MEASURING INSTRUMENT AND METHOD FOR MEASURING FEATURES ON A SUBSTRATE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] Referenced-Applications

[0002] This invention claims priority of a German filed patent application DE-A-100 01 239.6.

BACKGROUND OF INVENTION

[0003] The invention concerns a measuring instrument for measuring features on a substrate.

[0004] The invention furthermore concerns a method for measuring features on a substrate, the nonoptical measurement being performed under normal atmospheric pressure conditions.

[0005] The resolution of existing and future purely optical measurement systems will reach a limit in the 100 nm region. For the accuracy requirements of the current generation of semiconductor substrates (less than 10 nm), a resolution very much smaller than the feature dimensions is necessary. Even with current photolithographic masks, in which the masks and substrates have a 5× magnification, optical measurement technology is encountering its limits. This is true to an even greater extent for future lithography methods, which may have 1-to-1 imaging, and for the measurement of wafers. Nonoptical systems could achieve a greatly improved resolution. A high throughput rate and user-friendly operation are absolutely necessary in order for the new systems to be successful.

[0006] A measurement system that combines an optical and a nonoptical method is disclosed in JP Unexamined Application 09/119825. The measurement system comprises a large vacuum chamber in which the coordinates of the specimen are measured both with an optical method and with a nonoptical method. A light beam and a photodetector are used to determine the absolute coordinate I of a reference point on the specimen that is located a specific distance away from the origin. The relative coordinate L-I, referred to the absolute coordinate, is determined using an electron beam and a charged-particle detector. The specimen is displaced inside the vacuum chamber, using a slide, from the optical measurement point to the electron beam measurement point. An interferometer monitors and controls the displacement travel inside the vacuum chamber. This system has one critical disadvantage: the entire measurement must be performed in a vacuum, resulting in cumbersome handling for the user. The throughput with this system is also limited by the vacuum chamber.

[0007] A purely optical measuring instrument for determining the position of features on a transparent substrate is disclosed in DE Patent Application A-198 19 492.7-52. In this, the position of a feature on the substrate is defined by the distance of an edge of the feature relative to a reference point. The measuring instrument comprises a reflected-light illumination device, an imaging device, and a detector device for the imaged features, and a measurement table that is displaceable interferometrically relative to the optical axis. To receive the substrate, the measurement table is configured as an open frame. Provided beneath the measurement table is an illumination device whose optical axis aligns with the optical axis of the reflected-light illumination device.

SUMMARY OF THE INVENTION

[0008] It is the object of the invention to create a measuring instrument that yields reproducible measurement results of very small features on a substrate of future feature dimensions, guaranteeing user-friendliness and a high throughput rate.

[0009] The object is achieved by a measuring instrument which is characterized in that a support element is provided opposite the substrate; that a nonoptical measurement device is mounted on the support element; and that ambient air pressure exists between the nonoptical measurement device and the substrate.

[0010] A further object of the invention is to create a method that yields reproducible measurement results of very small features on a substrate of future feature dimensions, guaranteeing user-friendliness and a high throughput rate.

[0011] This object is achieved by a method which comprises the following steps:a) moving to the feature (**19**) that is to be measured, under ambient air pressure;b) ascertaining a coarse position of the feature (**19**) on the substrate;c)measuring the feature (**19**) that was moved to, using a nonoptical measurement device (**23**) under ambient air pressure; and d)determining the exact position and extent of the feature (**19**)Advantageous developments are evident from the features of the dependent claims.

[0012] Reproducible measurement results can be obtained with the configuration according to the present invention of the measuring instrument and the method. A particularly cost-effective and user-friendly effect results from the fact that the nonoptical measurement is performed under ambient atmospheric pressure. "Ambient atmospheric pressure" is considered to be the air pressure that is naturally present; this also refers to the air pressure in a climate chamber which regulates relative humidity and temperature but not air pressure. This becomes particularly apparent when the feature arrived at is measured using an electron beam that is generated with an electron beam lens. In this case it is then not necessary for the entire measuring instrument to be surrounded by a vacuum chamber in order to be able to perform the measurement.

[0013] The nonoptical measurement can be performed, for example, with an AFM (atomic force microscope). The throughput can be increased with an additional optical microscope or a corresponding lens. What is exploited in this context is the fact that the measurement with the optical microscope is accomplished much more quickly than with the nonoptical measurement device. For that purpose, the lens is used to select the point on the substrate that is to be more precisely examined or measured. The AFM then measures maximally in the measurement window selected by the lens.

[0014] A rigid connection, here in the form of the support element, between the AFM and the lens results in a rigid coupling of these two components. An interferometer allows an accurate determination of the position of the support element and thus also of the components arranged on the support element. The AFM can thus be positioned exactly in