Graduate instrumental science program

Since 1968, 44 MS and 5 PhD degrees have been awarded in a unique, research-oriented program at the University of Arkansas. Here is a current evaluation of the operation—what it has accomplished, what its graduates are doing and the outlook for the future

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The Graduate Institute of Technology at Little Rock was formed some 15 years ago by a small group from the large Fayetteville campus of the University of Arkansas. In addition to offering traditional programs in chemistry, engineering and mathematics, a unique MS and PhD program in Instrumental Sciences was instituted. Starting with the concept that instrumentation is a field in itself, worthy of the highest quality of education, the program leading to a PhD displays many departures from tradition.

Entering students are accepted with a BS in any of the physical sciences, mathematics or engineering. Their graduate assistantships involve not undergraduate teaching but research work on early stages of real, mission-oriented problems. About 4 hours a day must be spent on such research, which preferably is not related to their thesis project. The PhD language requirements demand a knowledge of German and a computer language. There is a time-shared terminal tied to a large third generation computer facility in Cleveland to provide instruction in computer techniques. The course work for either the MS or PhD is flexible and provides a broad background in science and engineering.

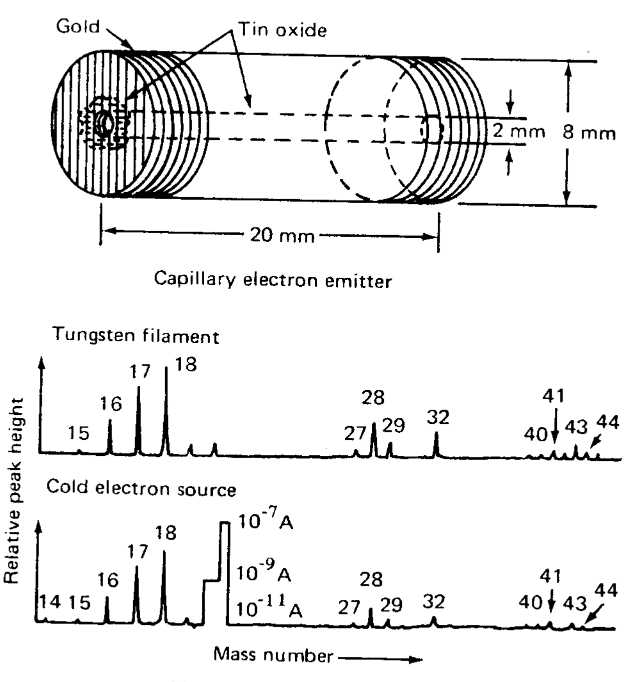

Fig. 1. Cold electron emitter (top) consists of capillary tubing containing thin film of tin oxide. Gold coating provides electrical contact points. Comparison of mass spectra produced is shown at bottom.

The educational and research program was described by M. K. Testerman in 1968 when the first PhD degrees were granted (1). By now there have been 44 MS and 5 PhD degrees awarded. Typical of the graduates is James F. Sprouse, whose PhD was awarded this spring. He is now in the Panama Canal Zone setting up an instrumentation laboratory to make physical and chemical measurements related to the environment. A recent appraisal of the value of such education was given by Edward E. David, Jr., Presidential Science Advisor (2): "The obvious success of the GIT plan is gratifying to see in the Institute itself and its accomplishments. I might say that it is particularly significant that the first degree given by the institute was won in Instrumental Sciences. The importance of instrumentation and measurement to society as a whole is only now becoming widely recognized."

Education to develop the research attitude and approach is emphasized in this program, and working on real problems through the assistantship assignments is important to accomplish this. These research activities are supported by grants ranging over broad areas from studies of water quality to medical instrumentation, mass spectrometry and lasers. Research into sources of electron emission other than heated filaments has led to the development of a tin oxide cold-cathode emitter formed within a capillary. In spite of an inability to determine the precise mechanism by which this phenomenon occurs, emitters ca-

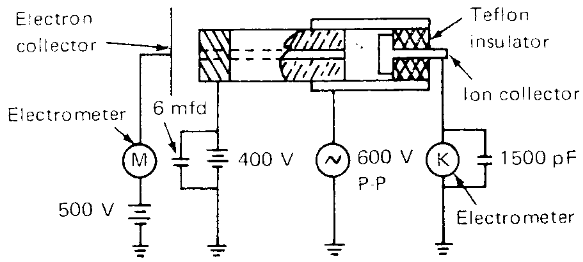

Fig. 2. Using cold electron source, small ac-operated ionization gage can be designed. Device produces 10^{-3} ampere per torr of ion current.

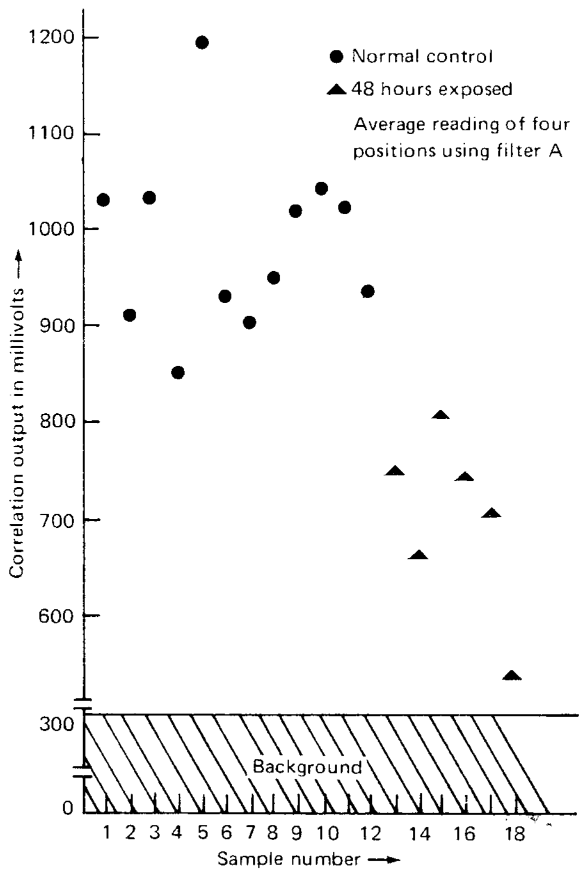

Fig. 3. Readings obtained in laser correlation system of 18 different rat liver tissue samples. Lower readings were obtained for CCl_4-damaged tissues.

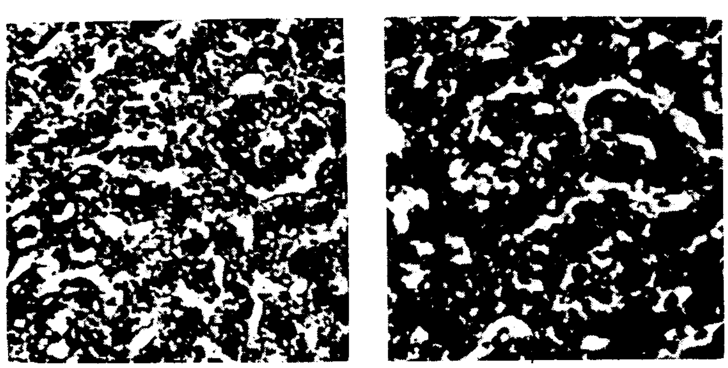

Fig. 4. Differences in tissue are revealed in photographs of slides used to obtain readings for samples 9 and 18 in Fig. 3. Normal tissue (sample 9) is at left.

pable of use in mass spectrometry and vacuum measurements have been demonstrated.

McLeod describes the design and performance of the electron emitter used as a mass spectrometer ion source and a high vacuum ion gage (3). The source (Fig. 1) consists of a short piece of Vycor capillary tubing of a 2-millimeter bore containing a thin film of tin oxide. Gold coating at each end provides electrical contact points. The tin oxide film is disrupted or etched electrically around the bore at one end using a metal probe with 100 volts dc.

Mechanical scribing for distances of 1 millimeter down the bore with a 0.001 inch radius diamond-tipped phonograph needle can also be used. If a positive potential is applied to the end of the capillary nearest the etch and the opposite end maintained negative, up to 400 microamperes of electrons will be emitted from the positive end in a moderately collimated beam. Reversal of these potentials produces a collimated beam from the other end at a reduced intensity up to 20 microamperes. The device can be operated in either an ac or dc mode. Its performance in the dc mode as a mass spectrometer ion source also is shown in Fig. 1. Frequency response of the device is flat to 50 kHz and 3 db down at 100 kHz, so that it can be operated as a pulsed electron source in a mass spectrometer.

These characteristics also make possible a small ac-operated ionization gage. The design shown in Fig. 2 measures both electron and ion current. For all ionization measurements with the cold electron source, the electron current must be measured because, as the pressure approaches 10^{-5} torr, the electron emission decreases. It is the ratio of ion current to electron current that varies linearly with pressure throughout the range. Emission can be controlled by varying the width of the ac pulse applied to the emitter to maintain average electron emission constant regardless of pressure. Since there is little heat generated by the cold electron source, an outgassing problem does not exist. Such an ionization gage can be switched on when needed and pressure determined immediately.

Lasers measure pathological specimens

Work with lasers has been active almost from the inception of GIT. Based on this background a system has been conceived and demonstrated by R. L. Bond and M. K. Mazumder of GIT that promises to lead to a tool for rapid mass screening of pathological specimens. This can greatly ease the work load of laboratories studying the effect of chemicals and environmental pollutants on small test animals. An optical correlation technique employs a coherent optically matched filtering process in which the optical spatial frequency spectrum of a test specimen is correlated with a Fourier hologram of a control specimen.

The system essentially performs a real time correlation between a large area specimen of known pathology and an unknown one from the same organ from different sources. Changes in a tissue subjected to injury produce significant differences in the optical scattering characteristics of the specimen. An optically matched filter of a control specimen (Fourier hologram) is a photographic transparency on which the Fourier transform of both the amplitude and phase distribution of light diffracted by an object is recorded. This photographic plate becomes the reference filter in the optical system that compares it to a test specimen. The intensity of the central light peak in the correlation plane between the two Fourier

Fig. 5. M. K. Testerman, Head of the Instrumental Sciences program at GIT working on cold electron source experiment.

spectra gives a single value measure of the difference between the two objects.

The system has been demonstrated on samples from livers of rats that have been exposed to carbon tetrachloride (4). The data plotted from a number of samples are shown in Fig. 3, revealing a correlation between normal and CCl_4-damaged tissue with a single millivolt reading. Enlarged photographs from the slides of tissues undergoing correlation in the laser instrument at two points (9 and 18) in Fig. 3 are shown in Fig. 4. The work described here is in its very early stages, but it does hold promise that further development can lead to an automated, reliable screening system. Essentially, the laser beams and holograms are able to evaluate simultaneously about 4000 points on a given liver specimen, a feat difficult to achieve by any other means. About 3000 slides might be examined this thoroughly in one 8-hour day—theoretically equivalent to the work of 480 pathologists. This work is supported by the National Center for Toxicological Research.

Scope of future research will broaden

According to M. K. Testerman (Fig. 5), who has guided the Instrumental Sciences program from its beginning, the original concepts have produced good results. By working actively on instrumental research projects that lead to concrete results the students gain an insight and appreciation that adds value to their course work. There is a steady demand for students who obtain these degrees. The need for people trained in these disciplines is growing, and the fields of activity are covering newer areas, as evidenced by the current and anticipated research into the medical and environmental fields.

References

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