

CLAIMS

1. A measurement device for measuring a thin film on a transparent substrate, comprising, disposed sequentially along a direction of light propagation, a light source, a collimator lens, a filter, a polarizer, a beam splitter and an objective lens, the beam splitter being in connection with a planar array detector and a processor, an illumination light emitted by the light source sequentially passing through the collimator lens, the filter, the polarizer, the beam splitter and the objective lens and thereby forming a measuring light incident on the thin film on the transparent substrate, the objective lens and the beam splitter gathering light reflected from the thin film on the transparent substrate, the planar array detector and the processor measuring physical parameters of the thin film on the transparent substrate based on the gathered reflected light, wherein the measurement device further comprises a stop configured to block interfering light reflected from the transparent substrate during the measurement,

wherein the stop is disposed in a back focal plane of the objective lens.

2. The measurement device according to claim 1, wherein the stop has a diameter L1 calculated as:

$$L1 = \frac{NA_interferece}{NA_objective} \times L2, \text{ where } NA_interferece = n \times \sin\theta_1, \theta_1 = \arctan\left(\frac{L3 + L4}{4h}\right),$$

$NA_interferece$ represents a maximum numerical aperture of interfered light reflected from the thin film, $NA_objective$ denotes a maximum numerical aperture of the objective lens, L2 is a diameter of the back focal plane of the objective lens, n is a refractive index of the transparent substrate, h is a thickness of the transparent substrate, θ_1 is an angle of refraction of the measuring light within the transparent substrate, L3 is a diameter of a maximum field of view of the objective lens, and L4 is a diameter of a field of illumination of the light source during the measurement.

3. The measurement device according to claim 1, wherein the light source is a halogen lamp or a xenon lamp.

4. The measurement device according to claim 1, wherein the filter is a narrow-band filter.

5. The measurement device according to claim 1, wherein the polarizer is a polarizing plate or a polarizing prism.

6. The measurement device according to claim 1, wherein the beam splitter is a right-angle splitting prism or a half-silvered mirror.

7. The measurement device according to claim 1, wherein the planar array detector is a charge-coupled device detector or a complementary metal-oxide-semiconductor detector.

8. A measurement method for measuring physical parameters of a thin film on a transparent substrate, comprising the steps of:

1) provision of a measurement device for measuring the thin film on the transparent substrate, the measurement device comprising, disposed sequentially along a direction of light propagation, a light source, a collimator lens, a filter, a polarizer, a beam splitter, an objective lens and a stop, wherein the stop is disposed in a back focal plane of the objective lens;

2) provision by the light source of an illumination light that passes sequentially through the collimator lens, the filter and the polarizer and is reflected by the beam splitter, wherein a planar array detector and a processor is connected to the beam splitter;

3) passage of the reflected light resulting from step 2) through the objective lens to form a measuring light and incidence of the measuring light on the thin film on the transparent substrate;

4) convergence of light reflected from the thin film on the transparent substrate on the back focal plane of the objective lens, blockage by the stop of interfering light reflected from the transparent substrate, and reflection by the beam splitter of unblocked reflected

light onto the planar array detector which thereby forms an image and feeds signals of the image to the processor; and

5) measurement by the processor of the physical parameters of the thin film by processing the signals of the image fed back from the planar array detector.

9. The measurement method according to claim 8, wherein the measurement of the physical parameters of the thin film is accomplished by filtering out angular spectrum signals in light scattered from the thin film that are interfered with by the light reflected from the transparent substrate based on a thickness of the transparent substrate, a diameter of a field of view of the objective lens, a diameter of a field of illumination of the light source during the measurement and a diameter of the stop.

10. The measurement method according to claim 9, wherein the diameter of the stop is indicated at L1 and calculated as:

$$L1 = \frac{NA_interference}{NA_objective} \times L2, \text{ where } NA_interference = n \times \sin\theta_1, \theta_1 = \arctan\left(\frac{L3 + L4}{4h}\right),$$

NA_interference represents a maximum numerical aperture of interfered light reflected from the thin film, NA_objective denotes a maximum numerical aperture of the objective lens, L2 is a diameter of the back focal plane of the objective lens, n is a refractive index of the transparent substrate, h is the thickness of the transparent substrate, θ_1 is an angle of refraction of the measuring light within the transparent substrate, L3 is a diameter of a maximum field of view of the objective lens, and L4 is a diameter of the field of illumination of the light source during the measurement.

11. A measurement method for measuring physical parameters of a thin film on a transparent substrate, comprising the steps of:

1) provision of a measurement device for measuring the thin film on the transparent substrate, the measurement device comprising, disposed sequentially along a direction of light propagation, a light source, a stop, a collimator lens, a filter, a polarizer, a beam

splitter and an objective lens, wherein the stop is disposed at a conjugate of a pupil plane of an illumination optical path of the light source;

2) provision by the light source of an illumination light in which components with small angles of incidence are blocked by the stop and components with large angles of incidence pass therethrough, resulting in annular illumination light that passes sequentially through the collimator lens, the filter and the polarizer and is reflected by the beam splitter, wherein a planar array detector and a processor is connected to the beam splitter;

3) passage of the reflected light resulting from step 2) through the objective lens to form a measuring light and incidence of the measuring light on the thin film on the transparent substrate, which avoids focusing of interfering light signals resulting from reflection of components of the illumination light that are incident at small angles;

4) passage of light reflected by the thin film on the transparent substrate at a same angle through the objective lens and reflection thereof by the beam splitter onto the planar array detector which thereby forms an image and feeds signals of the image to the processor; and

5) measurement by the processor of the physical parameters of the thin film by processing the signals of the image fed back from the planar array detector,

wherein the measurement of the physical parameters of the thin film is accomplished by filtering out angular spectrum signals in light scattered from the thin film that are interfered with by the light reflected from the transparent substrate based on a thickness of the transparent substrate, a diameter of a field of view of the objective lens, a diameter of a field of illumination of the light source during the measurement and a diameter of the stop,

wherein the diameter of the stop is indicated at L1 and calculated as:

$$L1 = k \frac{NA_interferece}{NA_objective} \times L2, \text{ where } NA_interferece = n \times \sin \theta_1, \theta_1 = \arctan\left(\frac{L3 + L4}{4h}\right),$$

NA_interferece represents a maximum numerical aperture of interfered light reflected

from the thin film, $NA_{\text{objective}}$ denotes a maximum numerical aperture of the objective lens, $L2$ is a diameter of the back focal plane of the objective lens, n is a refractive index of the transparent substrate, h is the thickness of the transparent substrate, θ_l is an angle of refraction of the measuring light within the transparent substrate, $L3$ is a diameter of a maximum field of view of the objective lens, $L4$ is a diameter of the field of illumination of the light source during the measurement, and k is a magnification coefficient.

12. The measurement method according to claim 11, wherein the stop is an adjustable stop.