Low-Cost Hot Stage For Crystal Studies

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I required a hot stage to do some work with liquid crystals. Hot stages on the market are very expensive. I decided to try using electro-conductive glass. This is the NESA glass used by automotive manufacturers in electrically operated defrosting windows. A local glazier ordered some of the glass for me in 8 x 8 inch squares. I had the squares cut and edge polished into 2 x 2 inch pieces by a filter manufacturer. One sheet of 8 x 8 inch glass cost me about $15.00. Cut down, I got nine 2 x 2 inch pieces suitable for my experiments at an additional cost of $3.00 per cut piece.

A piece of 2 x 2 inch electro-conductive glass is prepared with two thin copper strips epoxied to the outer margins. One needs a conductive epoxy, and I used a silver epoxy (40-3900 resin and catalyst) obtained from Epoxies, Etc. of Greenville, RI.

In the center of the conductive glass surface, place a small drop of a high boiling point, non-reactive liquid such as glycerol (bp 290 degrees C). Next, lay a thin microscope cover glass (#0 is ideal) about 22 x 30 mm in size on top of the drop of liquid. Place a few crystals of the material being studied on the cover slip either in solid form or dissolved in a suitable solvent. If a solvent is used, allow it to partially evaporate, and lay another cover glass about 18 x 18 mm (thickness dependent on objective correction), centering the smaller cover glass in the larger. (See Figure 2.)

Place the heating device on the microscope stage and connect the leads to a DC power supply (variable 20 volts @ 1 amp is fine), and set up the polarizers (if these are being used) in the crossed position. While examining the crystals, slowly raise the applied voltage and look for melting. Fine adjustment of the applied power will increase, decrease, stop, or reverse the melting rate. Examining anisotropic crystals forming or melting while viewed under polarized light is an unforgettable experience.

A few materials to start with include thymol, camphor, menthol, stearic acid, and myristic acid. Studies of crystal habits, changes of polarization, etc., may now be easily and inexpensively performed. Bear in mind that the device is unsealed. If materials such as naphthalene, anthracene, biphenyl, and other hazardous compounds are to be studied, some provision must be made to produce a sealed heating cell.

If you need to measure the temperature of the plate, use a digital thermometer with a fine metal probe tip and immerse the tip in a drop of glycerol (or similar high boiling point liquid) placed on the glass surface in the region of interest. Alternatively, the temperature can be measured using pure organic solid reagents with known melting points. Also, liquid crystal sheets and thermometers are available which can be placed in contact with the glass to map the temperatures.

The benefits of this simple-to-construct hot stage include: (1) low-cost, very rapid response, low thermal lagging (due in part to the liquid interface between the tin oxide and lower cover glass), and (2) transparency which allows transmitted light viewing. The thinner the glass, the better as far as being able to set up critical (Koehler) illumination, but under low power, even the thicker glass will perform well. With this setup, I easily achieved 95 degrees C on the surface (16 volts @ 600 ma). If your temperature requirements are under 100 degrees C, this low-cost device may do the job.

The glass substrate (typically 1/8" thick float glass) is a fairly good heat insulator, but it has been pointed out that the microscope stage is a great heat sink. For your high temperature work, or for prolonged incubation, consider placing a thin gasket of teflon, mica, or reflective mylar with a central hole beneath the glass cell. The emphasis is on THIN since anything that further elevates the specimens will further reduce the criticality of illumination by the substage condenser as well.

Materials with melting points up to 95 degrees C may be readily examined with the setup. Definitely construct a number of hot stage plates and see how high a temperature you can reach safely. Be aware that prolonged viewing of a high-temperature surface with a high-power microscope objective may be detrimental to the objective. Also, evaporating solvents and subliming crystals could harm an objective. In the event that these deleterious conditions are encountered, some means must be taken to protect the microscope objective. A gentle flow of air near the objective lens could help keep the heat, solvent, and crystal vapors away.

Uses for this setup include:

(1) Observing and recording growth of bacteria and other microorganisms at different temperatures in an inexpensive, on-stage incubator. You might want to use a constant power output supply.

(2) Studying the behavior of liquid and ordinary crystals at different temperatures to study phase changes. Crystals may be observed during melting, subliming, or solidifying either as the pure crystalline compound or in a saturated solution.

(3) Testing for purity of low-melting point solids by checking melting points compared to suitable standards of the pure substances.

(4) Examining the effect of temperature changes on refractive indices.

(5) Looking for liquid inclusions in minerals and crystals.

(6) Examining plastic and polymeric films for their behavior during polymerization.

(7) Studing denaturing of proteins.

For a real treat, substitute a cover glass coated with aluminum nearest the NESA plate and use Reflected/Transmitted Nomarski lighting (described above) for your crystals, liquids, and biological studies.

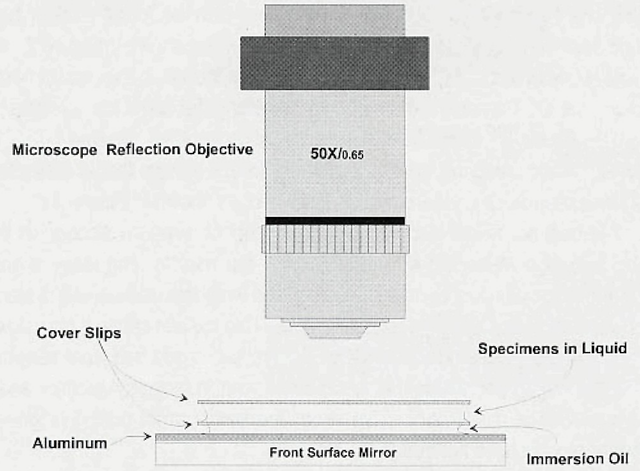

Figure 1: REFLECTION/TRANSMISSION TECHNIQUE

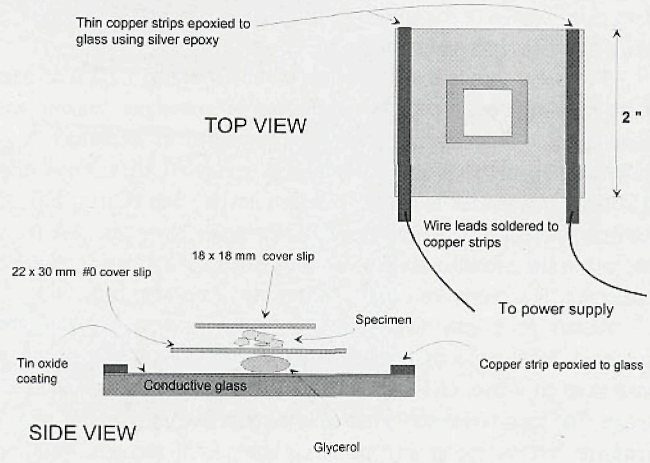

Figure 2: Electro-conductive glass hot-stage construction