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Variable wavelength interferometry. X. Instrumentation

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Principles, abilities and some applications of the VAWI method and its specific techniques have previously been discussed in the papers of this series. Due to the VAWI method, an old version of the double-refracting microinterferometer has been improved and two other versions have been constructed anew. These are described in this paper, which brings this series to an end.

1. Introduction

Double-refracting wavefront shear interferometric systems are especially suitable for the VAWI (variable wavelength interferometry) method. A specific microinterferometric system with variable wavefront shear was devised by the author many years ago [1], [2], which was a basis for designing a polarization (*P*) interference (*I*) microscope. This was and still is mass-produced by the Polish Optical Works (PZO), Warsaw. Originally, its short name was MPI 5 and then (from the 1970s) Biolar PI. In microscopy literature these two versions of the same instrument are known as the Pluta interference microscope (see, e.g., [3]–[6]).

This instrument was initially devoted to both quantitative and qualitative studies of cells and their organelles, tissues and other biological objects, thus was performed on a stand of a biological microscope. Its measuring abilities have next been spread over other areas of science and technology, including especially both textile and optical fibres, thin films, layers, stretched foils, microcrystals, polymers, powders, spherical glass shells for laser-fusion experiments, and many other objects and materials. There are more than hundred papers dealing with the use of the MPI 5 and Biolar PI microscopes for various studies which have been reported in scientific and technical journals in the past three decades.

Recently, the Biolar PI microscope has been enriched with accessories for variable wavelength interferometry. This improved version is referred to as the Biolar VAWI microinterferometer. Simultaneously, a highly advanced VAWI instrument for both transmitted-light and reflected-light microinterferometry, referred shortly to as the Biolar PI dia+epi, has been constructed. It is a standard that the latter includes the accessories for the VAWI techniques; while the former includes them only additionally. Both, however, can be transformed into a conventional biological microscope (Biolar) by removing the double-refracting equipment and devices for both common microinterferometry and VAWI method.

Quite recently, an individual technical solution has been introduced to the VAWI instrumentation, namely, a double-refracting microinterferometer has been constructed which includes originally the WAVI techniques and VADIC (variable DIC) interferometry. The latter is suitable for the study of surface roughness in reflected light. This instrument is simply denoted by VADRI–DE.

2. Biolar VAWI

This instrument was already presented, but sporadically and shortly, in the previous papers of this series. Its double-refracting interference system (Fig. 1) is capable of giving both fringe field and uniform field interference patterns in the image plane (Π'). Three combinations of two simultaneously acting birefringent prisms (W_0 and W_1 or W_2), made of quartz crystal, are used. Three prisms, referred to as the tube prisms, are incorporated in an intermediate tube (IT) and denoted by numbers 1, 2 and 3. The prisms No. 1 and No. 3 produce uniform field interference (UFI) in the image plane, while the prism No. 2 produces fringe field interference (FFI) in this plane. All these prisms are arranged in a switch-driven revolving disc (RD) mounted in a carriage (not shown in Fig. 1). The latter is installed in a housing (H), which is preceded by a tube lens (L_1) and followed by the analyser (A) and another tube lens (L_2). The above-mentioned optical elements and mechanical components are incorporated in the intermediate tube referred to as the interferometric head, mounted between the microscope body tube including the nosepiece and the binocular head or a monocular tube (the latter is shown in Fig. 1 and recommended for precise microinterferometric measurements).

The carriage, together with the birefringent prisms W_1 and W_2, can be slid in a direction perpendicular to the optical axis of the double-refracting interference system as shown by the arrowed line p. This movement is performed by means of a highly precise micrometer screw (PS), referred to as the phase screw due to the fact that the transverse movement of the tube birefringent prism changes linearly the phase between two interfering light waves. The elementary divisions of the phase screw scale are equal to 0.01 mm. The scale, however, can be read with an accuracy up to 1 μm by using additionally a loupe (see Fig. 2) which may readily by attached to the interferometric head. In general, the screw (PS) serves for measuring the

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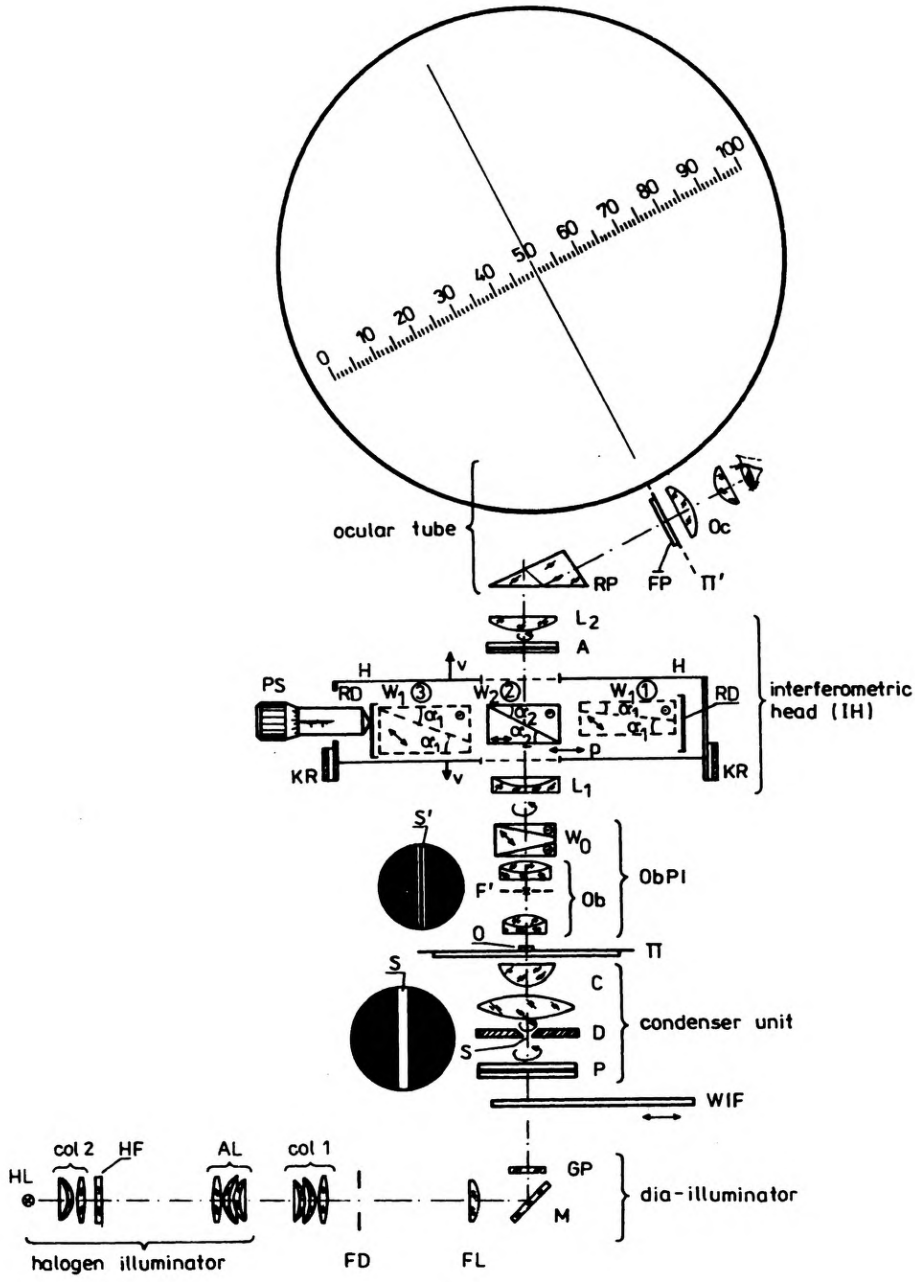
Fig. 1. Optical system of the double-refracting microinterferometer Biolar VAWI. HL – halogen tungsten lamp (12 V/100 W), col 1 and col 2 – collectors, HF – heat filter, AL – auxiliary lenses, FD – field diaphragm, FL – field lens, M – mirror, GP – glass plate, WIF – wedge interference filter (Veril S 200, Schott Glaswerke, Mainz), P – polarizer, D – slit diaphragm, S – slit coincident with the front focal point of the condenser C, Π – object plane, O – object under study, Ob – microscope objective, F' – its back focal point, S' – image of the slit (S) (S' is normally coincident with F'), W_0 – objective birefringent prism, L_1 and L_2 – tube lenses, W_1 and W_2 – tube birefringent prisms installed in a revolving disc RD, KR – knurled ring for adjusting the tube birefringent prisms along the vertical (v) direction, PS – micrometer screw, referred to as the phase screw, for moving the birefringent prisms W_1 and W_2 along the transverse



direction marked by the arrowed line (p), H – holder of the revolving disc (RD) with the tube birefringent prisms, A – analyser, RP – reflecting prism, Π' – image plane coincident with the front focal plane of microscope ocular (Oc), FP – focal plate with the central pointer line and scale (elementary divisions of the scale are equal to 0.1 mm). The figure is not quite true to the actual arrangement of the consecutive units of the microinterferometer (explanation in the text)

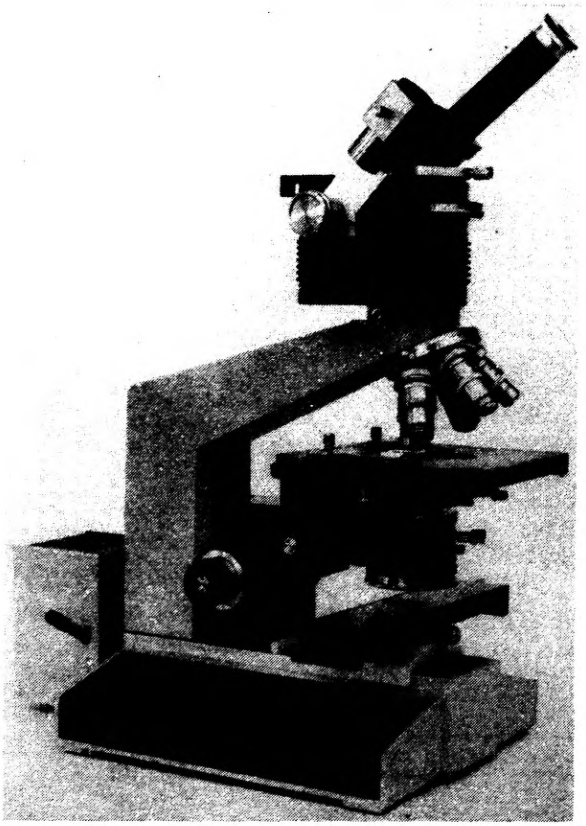


Fig. 2. Double-refracting variable-wavelength microinterferometer Biolar VAWI

optical path difference produced by an object under study and for varying the interference contrast or interference colours when UFI method and white light are used, but when the WAVI method or any its special technique (VAWI–1, VAWI–2, VAWI–3) is employed, this screw serves for measuring the interfringe spacing(s).

The tube birefringent prisms produce the wavefront shears or image duplications (d), relative to the object plane (Π), as follows: $d_1 = 20/M$ μm (prism No. 1), $d_3 = 65/M$ μm (prism No. 3), and $d_2 = 320/M$ μm (prism No. 2), where M is the magnifying power of the microscope objective used. Normally, four objectives are included to the microinterferometric equipment: $10\times/0.25$, $20\times/0.40$, $40\times/0.65$, and $100\times/1.25$ (oil immersion). Each of these objectives (Ob) is provided with a quartz birefringent prism W_0 rotatable about the objective axis and called the objective prism. The objective (Ob) together with its prism W_0 constitute a compact unit denoted by ObPI. The rotation of this prism enables the amount and direction of the resultant wavefront shear d (or image duplication) to be changed. The individual wavefront shears d_0 produced by the prism W_0 and related to the

object plane Π are equal to about 40 μm, 20 μm, 12 μm, and 4 μm for objectives of magnifying power 10×, 20×, 40×, and 100×, respectively. When rotated, the objective prism W_0 may be set at five privileged positions with respect to each of the tube birefringent prisms W_1 and W_2: 1) additive, 2) subtractive, 3) left-handed crossed, 4) right-handed crossed, and 5) four neutral positions.

For the first situation (shown in Fig. 1), the resultant wavefront shear d is equal to $d = d_0 + d_T$, where d_T denotes the individual wavefront shears due to the tube birefringent prisms ($d_T = d_1$, d_2 or d_3). This additive position of the objective prism W_0 produces the maximum resultant wavefront shear d.

When the prism W_0 is rotated through 180°, starting from its additive position, we will obtain the subtractive position for which $d = d_0 - d_T$. If the tube prism W_2No. 2 is used, the resultant wavefront shear $d \approx 0$, and such a situation is equivalent to fringe differential interferometry (FDI) suitable for the measurement of the optical path difference gradient or other optical gradient, and for the birefringence measurements.

The crossed positions (left-handed and right-handed) will be achieved if the prism W_0 is rotated through an angle +90° or −90°, starting from its additive or subtractive position. The crossed positions are the most useful ones since they produce two images of a fibre, an extended narrow strip, a groove, and other lengthwise extended objects when they are oriented at right angles to the interference fringes produced by the tube birefringent prism W_2 in the image plane. The two images are fully separated from each other if the object width is smaller than d_0 though the resultant wavefront shear is now equal to $d = \sqrt{d_0^2 + d_T^2}$.

The neutral positions occur if the rotation angle of the objective prism W_0 is equal to 45°, 135°, 225° and 315°, starting from the additive position. In this case, the prism W_0 does not work and the resultant wavefront shear is simply equal to the wavefront shear produced by the tube birefringent prism ($d = d_T$). These positions are much less useful than the previous ones and do not apply to birefringent objects.

The maximum wavefront shear d which is attainable (with ObPI 10×) is equal to $445/M$ μm for the UFI method and $700/M$ μm for the FFI method. There are, however, no objections to increase these values (twice at least) by using an objective (PI) with lower magnifying power than 10× or a special objective 10× whose rear focal point is above or close to the last objective lens.

The objective birefringent prism W_0 is axially adjusted so that it produces individually uniform field interference in the image plane Π′, and thus the fringe interference pattern in this plane is created only by the tube birefringent prism W_2. Rotating the objective prism W_0 changes the amount and direction of image duplication, whereas the direction of fringes in the image plane and the interfringe spacing remain unchanged. Such an independence of the interfringe spacing from the image duplication is certainly an advantage of this interferometric system.

The Biolar WAVI instrument is normally equipped with a bright-field condenser for dia-illumination, but a slit diaphragm (D) (Fig. 1) is positioned in the front focal plane of this condenser (C). The diaphragm is rotatable about the condenser optical axis to orientate the slit (S) always at right angles to the direction of the resultant

wavefront shear *d*. The width of the slit (S) is controlled and optimized for a selected (additive, subtractive, crossed, neutral) position of the objective prism W_0. It is worth noting that for the additive, subtractive and neutral positions of this prism, the direction of the slit (S) is the same, as shown in Fig. 1, and differs for both crossed positions depending on the tube birefringent prism used. If, in particular, prism W_2 is used, the slit (S) must be rotated by about $+45°$ and $-45°$ for the crossed left-handed and right-handed positions of the prism W_0, respectively, starting from the slit orientation shown in Fig. 1.

The slit condenser diaphragm (D) is presented by a rotatable polarizer (P). This is normally set so that its transmission axis (direction of light vibration) is crossed with that of the analyser (A) and forms an angle of 45° with the principal section (shown in Fig. 1) of the tube birefringent prism used.

A tungsten-halogen lamp (12 V/100 W or 12 V/50 W) is standardly employed for illumination of an object under study (O) in accordance with the Köhler principle. Monochromatic light of continuously variable wavelength required for the VAWI method is extracted from the white light source mentioned above by means of the wedge interference filter WIF (linear variable interference filter VERIL S 200, Schott Glaswerke, Mainz), whose spectral dispersion is equal to 0.37–0.47 mm/nm. Due to the slit condenser diaphragm (D), this filter especially well functions as an extremely simple monochromator. Its local peak wavelength is determined in real time by using a basic calibration plot $b(\lambda)$ attributed to the microinterferometer in question, where b is the interfringe spacing produced by a given tube birefringent prism and measured directly by means of the phase screw (PS). The interference fringes produced by the prism W_2 are observed in the image plane Π' with the help of the ocular (Oc) of magnifying power $12.5\times$. This ocular is fitted with a graticule consisting of a central pointer line and a scale. The pointer line serves as a reference line to measure the interfringe spacing as mentioned above and process the fringe interference patterns when the VAWI–3 technique is employed. On the other hand, the VAWI–2 technique requires two pointer lines, which may be selected from the longer lines of the scale; those denoted by the numbers 10 (or 20) and 90 (or 80) are the most convenient.

The tube birefringent prisms W_1 No. 1 and No. 3 produce uniform field interference in the image plane Π', but their own interference fringes may be observed in the back focal plane of the objective (Ob) if the ocular (Oc) will be replaced by an auxiliary low-power microscope. Now the image (S′) of the sub-condenser (S) serves as a reference line for measuring the interfringe spacings (another measuring procedure has been described in [7]).

Like the original Biolar PI instrument its VAWI version is (or can be) equipped with conventional microscope objectives (i.e., without birefringent prisms W_0), which are primarily useful for differential interference contrast (DIC) microscopy of the Nomarski type. This technique is realized by using the tube birefringent prism W_1 No. 1 and either the condenser with slit diaphragm (shown in Fig. 1) or that with birefringent compensators (Wollaston prisms); the latter, in contrast to the slit, do not reduce the numerical aperture of the condenser.

Additionally, four homogeneous (constant-wavelength) interference filters of high monochromaticity (system design DIF, after [8]) are also available for conventional constant-wavelength interferometry using alternatively the Biolar VAWI instrument. Their peak wavelengths are equal to about 463 nm, 546 nm, 590 nm, and 656 nm.

An accurate calibration graph $b(\lambda)$, i.e., the plot of the interfringe spacing b as a function of light wavelength λ, is extremely essential to use the VAWI method effectively and precisely. This can be done with the help of a quartz calibration plate (see [9]), which is also included to the supplementary equipment of the Biolar VAWI microinterferometer.

It should be noted that Fig. 1 is not quite true to the actual arrangement of the successive units of the microinterferometer Biolar VAWI. For clarity, the wedge interference filter WIF, the slit diaphragm (D), the slit image (S′), and the interferometric head (IH) are turned round the optical axis of the interferometer by an angle of 90°.

It is also worth noting that the halogen illuminator can be replaced by an ordinary microscope lamp (low-voltage lamp 6 V/15 W or 6 V/30 W) which works only with a single collector (col 1) permanently installed within the microscope base. To balance the focusing power of the collector col 1, when the halogen illuminator replaces the ordinary low-voltage lamp, an auxiliary lens system (AL) is added to the collector col 2 of the halogen lamp (HL). This lamp, its collector, heat filter (HF), and lenses (AL) constitue a compact unit available commercially from the Polish Optical Works (PZO), Warsaw (OH is the factory symbol of this unit).

If the wedge interference filter WIF and the halogen illuminator are removed, the microinterferometer Biolar VAWI will simply be transformed into the polarization-interference microscope Biolar PI available commercially from PZO.

However, the condenser unit of the original Biolar PI instrument incorporates a slit diaphragm which cannot be rotated about the optical axis of the interference system independently of the condenser (C) and polarizer (P). This disadvantage does not occur in the microinterferometer Biolar VAWI whose slit diaphragm (D) may be rotated round the condenser axis at will to adjust rapidly the orientation of the slit (S) when the position of the objective birefringent prism is changed from the additive or subtractive to the crossed one and vice versa. Fortunately, the condenser units with rotatable slit diaphragm for the Biolar PI microscope are commercially available from the author's institution.

3. Biolar PI dia + epi

There is no difficulty in extending the interference system described above (Figs. 1 and 2) to reflected light microinterferometry (Figs. 3 and 4). It is only important to note that an epi-illuminator does not require any slit diaphragm. In general, each double refracting prism of the Wollaston type divides the incident light wave into two components whose phase difference changes monotonically along the prism length starting from its centre. This phase difference gives rise to parallel and equidistant straight interference fringes which can be observed in the objective exit

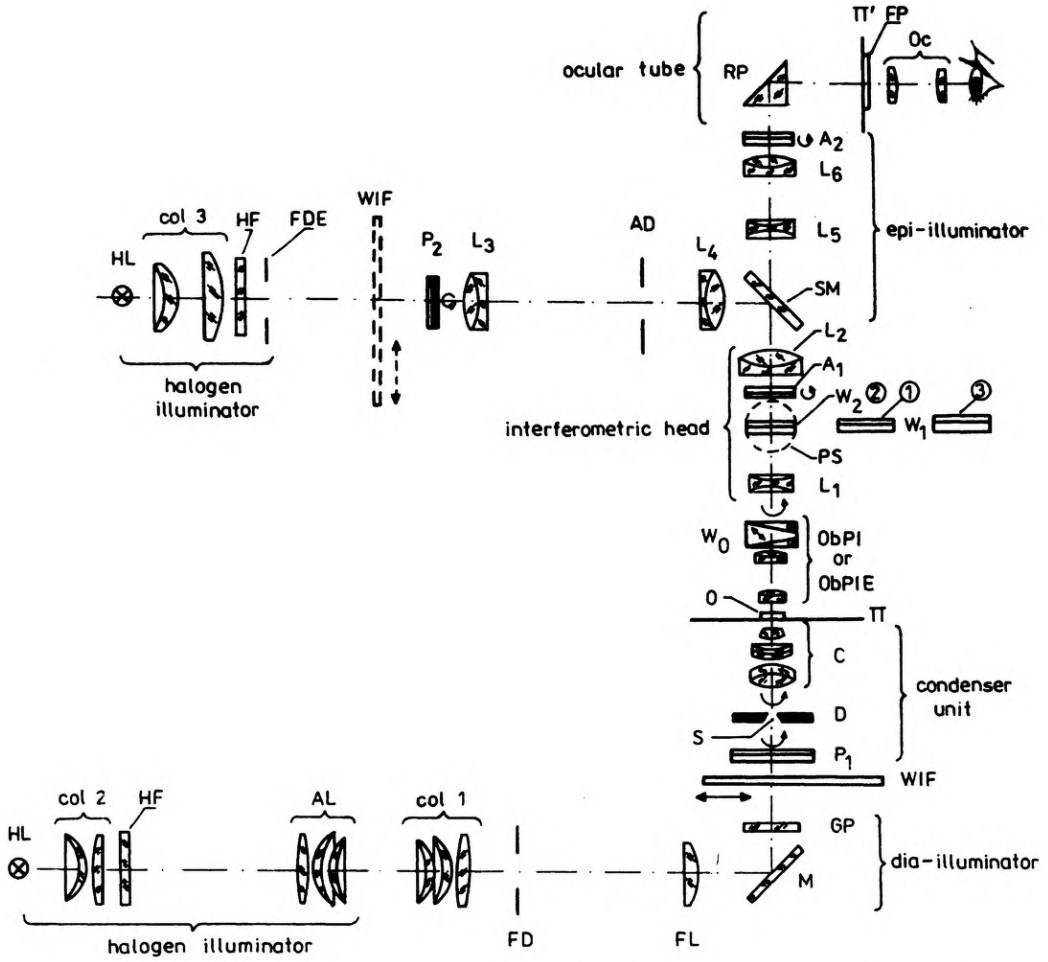


Fig. 3. Optical system of the variable-wavelength double-refracting microinterferometer Biolar PI dia+epi. HL – halogen lamp (12 V/100 W), col 1 and col 3 – collectors, HF – heat filter, FD – field diaphragm, FL – field lens, M – mirror, GP – glass plate, WIF – wedge interference filter (Veril S 200, Schott Glaswerke, Mainz), P_1 and P_2 – polarizer, D – slit diaphragm, S – slit coincident with the front focal point of the condenser (C), Π – object plane, O – object under study, Ob – microscope objective, W_0 – objective birefringent prism, L_1 and L_2 – tube lenses, W_1 and W_2 – tube birefringent prisms, PS – micrometer screw (phase screw) for transverse moving the prisms W_1 and W_2, A_1 – analyser for dia-microinterferometry, FDE – field diaphragm of the epi-illuminator, L_3 to L_6 – lenses of the epi-illuminator, AD – aperture diaphragm of the epi-illuminator, SM – semitransparent mirror, A_2 – analyser for epi-microinterferometry (A_1 is excluded when A_2 works, and vice versa), RP – reflecting prism, Π' – image plane coincident with the front focal plane of the ocular (Oc), FP – focal plate with a central pointer line and scale (such as shown in Fig. 1)

pupil or above it if only dia-illumination is used and the birefringent prisms W_0 and W_1 or W_2 are subjected to a single passage of light waves. On the other hand, the epi-illumination system shown in Fig. 3 causes the double-refracting prisms to be

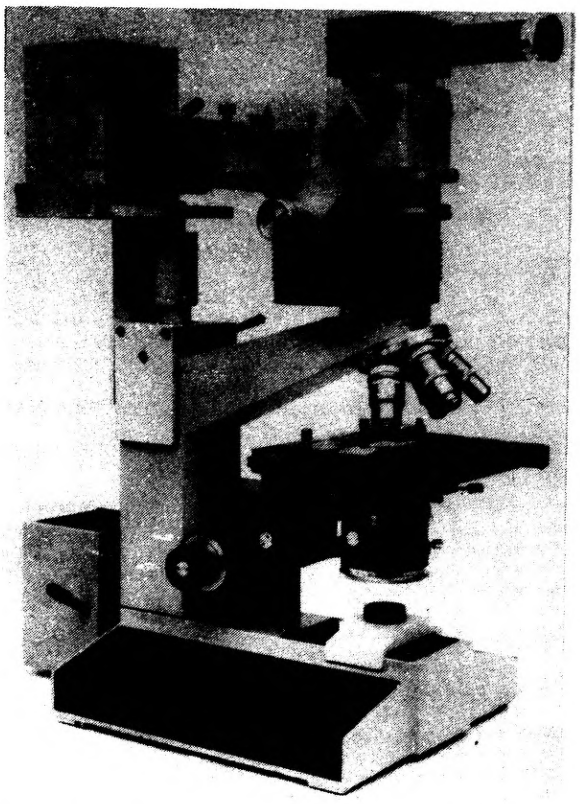


Fig. 4. Variable-wavelength double-refracting microinterferometer Biolar PI dia + epi

transilluminated two times: first by the rays incident upon and then by those reflected from the object under study (O). However, for the forwards rays and backwards rays the phase difference mentioned above is of opposite sign and cancels out, and thus the pupilar interference fringes overspread completely. Such a pupilar phase-difference autocompensation allows an extended light source to be used without any diaphragm to produce spatial coherency of epi-illumination. Consequently, any irys aperture diaphragm (AD) is quite satisfactory.

The epi-illumination system enables the object (O) to be illuminated in accordance with the Köhler principle to obtain interference patterns of high contrast in the image plane Π'. Unfortunately, the epi-illuminating beam, when passing through the objective lenses towards the object (O), is always partly reflected back from glass-air surfaces. These unwanted reflections of light are the source of stray light which considerably diminishes the contrast of interference patterns. It is, therefore, recommended to reduce the opening of the field diaphragm (FDE) as much as possible within the field of view. Normally, it is sufficient to observe such an object region which is actually measured.

The procedure of image duplication by rotating the objective birefringent prism

W_0 is the same for both transmitted-light and reflected-light microinterferometry. The objectives PI of magnifying power 10× and 20× for epi-microinterferometry do not differ from those for dia-microinterferometry. On the other hand, the epi-objective of magnifying power 40× (ObPIE) is another; namely, it is corrected at the zero thickness of cover slip. The immersion objective of magnifying power 100× is, as usual, inconvenient for epi-microinterferometry, but if necessary the same as for dia-microinterferometry can be employed.

4. VADRI—DE system

This system is similar to that shown in Fig. 3, but is free from the tube lenses L_2 and L_3. Thus, the level of stray light due to the reflections at the air-glass surafaces is significantly reduced in the epi-illumination mode of operation. This reduction is especially required for the reflected-light DIC technique.

The mechanical construction, however, differs (Fig. 5) from that of the Biolar PI dia+epi microinterferometer (Fig. 4). In particular, the interferometric head is completely changed and simplified. The tube birefringent prisms W_1 and W_2 are installed in three separate slides. Two of them incorporate the prisms W_1 for the UFI method using both conventional and PI objectives of magnifying power 10× and 20×. Each of these slides includes three prisms W_1 of different apex angle α_1 (equal to about 45′, 1.5° and 3°). These and the conventional objectives (10× and 20×) are used for DIC microscopy or rather variable differential contrast (VADIC) microscopy [10]. This technique is primarily recommended for the study of surface roughness in reflected light.

It is a well known fact that the Nomarski DIC technique is widely used for roughness studies of polished surfaces. In this technique, it is assumed that the wavefront shear (or image duplication) is extremely small, i.e., approximately equal to the resolving power of the microscope objective used. Is such a wavefront shear optimal for visualizing the surface relief? The question posed is answered in the negative. In general, surface roughness can be treated as a chaotic relief grating with a mean period or correlation length $\bar{l}_c$ averaged over a surface area. To assess the surface evenness and reveal roughness clearly in a global sense, the wavefront shear d must be equal to $\bar{l}_c/2$ or $d \approx \bar{l}_c/2$. The birefringent prisms W_1 mentioned above produce $d = d_1$, $2d_1$ and $4d_1$, where d_1 is the wavefront shear produced by the prism whose apex angle is equal to 45′ (d_1 is comparable with the objective resolving power). Consequently, we may assess the surface quality much more representatively than using only a single wavefront shear (d_1).

When the slides with the birefringent prisms W_1 are used together with the objective PI, then both conventional and VAWI techniques of the UFI method can be employed for a variety of measurements.

On the other hand, the third slide includes only a single double-refracting prism (symmetrical Wollaston) W_2 whose apex angle α_2 is equal to about 9°. This and the objectives PI of magnifying power 10×, 20× and 40× constitute the basic equipment for the fringe-field VAWI techniques and also for conventional fringe-field interferometry.

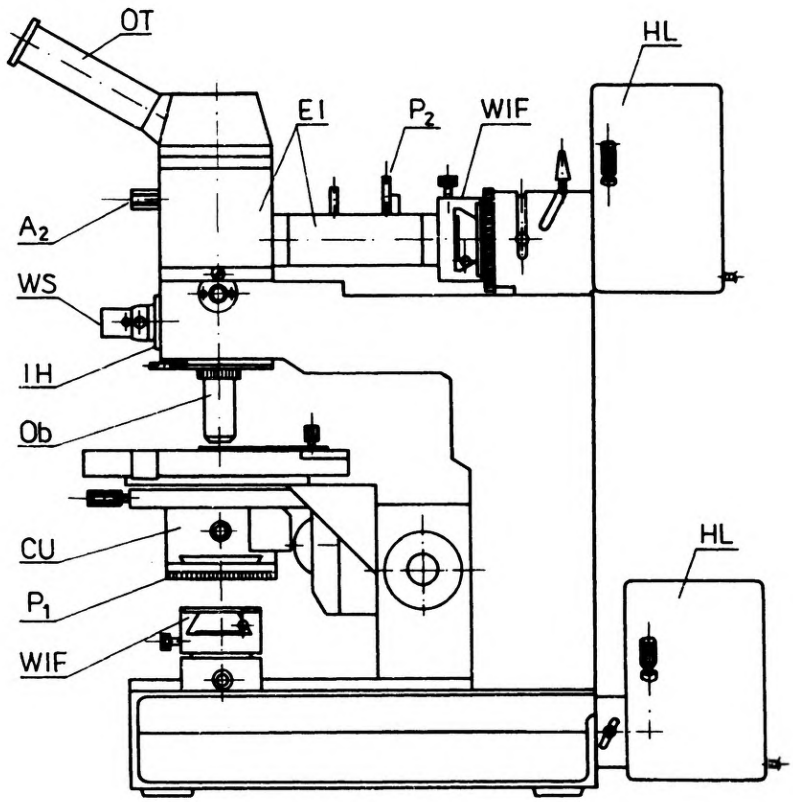


Fig. 5. Schematic diagram of the VADRI–DE microinterferometer. HL – halogen lamp, WIF – wedge interference filter (Veril S 200, Schott Glaswerke, Mainz), P_1 and P_2 – polarizers, CU – condenser unit, Ob – one of individually replaceable objectives, IH – interferometric head, WS – one of three slides with tube birefringent prisms, A_2 – analyser of the epi-illuminator (EI), OT – monocular tube. The phase screw and its loupe are attached to the opposite side of the interferometric head (IH), and thus are not visible. Also the analyser for dia-interferometry is not shown in this figure

In general, materials sciences rather than biological sciences are the areas where the VADRI–DE instrument may effectively be used for various measurements.

5. Fields of application and measuring accuracies

It is self-evident that the Biolar VAWI instrument is suitable only for the measurements of transparent objects in transmitted light. On the other hand, the microinterferometers Biolar PI dia+epi and VADRI–DE function in both transmitted and reflected light, and thus are suitable for the measurements of both transparent and opaque objects.

The main fields of application of these instruments are as follows:

i) measurements of the refractive index and/or thickness of transparent objects

from the materials sciences domain;

ii) interference microrefractometry of liquids and liquid-like materials;

iii) microinterferometry of thin films and layers, including photographic emulsions (measurements of the thickness and refractive index, homogeneity assessment);

iv) microinterferometry of periodic structures (relief gratings and other like objects);

v) microinterferometry of single microcrystals, birefringent crystal plates, double-refracting retarders, and other like anisotropic objects;

vi) microinterferometry of textile fibres, especially polymer fibres, and also birefringent foils;

vii) determination of the refractive index profile of optical fibres, measurements of the numerical aperture of high-aperture optical fibres;

viii) measurements on biological cells and their organelles (dry mass determination);

ix) studies of surface roughness of flat and cylindrical objects, including textile (polymer) fibres and also optical fibres;

x) testing spherical shells for laser-fusion experiments and examinations of many other specific objects and materials used in research and high technology.

The accuracies of measurement have in detail been discussed in the preceding paper of this series [11]. As far as the optical path difference δ is concerned, the measuring accuracies offered by the microinterferometers described here are as follows:

i) AVAWI(b) and AVAWI(λ) techniques – $\Delta\delta = \lambda/1000$ or even better;

ii) VAWI techniques (quasi-adaptive procedure) – $\Delta\delta = \lambda/50$ to $\lambda/500$, depending on the object under study and the technique used.

When conventional measuring techniques are used, the accuracies are not as good as those given above, and may be specified as follows:

iii) visual FFI – $\Delta\delta = \lambda/10$–$\lambda/20$;

iv) visual UFI – $\Delta\delta = \lambda/50$;

v) half-shade UFI – $\Delta\delta = \lambda/100$;

vi) half-shade UFI with mask – $\Delta\delta = \lambda/300$.

It is self-evident that the accuracy of the first two conventional techniques can be improved if a microscope photometer will be used.

6. Conclusions

This paper brings the series *Variable wavelength interferometry* to an end. Originally, three or at most four papers were planned and the VAWI method was qualified as a procedure for establishing the integral number of interfringe spacings by which the object under study displaces interference fringes. That procedure has then been transformed into an accurate and relatively universal measuring technique VAWI–1, and two other techniques, VAWI–2 and VAWI–3, have been developed as well as their specific versions referred to as object-adapted interferometry in the interfringe domain, AVAWI(b), and wavelength domain, AVAWI(λ), have been de-

vised. These are extremely accurate, but work under specific conditions. Otherwise, the quasi-object-adapted approach, QAVAWI, may be applied to the majority of microinterferometric problems. A simple and accurate method of the calibration of the interferometer used has been proposed on the basis of the AVAWI(b) and AVAWI(λ) techniques, and the measuring accuracies have also been discussed in detail. Finally, instrumentation required to use the VAWI techniques in the microscopy fields has been completed. The microinterferometers described here are commercially available from the author's institution.

The VAWI method uses monochromatic light of continuously variable wavelength λ. In particular, a white-light source and an interference monochromator (wedge interference filter) can be employed. The only parameter that is directly measured is the interfringe spacing b, while other quantities required for the final interferometric results are observed, read out from the calibration graph $b(\lambda)$, and derived from quite simple formulae. In comparison with common interferometric techniques, in which monochromatic light of constant wavelength is used, the VAWI method is therefore simpler and more accurate.

Due to the extremely constant relationship between the interfringe spacing b and the light wavelength λ, the double-refracting wavefront shear interference system which uses the Wollaston prism(s), such as shown in Fig. 1 or 3, is especially suitable for the VAWI method and its specific versions.

A disadvantage of this method is that the calculations leading to the final interferometric results are time consuming if no personal computer is used. Fortunately, the calculation procedure is quite simple or even trivial; moreover, all techniques presented in this series of papers are suitable for fully automatic or at least semi-automatic operation and processing. In any event, the author's intention is to present soon an automatic version of the VAWI method.

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Интерферометрия с плавно переменной длиной волны. X. Инструментализация

Принцип, возможности, применения и специфические варианты интерферометрии с плавно переменной длиной световой волны (VAWI) были представлены в предыдущих статьях из этого цикла. Благодаря методу VAWI усовершенствован старый вариант бирефракционного интерферометра и сконструированы два других варианта. Они описаны в настоящей статье, которая является одновременно завершающей цикл.

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