demonstrated[2] that the same material could be used as a photorecepter for xerography.

The hydrogenated silicon film used by Shimizu's group was produced by glow discharge of silane (SiH_4). This technique, which results in an amorphous film containing as much as 35 atomic percent of hydrogen, is the process by which the Dundee group had inadvertently hydrogenated their amorphous silicon in 1975. It seems that the single hydrogen electrons lower the density of trapping states by pairing up with the unpaired electrons of the dangling silicon bonds, which when unpaired tend to trap electron carriers. The group at Hitachi, on the other hand, produced hydrogenated film by reactive sputtering.

The problem of extracting photoexcited carriers from a thin film is much the same for office copiers, Vidicons and solar cells. The primary difference is that the photoconductive films for copiers and Vidicons are about a hundred times thicker than the 0.1-micron films contemplated for thin-film solar cells. The greater thickness makes the extraction of carriers a hundred times more difficult; but copiers and Vidicons need to draw only very small currents, on the order of microamps/cm^2, compared with milliamps/cm^2 for solar cells. Another difference is that Vidicons and office copiers employ externally applied electric fields to extract the photoexcited carriers, whereas solar cells make use of internal fields generated by p–n junctions, Schottky barriers or other blocking contacts.

Albert Rose, a pioneer in the development of television cameras at RCA, told us that the use of the same disordered material for all three applications has a venerable history, dating back to 1948, when Paul Weimer at RCA developed an amorphous-selenium Vidicon target, and Xerox first began making selenium copiers. The selenium exposure meter is of course the "grand-daddy" of solar cells, as Rose calls it. He believes that the lesson of this history is too little appreciated—namely, when a material has shown itself useful in one of these disciplines, it ought to be regarded as a candidate for the other two. He points out that, unlike the history of solar-cell technology, the development of copiers and Vidicons has not been burdened with a prejudice against disordered materials.

Vidicons. In the early days of television, cameras generally made use of surface photoemission rather than the bulk phenomenon of photoconductivity, where incident photons generate electron–hole pairs of carriers inside the photoconducting material. But the higher quantum efficiency of the photoconducting phenomenon has led in the last decade to the almost complete displacement of photoemission tubes (such as the Image Orthicon) by the Vidicon, first developed by Rose's group at RCA in the late 1940's. Whereas in photoemission one gets only about 0.1 electrons per incident photon, photoconductivity generates close to one carrier per photon in the Vidicon. This higher quantum yield eliminates the need for elaborate electron-multiplying electronics in most pickup tubes, greatly reducing the size and complexity of television cameras.

Most commercial Vidicons nowadays use lead oxide (for high-quality studio cameras) or antimony trisulfide (for less demanding applications such as surveillance or amateur TV cameras) as the photoconducting target film. The back surface of the film is scanned by a beam of thermal electrons in a raster pattern of about 500 lines in 1/30 of a second. The front surface is covered by a thin, transparent electrode maintained at about +30 volts relative to the beam. In the absence of light the target is highly resistive, permitting very little discharge of the charges accumulated by the beam on the back surface to the electrode. When light impinges on the front surface through the electrode, a local conducting channel is produced by the photogeneration of carriers in the target.

When the electron beam arrives at the illuminated area that has been photoconductively discharged, it recharges the back surface, producing a signal at the electrode which, given the known x,y coordinates of the beam at that moment, can be translated into an image. One can think of the electrode and beam spot as

Stationary vortex arrays

Take a good look at these photographs; eventually they will probably be in many textbooks. These photographs represent visual evidence for macroscopic quantization in rotating superfluid helium and are the latest in a series of experiments by Richard Packard and his collaborators at the University of California, Berkeley. E. J. Yarmchuk, M. J. V. Gordon and Packard recently published these pictures in Phys. Rev. Lett. **43,** 214 (1979). These patterns display the model structure of the stationary states of a single macroscopic wave function describing superfluidity.

The Berkeley experimenters make vortex lines visible by trapping electrons at their centers. These trapped charges are imaged onto a phosphor screen, amplified and recorded on film. In earlier Berkeley experiments (PHYSICS TODAY, October 1974, page 17), vortex positions were recorded but the stationary states were not visible.

A straightforward calculation for the positions of N singly quantized vortices (in a stable configuration) with angular velocity ω is

$$\sum_{j=1}^{N} r_j^2 = \frac{h}{m}\,\frac{[N(N-1)]}{4\pi\omega}$$

where r_j is the distance of the jth vortex from the axis of the cylindrical container. So in principle one can determine h/m (where m is the mass of the helium atom), just as, from the ac Josephson effect, one can determine h/e. In practice, though, the resolution of the Berkeley technique, roughly 5%, is not sufficiently high.

The apparatus was rotated at an angular velocity ranging from 0.30 sec^{-1} for photograph a, to 0.86 sec^{-1} for photograph i.

The technique of visualizing vortex arrays is expected to provide information on how the vortices are created and how they are arrayed. In particular, the Berkeley group expects to be able to observe directly vortex waves involving small numbers of vortices.

—GBL