RT Measurements at 45º Angle of Incidence

System Description

The measurement system layout is shown in Fig.1.
A YAG laser beam is modulated by a chopper and combined with He-Ne laser beam a dichroic mirror DM. Both beams pass through alignment aperture and Glan-Thompson polariser with polarisation ratio approximately 1:1000000. An aluminium mirror M directs the beam onto the beam splitter surface. The mirror is mounted in a gimbal adjuster and fixed on a rotation stage with a resolution 0.017º (1 arc second). Two nominally identical integrating spheres (Thorlabs IS 200-4) are used to detect the transmitted and reflected portions of the beam (SA and SB in fig. 1). The spheres are connected to the inputs of two lock-in amplifiers with identical parameters (Signal Recovery models 7230 and 7270). In order to obtain reflectance/transmittance maps, the substrate is translated in the X-Y plane and signals from both channels are recorded simultaneously.

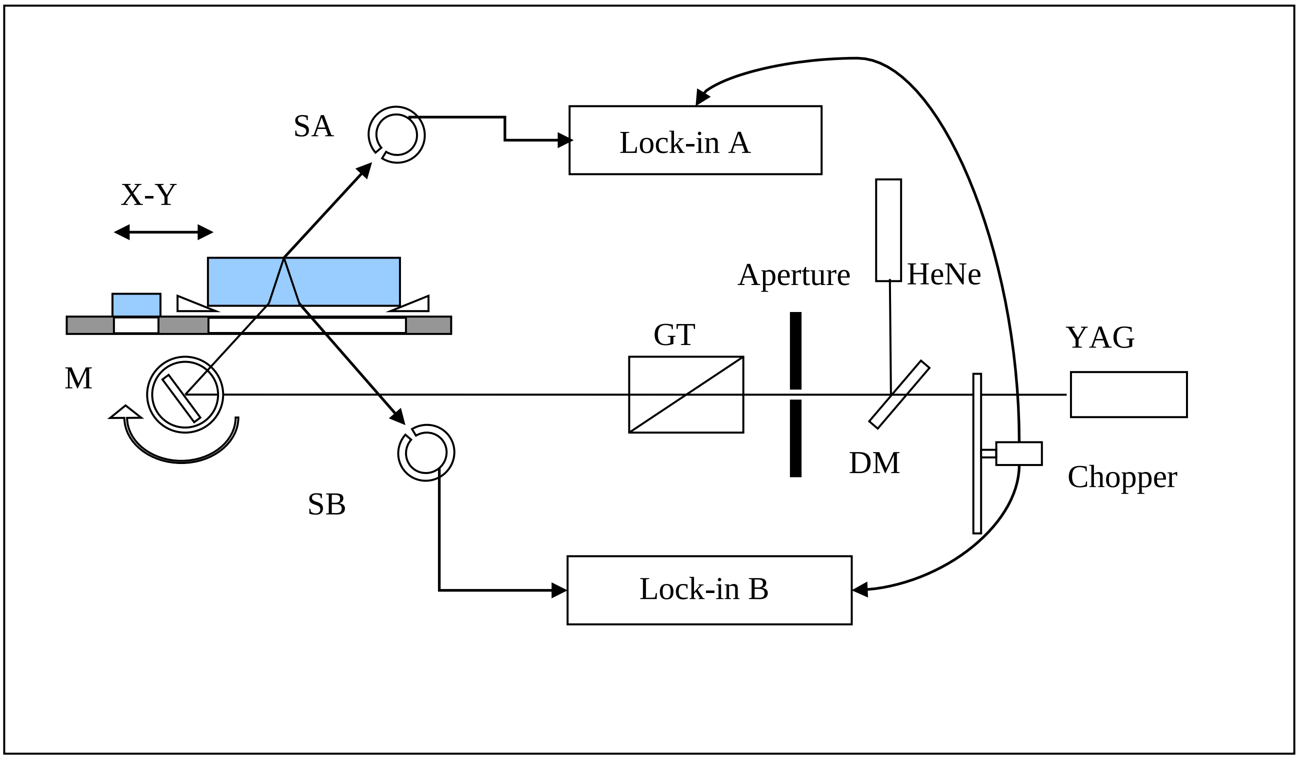

Fig. 1. RT measurement system layout.

Initial Alignment

Initially scale of the rotation stage is set to 0 ±0.02º and the X-Y stage positioned in such way that the laser beams are reflected from a reference flat which is placed on the X-Y stage platform (Fig. 2). The gimbal mount holding the mirror M adjusted so that the beams are reflected back to the alignment aperture. After that the substrate is positioned above the beam and aligned by means of three adjustable lifters (not shown in the figure) to reflect the beam back to the aperture. After that the rotation stage with the mirror M is set to 22.5±0.02º and measurement scans are started.

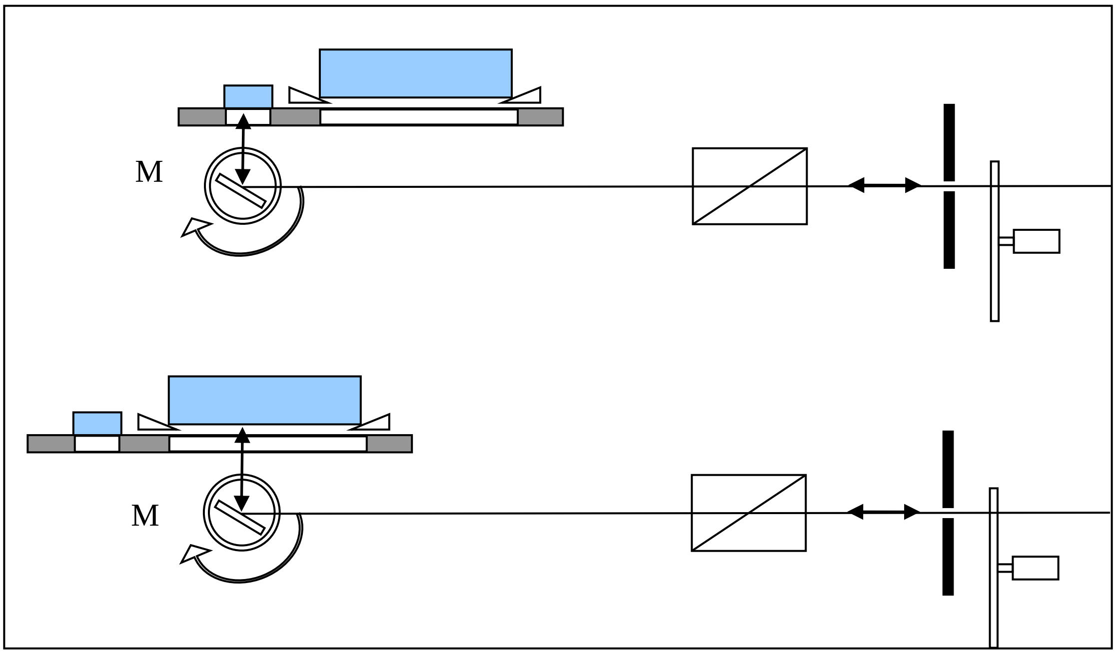

Fig.2. Initial alignment.

RT Measurements

During the first scan two sets of signals (photodiode currents) are obtained from the spheres that are proportional to transmission and reflection:

$$I_{Ta} \propto T_a$$

$$I_{Rb} \propto R_b$$

Then the spheres are swapped and another scan is performed, providing a second set of data:

$$I_{Ra} \propto R_a$$

$$I_{Tb} \propto T_b$$

On the assumption that the reflection of the anti-reflection coating is negligible the sum of the signals from the two scans for each detector at each point must be constant:

$$I_{Ta} + I_{Ra} = const_a = 100\%$$
$$I_{Tb} + I_{Rb} = const_b = 100\%$$

The transmission/reflection of the surface can be than calculated as:

$$T_a = \frac{I_{Ta}}{I_{Ta} + I_{Ra}}$$

$$R_b = \frac{I_{Rb}}{I_{Tb} + I_{Rb}}$$

Results of measurements for BS02HR and BS03HR are shown in Figs. 3 and 4. The accuracy of the data obtained is mostly affected by drift of the laser intensity and the position sensitivity of the detectors. These errors can be estimated by the value of the sum $T_a + R_b$ (Figs. 5 and 6).

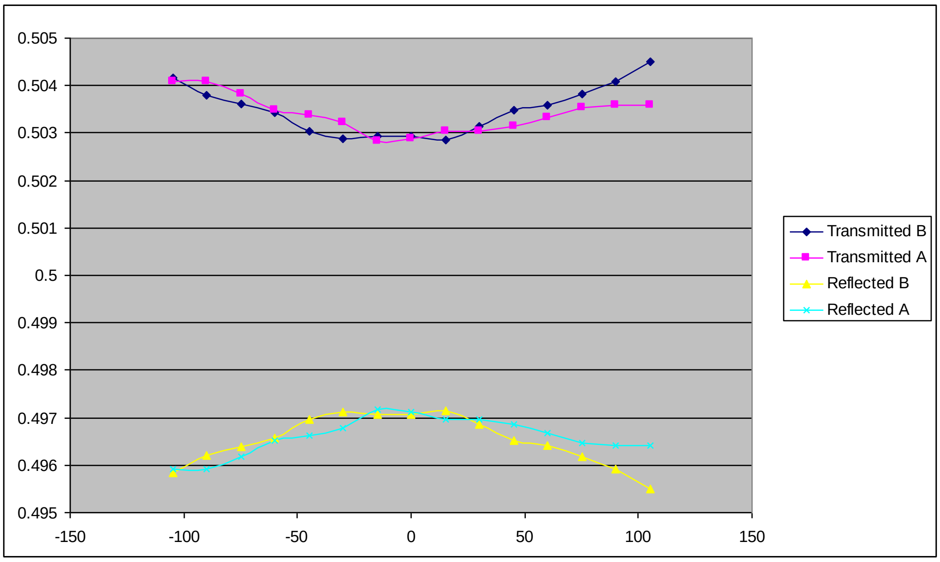

Fig.3. RT measurements of BS02HR.

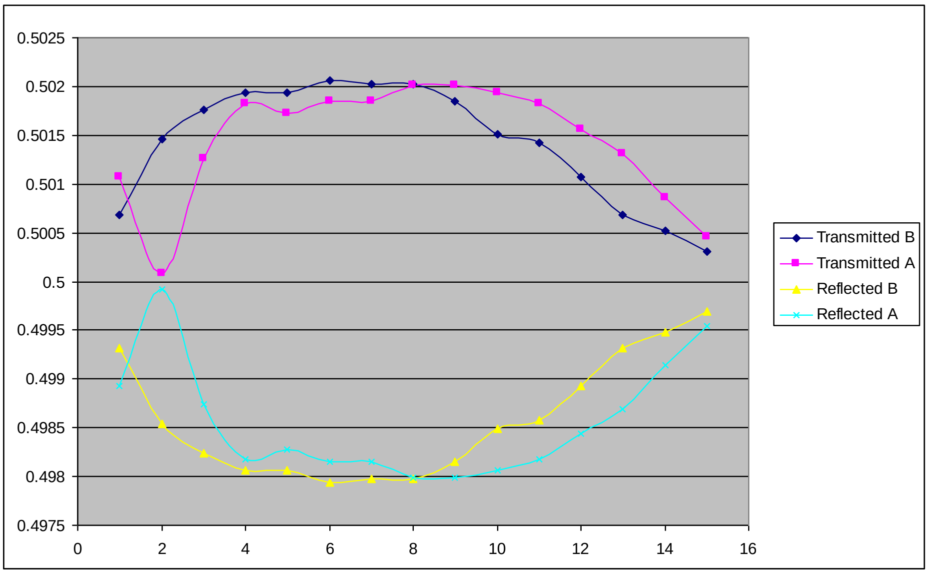

Fig.4. RT measurement of BS03HR.

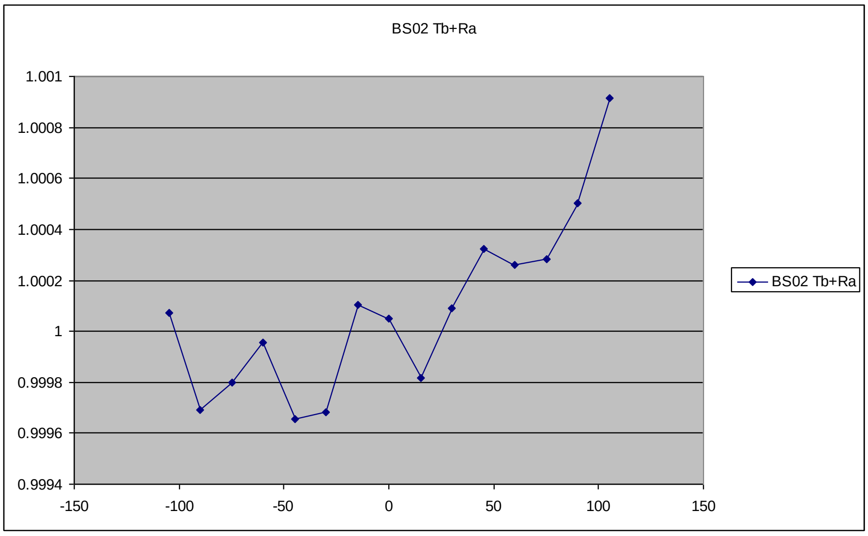

Fig.5. Sum of R and T obtained from two detectors for BS02HR.

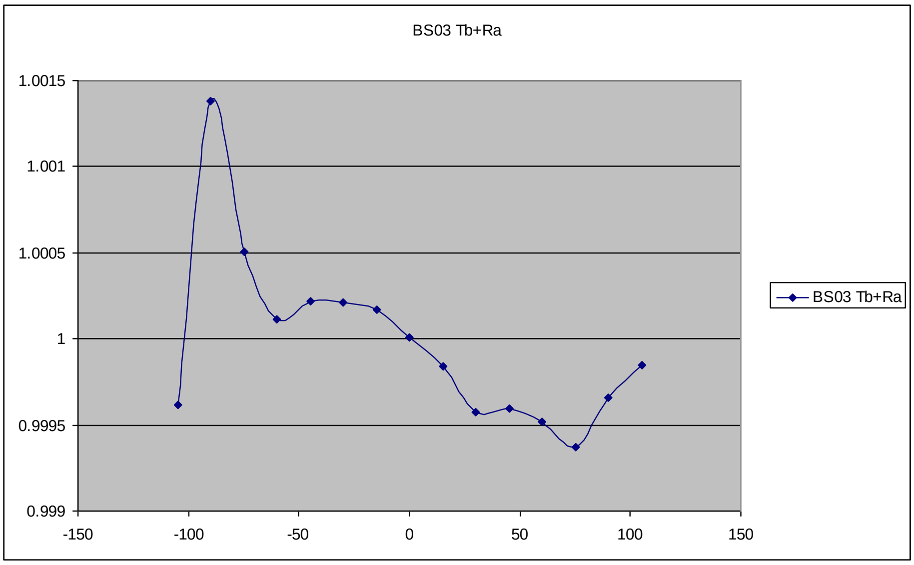

Fig.6. Sum of R and T obtained from two detectors for BS03HR.