ACOUSTIC MICROSCOPY AT CRYOCOLD TEMPERATURES (U)

JUN 82

UNCLASSIFIED 6L-3435

END PAGE

6 82
ACOUSTIC MICROSCOPY AT CRYOGENIC TEMPERATURES

Summary Report

Index of Research Performed from July 1977 - June 1982

Task NR 384-924

Contract N00014-77-C-0412

G. L. Report No. 3435

June 1982
Some years ago it became evident that research devoted to acoustic microscopy at cryogenic temperatures would allow us to realize the full potential of this new instrument and extend the resolving power beyond the limits imposed by the room temperature microscope. In 1977, the Office of Naval Research agreed to fund such a program at Stanford University. It was to be directed toward an increase in our understanding of the propagation of acoustic waves in cryogenic fluids and the physics of imaging with these waves. We were to concern ourselves with the sub-micron region.

This short report includes a compilation of the written materials and presentations that have resulted from this program. The work of Dr. Logan Hargrove, who has guided the program since its inception, is deeply appreciated.

Cryogenic fluids are attractive for propagation of acoustic waves with short wavelengths since the velocity of sound is low and the attenuation is moderate. Much of our work has been done with liquid argon and liquid nitrogen. High quality acoustic images have been recorded in these media and it has been shown that an operating instrument can be a rather simple device.

One recent achievement is the demonstration that operation in the non-linear region can improve the resolution in a significant way.

During the period of this research, it has become increasingly clear that the ultimate resolution - perhaps rivaling that of the Scanning
Electron Microscope, and certainly exceeding that of the optical microscope —
will be achieved in liquid helium. Our first work was done in $^4$He at
1.95°K where we demonstrated that quality images could be recorded.
But, the tantalizing prospect of helium at a temperature of 0.1°K attracts
us and that is where we will place the emphasis from this point on.

The acoustic absorption decreases as the fourth power of temperature
in the range below 0.5°K. At 0.1°K the acoustic absorption at
microwave frequencies is no longer an important property in the imaging
instrument. It will be dominated by other factors such as the smoothness
of the lens surface and the non-linear behavior of the liquid itself.

The most recent result — coming at the conclusion of this program
period — is a demonstration of an operating instrument in $^4$He — cooled to
a temperature of 0.1°K. The wavelength was near 3000 Å and the
signal-to-noise ratio was sufficient to record acceptable images.

We find that this program spans an interesting period in cryogenic
acoustic microscopy. It began with the first images in cryogenic fluids —
argon and nitrogen. It proceeded through a period of investigating
properties of helium at ultralow temperatures and it now ends with a
prototype instrument that is capable of generating images at 0.1°K where
the liquid absorption has decreased to a negligible value. It suggests
that we are on the threshold of a new era for imaging in the sub-micron
region of the microscopic world.
Reports

Semiannual Report, 1 July 1977 - 1 January 1978 (G.L. Report No. 2773)
Semiannual Report, 1 July 1978 - 1 January 1979 (G.L. Report No. 2921)
Semiannual Report, 1 July 1979 - 1 January 1980 (G.L. Report No. 3083)

Publications

Publications, continued


J. Heiserman, "Thermal Grounding of a Transmission Line in a Dilution Refrigerator". To be published in Cryogenics.

Meetings


Meetings, continued


C. F. Quate - Recipient of the 1981 IEEE Morris N. Liebmann Award at the IEEE Ultrasonics Symposium, October 14, 1981, Chicago, Illinois. Citation "For development of an acoustic microscope capable of sub-micron resolution".


C. F. Quate - Recipient of the Rank Prize for Opto-Electronics, Royal Institution, London, England, April 27, 1982. Sponsored by the Rank Prize Funds. Awarded in "recognition of his contribution to medical, biological and physical research through the concept of the scanning acoustic microscope, which uses sound rather than light to form images".
Meetings, continued


Invited Talks


C. F. Quate - Invited Seminar, Max-Planck-Institut fur Festkorperforschung, Stuttgart, West Germany, December 10, 1979. Talk entitled "Acoustic Microscopy at Microwave Frequencies".

C. F. Quate - Invited Colloquium, University of California, Santa Cruz, Department of Natural Science, Santa Cruz, California, April 3, 1980. Talk entitled "A New Form of Microscopy with Acoustic Waves".

C. F. Quate - Invited Colloquium, Princeton University, Department of Physics, February 26, 1981. Abstract entitled "The Acoustic Microscope - a System for Imaging with Microwaves".


C. F. Quate - Invited Speaker, Naval Postgraduate School, Monterey, California, 23rd October, 1981. Talk entitled "Acoustic Microscopy".


C. F. Quate - Invited Colloquium, University of California, Davis, Department of Physics, June 1, 1982. Talk entitled "Acoustic Imaging and Microscopy".
Review Articles/Write-ups


INDUSTRIAL RESEARCH/DEVELOPMENT, December 1978, "Acoustic Scope has Optical Resolution", p. 35.


Awards


C. F. Quate - 1981 IEEE Morris N. Liebmann Award.

C. F. Quate - 1982 Rank Prize for Opto-Electronics.