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NASA TECH BRIEF

Goddard Space Flight Center

An Improved Apochromatic Wedge Utilizing Optical Molecular Contact Bonding

The problem:

Small dispersion angles are commonly generated by rotating an optical wedge in the path of a beam of monochromatic light. If an apochromatic wedge is used, the light source need not be monochromatic, or if it is monochromatic, the wavelength need not be known.

This substantial advantage of the apochromatic wedge is partially offset by the following considerations:

(1) transmission studies must include the uncertainty of refractive index of the cement used for bonding;
(2) cement homogeneity must be considered;
(3) dust and even sub-micron particles in the cement cause undesirable angles between the elements; and
(4) adhesive pull stresses on the elements cause distortions and possible fracture.

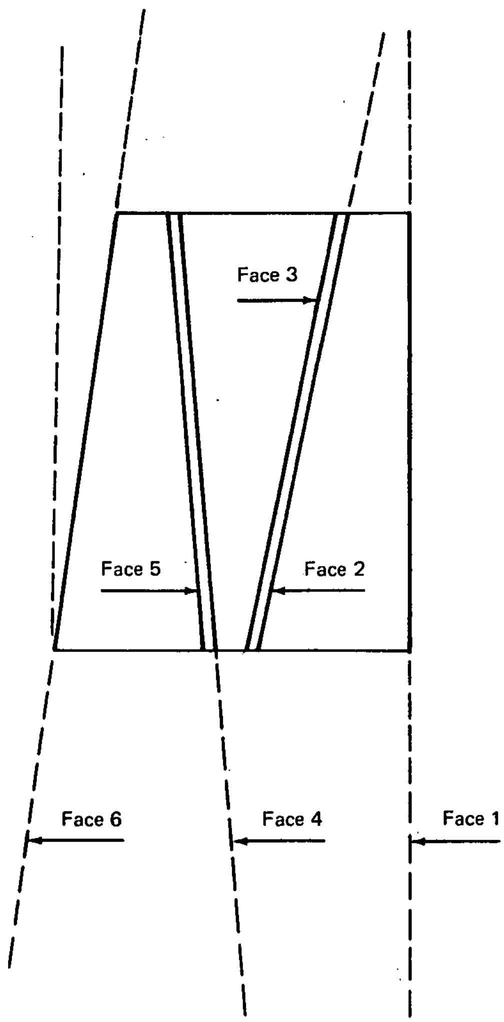
The solution:

The three elements of the apochromatic wedge are assembled by optical molecular contact; thus, all the difficulties and inaccuracies inherent in cement bonding are eliminated.

How it's done:

The contact surfaces must all be prepared by use of a high grade optical flat. Extreme care must be exercised in testing for flatness. When the plano-optical glass surfaces are properly prepared, they are placed in contact and will remain permanently adhered until thermal shock causes separation. Once adhered, glasses having near zero coefficients of thermal expansion cannot be separated.

The apochromatic wedge, shown in the figure, consists of three glass prisms whose refractive indices are exactly known. Included angles between transmission faces are determined by a computerized optimization program. The program utilizes Snell's Law (first-order optics) and geometry. An initial determination and



Apochromatic Wedge

(continued overleaf)

three subsequent evaluations are made during the assembly.

The assembly is done in three stages. In the first stage, the angle included between faces 1 and 2 is measured. The angle included between faces 1 and 4 is then redetermined. Finished faces 2 and 3 are bonded, and face 4 is ground and polished to comply with the redetermined value. In stage two, the angle included between faces 1 and 4 is measured. Then the angle included between faces 1 and 6 is redetermined. Finished faces 4 and 5 are bonded. Face 6 then is ground and polished to comply with the redetermined value. In the third stage, the angle including all the faces is measured, and face 6 is reworked as necessary.

For the measurement, face 1 is transferred 180° by the bonding of a small front surface mirror, thus allowing auto-collimation with the surface being measured. A first-order auto-collimating theodolite which projects an illuminated target is used. Pyramidal error is controlled by achieving a roll orientation wherein reference and test surfaces are back viewed on a horizontal crosshair of the theodolite reticule.

The surfaces to be bonded are carefully polished to be free from blemishes, scratches, and pits. These surfaces are tested to be plane at thermal equilibrium using helium light sources within 1/10 fringe degree of flatness (41nm or 16×10^{-7} inch). Before bonding, the surfaces are cleaned with solvents, as in pre-cleaning for vacuum deposit coating. When the surfaces are dry, they are placed in physical contact under clean-room conditions. Newton bands will appear when the surfaces are first placed in contact. The bands will indicate a degree of convexity since the glass will have absorbed heat from handling. As the glass cools, the bands will straighten. Particles of dust, if present, will appear as small bright circles. At this point experience will indicate if the presence of such a dust particle will prevent the molecular adhesion. If decision is made to proceed, a slight pressure is applied to one corner of two pieces as if squeezing them together. A dark spot will appear at the pressure point and, in a matter of a few seconds, creep into the center of the surfaces. The Newton bands will disappear. When the entire polished area is covered by the dark area, the surfaces will be in molecular bond, often called an optical contact.

Note:

No additional information is available. Specific questions, however, may be directed to:

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Patent status:

No patent action is contemplated by NASA.

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