1 to 2-1-n are formed in a line in the x
20 direction on the chip 1-1. The light-receiving
elements are of a type of storing optical pumping
carriers in a control electrode region of a transistor
and extracting an output corresponding to the stored
charge as needed. That is, optical pumping carriers
25 generated upon inputting of optical information are
stored in the base region of a transistor to store a
charge corresponding to the optical input information,

1 and an output corresponding to the stored charge is
extracted as an electrical output signal as needed. In
this type, the stored charge can be basically
nondestructively read. When the stored charge becomes
5 unnecessary, it is generally refreshed by a certain
means (not shown). The light-receiving element need
not be of this type but may be of another type. A
circuit 3-1 (e.g., a shift register) for sequentially
selecting outputs from the light-receiving elements
10 2-1-1 to 2-1-m is formed on the chip 1-1. An amplifier
4-1 for amplifying an output from the circuit 3-1 is
formed on the chip 1-1.

In this embodiment, an analog switch 6-1 for
connecting/disconnecting an output signal line 5-1 of
15 the amplifier 4-1 and a controller 7-1 for controlling
a switching operation of the switch are formed on the
chip 1-1. The controller 7-1 outputs a control signal
on the basis of a signal from the circuit 3-1. The
circuit 3-1 is driven by an external driver via an
20 input line 8-1.

Figs. 3A, 3B and 3C are circuit diagrams
showing detailed arrangements of the analog switch 6-1.

Referring to Fig. 3A, passing of a signal V_{in} as
an output from the amplifier 4-1 to V_{out} is controlled
25 by a control signal ϕ_c supplied from the controller 7-1
to the gate of an n-type MOS transistor Q_1 .

1 Referring to Fig. 3B, passing of a signal V_{in} as
an output from the amplifier 4-1 to V_{out} is controlled
by a control signal $\overline{\phi_c}$ supplied from the controller 7-1
to the gate of a p-type MOS transistor Q_2 .

5 Referring to Fig. 3C, the sources and the drains
of an n-type MOS transistor Q_1 and a p-type MOS
transistor Q_2 are commonly connected. A control
signal ϕ_c is directly supplied to the gate of the
transistor Q_1 , while it is supplied to the gate of the
10 transistor Q_2 via an inverter, thereby controlling
passing of a signal V_{in} as an output from the amplifier
4-1 to V_{out} . This arrangement is a C-MOS type gate.

Although Figs. 3A to 3C show analog switches
using a MOS transistor, an analog switch having the
15 same function can be constituted by using a bipolar
transistor.

Referring to Fig. 2, sensor chips 1-2 to 1-m have
the same arrangement as that of the sensor chip 1-1,
and the same reference numerals as in the sensor chip
20 1-1 denote the same parts in the sensor chips 1-2 to
1-m.

Output lines 5-1 to 5-m of the sensor chips are
connected to a common signal line 10 outside the chips
generally via a signal extracting portion. This sensor
25 chips are connected to an external signal processor via
the signal line.

1 The sensor chips 1-1 to 1-m are arranged in a line
in the x direction. Therefore, a total of (n x m)
light-receiving elements are arranged in a line in the
x direction. All the sensor chips are arranged and
5 fixed on a substrate (not shown). Upon image reading,
an original carrying an image to be read and/or the
light-receiving elements are conveyed relative to each
other in the y direction so that the original faces the
light-receiving elements.

10 An operation of this embodiment will be described
below.

Fig. 4 is a timing chart for explaining an
operation of the above embodiment.

Referring to Fig. 4, an output control signal ϕ_1
15 is supplied from the controller 7-1 of the sensor chip
1-1, an output control signal ϕ_2 is supplied from the
controller 7-2 of the sensor chip 1-2, and outputs
 V_{out_1} and V_{out_2} are supplied from the switches 6-1 and
6-2 of the sensor chips 1-1 and 1-2, respectively.

20 The signal ϕ_1 is synchronized with an operation of
the circuit 3-1 driven by the input line 8-1. That is,
the signal ϕ_1 is output only for a specific duration
including a time interval in which the outputs from all
the light-receiving elements of the chip 1-1 are
25 sequentially selected by the circuit 3-1. Only for
this duration, the switch 6-1 is closed, and V_{out_1} is

1 output. The output V_{out_1} includes the outputs from all
the light-receiving elements of the sensor chip 1-1.

Similarly, the signal ϕ_2 is synchronized with an
operation of the circuit 3-2 driven by the input line
5 8-2. That is, the signal ϕ_2 is output only for a
specific duration including a time interval in which
outputs from all the light-receiving elements of the
chip 1-2 are sequentially selected by the circuit 3-2.
Only for this duration, the switch 6-2 is closed, and
10 V_{out_2} is output. The output V_{out_2} includes the outputs
from all the light-receiving elements of the sensor
chip 1-2.

As shown in Fig. 4, the duration of the signal ϕ_2
starts at the same time as the duration of the
15 signal ϕ_1 ends.

Output control signals are similarly generated
from the controllers 6-3 to 6-m of the third and
subsequent sensor chips 1-3 to 1-m, respectively.

As described above, signals are sequentially read
20 from the light-receiving elements, and outputs from the
light-receiving elements are time-serially output from
the common output line 10.

In this embodiment, in each sensor chip, an output
from the amplifier is connected to the common output
25 line 10 only for the duration substantially
corresponding to the time interval in which signals are
output from the light-receiving elements, and is

1 disconnected therefrom for a duration except for the
above duration. Therefore, no crosstalk occurs during
signal reading to reduce the S/N ratio of the read
signal.

5 According to this embodiment, since switching can
be automatically set and no wiring is provided for the
controller or the switch of each chip from an external
driver, an external circuit can be simplified.

Another embodiment of the present invention will
10 be described in detail below with reference to the
accompanying drawings.

Fig. 5 is a block diagram showing an arrangement
of another embodiment of a photoelectric conversion
apparatus of the present invention.

15 Referring to Fig. 5, a sensor chip 1-1 consists of
a semiconductor such as silicon. N light-receiving
elements 2-1-1 to 2-1-n are formed in a line in the x
direction on the chip. The light-receiving elements
are of a type of storing optical pumping carriers in a
20 control electrode region of a transistor and extracting
an output corresponding to the stored charge as needed.
That is, the type used in the first embodiment is
adopted. A circuit 3-1 such as a shift register for
sequentially selecting outputs from the light-receiving
25 elements 2-1-1 to 2-1-n is formed on the chip 1-1. An
amplifier 4-1 for amplifying an output from the circuit
3-1 is formed on the chip 1-1. An output from the

1 amplifier 4-1 is externally output from an output line
5-1 generally via a signal extracting portion. This
output is generally supplied to a signal processor and
processed as needed.

5 In this embodiment, a controller 506-1 for
outputting a switching control signal for switching
operative and nonoperative states of the amplifier 4-1
is formed on the chip 1-1. The controller 506-1 is
driven by an external driver via an input line 507-1.
10 The circuit 3-1 is also driven by an external driver
via an input line 508-1.

Sensor chips 1-2 to 1-m have the same arrangement
as that of the sensor chip 1-1, and the same reference
numerals as in the sensor chip 1-1 denote the same
15 parts in the sensor chips 1-2 to 1-m.

The sensor chips 1-1 to 1-m are arranged in a line
in the x direction. Therefore, a total of (n x m)
light-receiving elements are arranged in a line in the
x direction. All the sensor chips are arranged and
20 fixed on a substrate (not shown). Upon image reading,
an original carrying an image to be read and/or the
photoelectric conversion apparatus are conveyed
relative to each other in the y direction so that the
original faces the light-receiving elements.

25 An operation of this embodiment will be described
below.

1 Fig. 6 is a timing chart for explaining an
operation of the above embodiment.

Referring to Fig. 6, an output control signal ϕ_{501}
is supplied from the controller 506-1 of the sensor
5 chip 1-1, an output control signal ϕ_{502} is supplied
from the controller 506-2 of the sensor chip 1-2, and
outputs V_{out_1} and V_{out_2} are supplied from the
amplifiers 4-1 and 4-2 of the sensor chips 1-1 and 1-2,
respectively.

10 The signal ϕ_{501} is synchronized with an operation
of the circuit 3-1 driven by the input line 508-1.
That is, the signal ϕ_{501} is output only for a specific
duration including a time interval in which outputs
from all the light-receiving elements of the chip 1-1
15 are sequentially selected by the circuit 3-1. Only for
this duration, the amplifier 4-1 is operated, and V_{out_1}
is output. The output V_{out_1} includes the outputs from
all the light-receiving elements of the sensor chip
1-1.

20 Similarly, the signal ϕ_{502} is synchronized with an
operation of the circuit 3-2 driven by the input line
508-2. That is, the signal ϕ_{502} is output only for a
specific duration including a time interval in which
outputs from all the light-receiving elements of the
25 chip 1-2 are sequentially selected by the circuit 3-2.
Only for this duration, the amplifier 4-2 is operated,
and V_{out_2} is output. The output V_{out_2} includes the

1 outputs from all the light-receiving elements of the
sensor chip 1-2.

As shown in Fig. 6, the duration of the
signal ϕ_{502} starts at the same time as the duration of
5 the signal ϕ_{501} ends.

Output control signals are similarly generated
from the controllers 506-3 to 506-m of the third and
subsequent sensor chips 1-3 to 1-m, respectively.

As described above, signals are sequentially read
10 from the light-receiving elements, and outputs from all
the light-receiving elements are time-serially output.

In this embodiment, in each sensor chip, the
amplifier is operated only for the duration
substantially corresponding to the time interval in
15 which signals are output from the light-receiving
elements and is not operated for a duration except for
the above duration. Therefore, consumption power of
the amplifiers 4-1 to 4-m is reduced to be $1/m$
conventional consumption power.

20 Fig. 7 is a timing chart for explaining another
operation of the above embodiment. In Fig. 7, the same
reference numerals as in Fig. 6 are used.

As shown in Fig. 7, a control signal ϕ_{501} of the
first sensor chip and a control signal ϕ_{502} of the
25 second sensor chip overlap each other by a time t . The
signals ϕ_{501} and ϕ_{502} are activated slightly before (by
the time t) the first light-receiving element is

1 selected by the selecting circuit in each sensor chip.
This also applies to the third and subsequent sensor
chips.

As described above, the control signal is started
5 slightly before the first light-receiving element of
each sensor chip is read. Therefore, a time required
for starting and stabilizing an operation of each
amplifier is assured, and signals from all the
light-receiving elements including the first
10 light-receiving element can be stably output with high
precision in each sensor chip. In addition, since the
overlap time of the control signals is sufficiently
short with respect to the total time, the consumption
power is not much increased than that of the operation
15 shown in Fig. 6.

Fig. 8 is a block diagram showing an arrangement
of still another embodiment of a photoelectric
conversion apparatus of the present invention. In
Fig. 8, the same reference numerals as in Fig. 5 denote
20 the same parts.

This embodiment is the same as that shown in
Fig. 5 except that controllers 506-1 to 506-m are
controlled by control signals from circuits 3-1 to 3-m,
respectively, in sensor chips.

25 That is, in correspondence with a time interval in
which an operation command signal for sequentially
selecting outputs from all the light-receiving elements

1 of each chip is supplied from one of input lines 508-1
to 508-m to a corresponding one of the circuits 3-1 to
3-m, the circuit supplies a signal to the controller,
thereby switching operative and nonoperative states of
5 the amplifier as in the embodiment shown in Fig. 5.

According to this embodiment, unlike the
embodiment shown in Fig. 5, the operative and
nonoperative states of the amplifier can be
automatically switched, and no external driver having
10 an output for the amplifier need be used. In addition,
unlike the first embodiment, no wirings 507-1 to 507-m
need be provided from the external driver to the
controllers of the respective chips. As a result, the
external circuit can be simplified.

15 Switching between the operative and nonoperative
states of the amplifier and connection/disconnection of
the outputs can be simultaneously performed.

In this case, crosstalk and the consumption power
can be further reduced.

20 Fig. 9 shows an arrangement of a multichip image
sensor using an image sensor chip, and Fig. 10 shows
operation waveforms (timing chart) thereof.

Referring to Fig. 9, image sensor chips (to be
sometimes referred to as merely "chips" hereinafter)
25 1-1, 1-2, ..., 1-m are connected to constitute a
multichip image sensor. Light-receiving elements 2-1-1
to 2-1-n are formed on the image sensor chip 1-1 and

1 convert input light signals into electrical signals.
Since the light-receiving elements 2-1-1 to 2-m-n are
arranged and connected in this multichip image sensor,
the sensor length of this image sensor is long enough
5 to correspond to a large original size.

 This multichip sensor starts its operation when a
start signal is supplied from a start terminal 908 to
the first chip 1-1 in synchronism with a clock signal
from a clock terminal 909. Upon reception of this
10 start signal, shift registers 904-1-1 to 904-1-n
sequentially turn on MOS switches 903-1-1 to 903-1-n to
activate the light-receiving elements 2-1-1 to 2-1-n
connected to the MOS switches, thereby reading a light
signal.

15 This light signal is amplified by a light signal
output amplifier 906-1 and output to an output terminal
907 as an optical output signal.

 A controller 905-1 switches operative and
nonoperative states of a constant current circuit of
20 the light signal output amplifier 906-1. The
controller 905-1 activates the constant current circuit
substantially at the same time as the first shift
register 4-1-1 receives the start signal, thereby
activating the light signal output amplifier 906-1.

25 An output from the last shift register 904-1-n of
the chip 1-1 turns on the last MOS switch 903-1-n and
is externally output to be supplied as a start signal

1 to the first shift register 904-2-1 of the next chip
1-2.

In the next chip 1-2, the same operation as in the
chip 1-1 described above is performed, and a start
5 signal is output to the next chip 1-3 (not shown). In
this manner, the start signal is sequentially output to
the next chip to execute a reading operation of a light
signal having the sensor length.

Fig. 10 shows operation waveforms (timing chart)
10 of the above multichip image sensor. Referring to
Fig. 10, a light signal of the light-receiving element
2-2-1 is read a time S after a start signal is output
to the chip 1-2. Therefore, the chip 1-2 must activate
the constant current circuit of the amplifier within
15 the time S. In addition, since the time S is shortened
when a clock frequency is increased, the constant
current circuit must be activated within a short time
period.

As described above, light signal read from the
20 light-receiving element 2-1-1 upon inputting of the
start signal and activation of the constant current
circuit of the light signal output amplifier 906-1 are
performed at substantially the same time. Therefore,
in order to read the light signal after the constant
25 current circuit is completely activated, the frequency
of a block signal must be decreased to sufficiently

1 increase the read time of the light-receiving element
per pixel.

When the frequency of a clock signal is increased
to reduce the read time to achieve high-speed
5 processing, the constant current circuit sometimes
cannot be perfectly activated. That is, a light signal
from the light-receiving element is output before the
light signal output amplifier 906-1 is perfectly set in
the operative state, and accurate signal amplification
10 is disabled.

In order to solve this problem, the frequency of a
clock signal for the first light-receiving element of
each chip may be reduced. In this case, however, a
complicated circuit must be externally provided to
15 increase the cost.

Therefore, even if the frequency of a clock signal
is increased in order to reduce the read time of a
light signal of the multichip image sensor to achieve
high-speed read, this increase is limited by the
20 activation time of the constant current circuit.

Still another embodiment in which a constant
current circuit of a light signal amplifier is
activated beforehand to solve this problem will be
described below with reference to the accompanying
25 drawings. This method can be applied to the above
embodiment.

1 Fig. 11 is a block diagram showing an arrangement
of a multichip image sensor as an embodiment of an
image sensor chip according to the present invention
and a photoelectric conversion apparatus using the
5 same.

Referring to Fig. 11, in image sensor chips 1-1,
1-2, ..., 1-m, the same reference numerals as in Fig. 9
denote the same parts. First (from the left in
Fig. 11) shift registers 904-1-i, 904-1-j, 904-2-i,
10 904-2-j, ..., 904-m-i, and 904-m-j of the respective
chips delay start signals.

A sensor operation of the multichip image sensor
according to this embodiment is performed as follows.
That is, after light signals are stored, a clock signal
15 is supplied from a clock terminal 909 to each chip, and
a start signal is supplied from a start terminal 908 to
the first chip 1-1. This start signal is supplied to a
controller 905-1 via a delay shift register 4-1-i. The
controller 905-1 turns on a constant current circuit
20 (not shown) of a light signal output amplifier 906-1.
As a result, the light signal output amplifier 906-1 is
enabled. The start signal is also supplied to the
shift register 904-1-1 via the delay shift register
904-1-j and turns on a light-receiving element
25 switching MOS switch 903-1-1. As a result, a light
signal is read from the light-receiving element 2-1-1,
amplified by the light signal output amplifier 906-1,

1 and output to an output terminal 907. Subsequently,
the light signal read operation is sequentially
performed up to the light-receiving element 2-1-n in
synchronism with the clock signal via the shift
5 registers.

During this read operation to be sequentially
executed, an output signal from the shift register
904-1-l is externally output from the chip 1-1 and used
as a start signal for the next chip 1-2 at the same
10 time the light-receiving element 2-1-l is read.

The start signal received by the next chip 1-2 is
supplied to a controller 905-2 via the delay register
904-2-i. As a result, the controller 905-2 turns on a
constant current circuit of a light signal output
15 amplifier 906-2 beforehand.

Thereafter, in the chip 1-1, shift registers
904-1-(l + 1) to 904-1-n are activated by a clock
signal to read the remaining light-receiving elements
2-1-(l + 1) to 2-1-n, respectively.

20 At the same time, in the chip 1-2, a read
operation for the light-receiving element 2-2-1 is
delayed by the delay shift registers 904-2-i and
904-2-j. This delay operation ends at the same time as
the read operation of the chip 1-1 ends. The MOS
25 switch 903-2-1 is turned on by the shift register
904-2-1, and reading of a light signal of the
light-receiving element 2-2-1 is started. At this

1 time, since a constant current circuit of the light
signal output amplifier 906-2 of the chip 1-2 can
satisfactorily operate, accurate signal amplification
can be executed.

5 In this embodiment as described above, an
operation time from the shift registers 904-1-1 to
904-1-n of the chip 1-1 and an operation time from the
delay shift registers 904-2-i to 904-2-j of the chip
1-2 are adjusted such that the read operation of the
10 chip 1-2 is started immediately after the read
operation of the chip 1-1 is ended. In addition, a
time enough for activating the constant current circuit
of the chip 1-2 is assured.

Fig. 12 shows operation waveforms (timing chart)
15 for explaining the above operation of this embodiment.
Referring to Fig. 12, the start signal for the chip 1-2
is output simultaneously with the output signal from
the shift register 904-1-1 of the chip 1-1, thereby
activating the constant current circuit of the chip 1-2
20 (not shown). The start signal is delayed by a time T
by the shift register 904-2-i and the shift register
904-2-j (not shown). Thereafter, the shift register
904-2-1 reads a light signal output from the
light-receiving element 2-2-1. Even if the clock
25 frequency is increased, accurate light signal
amplification can be performed since the time T is

1 designed to be a time enough for activating the
constant current circuit.

In this embodiment, the shift registers are
arranged in a line in correspondence with the
5 light-receiving elements. The shift registers,
however, can be arranged in any place of the chip as
long as the wiring can be made.

As has been described above, according to the
present invention, there is provided a multichip
10 photoelectric conversion apparatus in which a common
signal line is used to extract signals from a plurality
of sensor chips to an external signal processor without
generating crosstalk or reducing an S/N ratio of a read
signal. In addition, switching can be effectively,
15 automatically set to simplify an external circuit.

According to the present invention, consumption
power of a multichip photoelectric conversion apparatus
can be largely reduced without externally providing a
specific circuit. In addition, heat generated on the
20 basis of the consumption power can be reduced to
prevent degradation in characteristics.

Furthermore, according to the present invention,
each chip constituting a multichip image sensor
comprises means for outputting a start signal to the
25 next chip during a read operation of a light signal,
and means for activating a light signal amplifier
(e.g., a constant current circuit) upon inputting of

1 the start signal and delaying the read operation until
the read operation of the previous chip is perfectly
finished. Therefore, even if a clock frequency is
increased, the amplifier of each chip can be activated
5 beforehand. As a result, a high-speed reading
operation and an accurate light signal output can be
obtained.

Moreover, since a shift register is used as the
delay means, no complicated circuit need be externally
10 arranged. Therefore, a compact photoelectric
conversion apparatus as a multichip image sensor can be
realized with high reliability and low cost up.

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1 WHAT IS CLAIMED IS:

1 1. A sensor chip which can be used in a multichip
photoelectric conversion apparatus in which a plurality
of sensor chips each having a plurality of
5 light-receiving elements are arranged, comprising:

output signal lines for outputting signals outside
said sensor chip from light-receiving elements of said
sensor chip;

10 a switch for connecting/disconnecting said output
signal lines; and

 a controller for closing said switch only for a
duration including a time interval in which signals are
output outside said sensor chip from said
light-receiving elements, and opening said switch for a
15 duration except for said duration.

2. A chip according to claim 1, wherein said
light-receiving element is of a type of storing optical
pumping carriers in a control electrode region of a
20 transistor.

3. A chip according to claim 1, further
comprising a selector for sequentially selecting output
signals from said light-receiving elements,
25 wherein said controller is operated by a signal
from said selector.





1 4. A chip according to claim 3, wherein an output
from said selector is supplied to a common amplifier,
and a switch is provided for an output signal line of
said amplifier.

5

5. A multichip photoelectric conversion apparatus
in which a plurality of sensor chips each having a
plurality of light-receiving elements are arranged,
comprising:

10 output signal lines, connected to a common signal
line, for outputting signals outside said sensor chip
from light-receiving elements of said sensor chip;

 a switch, provided for each of said sensor chips,
for connecting/disconnecting said output signal lines;

15 and

 a controller, provided in each of said sensor
chips, for closing said switch only for a duration
including a time interval in which signals are output
outside said sensor chip from said light-receiving

20 elements, and opening said switch for a duration except
for said duration.

 6. An apparatus according to claim 5, wherein a
plurality of said light-receiving elements are linearly
25 arranged in each of said sensor chips, and said sensor
chips are arranged in an arranging direction of said
light-receiving elements.





1 7. A sensor chip which can be used in a multichip
photoelectric conversion apparatus in which a plurality
of sensor chips each having a plurality of
light-receiving elements are arranged, comprising:
5 an amplifier for amplifying output signals from
light-receiving elements of said sensor chip; and
 a controller for enabling said amplifier only for
a duration including a time interval in which signals
are output outside said sensor chip from said
10 light-receiving elements, and disabling said amplifier
for a duration except for said duration.

 8. A chip according to claim 7, wherein said
light-receiving element is of a type of storing optical
15 pumping carriers in a control electrode region of a
transistor.

 9. A chip according to claim 7, further
comprising a selector for sequentially selecting output
20 signals from said light-receiving elements and
supplying the signals to a common amplifier,
 wherein said controller is operated by a signal
from said selector.

25 10. A chip according to claim 7, wherein a start
timing of said duration is slightly before a timing at





1 which a first signal is output outside said sensor chip
from said light-receiving elements.

11. A multichip photoelectric conversion apparatus
5 in which a plurality of sensor chips each having a
plurality of light-receiving elements are arranged,
comprising:

an amplifier, provided for each of said sensor
chips, for amplifying output signals from said
10 light-receiving elements; and

a controller, provided in each of said sensor
chips, for enabling said amplifier only for a duration
including a time interval in which signals are output
outside said sensor chip from said light-receiving
15 elements, and disabling said amplifier for a duration
except for said duration.

12. An apparatus according to claim 11, wherein a
plurality of said light-receiving elements are linearly
20 arranged in each of said sensor chips, and said sensor
chips are arranged in an arranging direction of said
light-receiving elements.

13. A sensor chip which can be used in a
25 multichip photoelectric conversion apparatus in which a
plurality of sensor chips each having a light-receiving
element are arranged, comprising:





1 means for delaying a start signal for a light
signal read operation performed by said light-receiving
element; and

means for outputting a signal used as a start
5 signal for the next sensor chip before the light signal
read operation is finished.

14. A chip according to claim 13, wherein said
sensor chip has a plurality of said light-receiving
10 elements.

15. A chip according to claim 13, wherein said
light-receiving element is arranged such that optical
pumping carriers can be stored in a control electrode
15 region of a transistor.

16. A chip according to claim 13, wherein said
means for delaying the start signal employs a shift
register circuit.

20

17. A multichip photoelectric conversion
apparatus in which a plurality of sensor chips each
having a light-receiving element are arranged, wherein
said sensor chip comprises:

25 means for delaying a start signal for a light
signal read operation performed by said light-receiving
element; and





1 means for outputting a signal used as a start
signal for the next sensor chip before the light signal
read operation is finished.

5 18. An apparatus according to claim 17, wherein
said sensor chip has a plurality of said
light-receiving elements.

10 19. An apparatus according to claim 17, wherein
said light-receiving element is arranged such that
optical pumping carriers can be stored in a control
electrode region of a transistor.

15 20. An apparatus according to claim 17, wherein
said means for delaying the start signal employs a
shift register circuit.

20 21. An apparatus according to claim 17, wherein a
constant current circuit of a light signal amplifier is
activated beforehand by the start signal.

22. A sensor chip having a plurality of
light-receiving elements, comprising:
a circuit connected to each of said plurality of
25 light-receiving elements;





- 1 a signal extracting portion electrically connected
to an output signal line for extracting a signal from
said circuit outside said sensor chip;
- 5 a controller for connecting/disconnecting a signal
output from said circuit and from said signal
extracting portion; and
- a signal line for operating said controller.

23. A chip according to claim 22, wherein said
10 circuit is a circuit for sequentially selecting output
signals from said plurality of light-receiving
elements.

24. A chip according to claim 22, wherein said
15 signal line is connected to said circuit.

25. A chip according to claim 22, further
comprising an amplifier provided between said circuit
and said signal extracting portion.

20

26. A chip according to claim 22, wherein said
circuit is connected to an input line for inputting an
external signal.

27. A chip according to claim 22, wherein an
25 output from said controller is supplied to a switch





1 provided between said light-receiving elements and said
signal extracting portion.

28. A chip according to claim 22, wherein said
5 light-receiving element is an element for storing
optical pumping carriers generated in accordance with
optical information.

29. A chip according to claim 28, wherein said
10 carriers are stored in a control electrode region of
said light-receiving element.

30. A photoelectric conversion apparatus
comprising a plurality of sensor chips according to
15 claim 22, said signal extracting portions of said
sensor chips being connected to a common signal line.

31. An apparatus according to claim 30, wherein
said plurality of sensor chips are arranged such that
20 light-receiving elements thereof are arranged in a
line.

32. A reading apparatus comprising:
a photoelectric conversion apparatus according to
25 claim 30;
a signal processor for receiving an output signal
from said photoelectric conversion apparatus; and





1 a driver for driving said photoelectric conversion
apparatus.

33. A sensor chip having a plurality of
5 light-receiving elements, comprising:

 a circuit connected to each of said plurality of
light-receiving elements;

 a signal extracting portion electrically connected
to an output signal line for extracting an output from
10 said circuit outside said sensor chip;

 an amplifier for amplifying the output from said
circuit;

 a controller for controlling an operation state of
said amplifier; and

15 a signal line for operating said controller.

34. A chip according to claim 33, wherein said
circuit is a circuit for sequentially selecting output
signals from said plurality of light-receiving
20 elements.

35. A chip according to claim 33, wherein said
signal line is connected to said circuit.

25 36. A chip according to claim 33, wherein said
amplifier is provided between said circuit and said
signal extracting portion.





1 37. A chip according to claim 33, wherein said
circuit is connected to an input line for inputting an
external signal.

5 38. A chip according to claim 33, wherein said
light-receiving element is an element for storing
optical pumping carriers generated in accordance with
optical information.

10 39. A chip according to claim 38, wherein said
carriers are stored in a control electrode region of
said light-receiving element.

 40. A photoelectric conversion apparatus
15 comprising a plurality of sensor chips according to
claim 33.

 41. An apparatus according to claim 40, wherein
said sensor chips are arranged such that
20 light-receiving elements of said sensor chips are
arranged in a line.

 42. A reading apparatus comprising:
 a photoelectric conversion apparatus according to
25 claim 41;
 a signal processor for receiving an output signal
from said photoelectric conversion apparatus; and





1 a driver for driving said photoelectric conversion
apparatus.

43. A method of reading a photoelectric conversion
5 apparatus having:

 a plurality of light-receiving elements;
 an amplifier for receiving outputs from said
light-receiving elements; and
 a controller for controlling an operation state of
10 said amplifier, comprising the steps of:
 enabling at least an amplifier of an nth sensor
chip to be read; and
 enabling an amplifier of an (n+1)th sensor chip by
a signal output on the basis of an operation of said
15 nth sensor chip.

44. A method according to claim 43, wherein the
signal output on the basis of the operation of said nth
sensor chip is an output from said light-receiving
20 element in said nth sensor chip or an output signal
according to the output.

