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Technique for Polishing Single Crystal Yttrium-Iron-Garnet Spheres*

A simple method of polishing yttrium-iron-garnet spheres which produces samples of fractional oersted linewidths has been employed at the Air Force Cambridge Research Center. The technique consists of "hand-polishing" the crystal spheres in diamond pastes and aluminum oxide powders of diminishing grit sizes. This method significantly increases, both by greater pressure and efficiency of abrasive contact, the rate of removing material from the surface of the sample, which is fundamental in the polishing process. Results attest to a substantial reduction in fine-polishing time to a matter of hours. At present, fine-polishing using the more or less conventional technique of tumbling the sample in an air-cyclone chamber requires a period of days.

Rough samples are shaped into spheres and the coarse-polishing phase completed by either the previously mentioned air-cyclone chamber or metallurgical grinder[1] methods. Fine-polishing is initiated by rolling the spheres in a figure eight pattern under light finger pressure in 6 μ-grit diamond paste that has been dabbed on a metallurgical polishing cloth. Since a very small amount of material is removed by hand polishing, reasonable care insures uniform polish over the entire crystal surface and maintains sample sphericity. After approximately one hour of such polishing, the process is repeated with successively finer grits, *viz.*, 3 μ-, 1 μ-, and 0.5 μ-diamond pastes, followed by dry aluminum oxide powders of grit size 0.3 μ and 0.1 μ. Toward the conclusion of the process, the aluminum oxide powder was mixed with acetone into a slurry, yielding an extremely high degree of polish.

At regular intervals within each polishing phase, a visual inspection under a 90X microscope was made and the linewidth of the sample was measured to compare the effectiveness of each grit size in narrowing the linewidth. Table I lists the measured linewidths of three YIG spheres for various grit sizes and polishing times.

Samples A and B were grown in the same batch in the laboratory, while sample C was purchased. Sample B, though adequately polished, appears to have solvent inclusions which probably account for its relatively large linewidth.

Each value listed in the preceding table is the average linewidth taken over many sample orientations, thereby eliminating any dependency of linewidth on crystal orientation. These values were obtained using both the cavity perturbation technique,[2] where appropriate, and a new method[3] designed especially for use with narrow linewidth samples.

TABLE I
LINEWIDTH IN OERSTEDS

		Sample A	Sample B	Sample C
At completion of coarse-polishing phase		4.47	2.5	~3.0
Grit Size	*Hours*			
6 μ-Diamond Paste	½	—	—	1.89
	1	—	1.28	—
3 μ-Diamond Paste	½	2.72	—	1.39
	1	1.35	1.30	1.13
1 μ-Diamond Paste	½	1.27	—	1.16
	1	1.00	1.25	0.84
0.5 μ-Diamond Paste	½	1.05	—	—
	1	1.00	1.24	—
0.3 μ-Alumitum Oxide Powder	½	0.86	—	0.73
	1	0.95	1.25	—
	2	—	1.04	—
	3	—	1.03	—
0.1 μ-Aluminum Oxide Powder	½	0.80	—	—
	1	0.65	—	—
	2	—	1.07	—
	3	—	1.12	—
Final Diameters		0.015 inch	0.021 inch	0.014 inch

It is felt that further experience will reveal not only that one or more steps can be eliminated in the polishing procedure, but also that an optimum polishing time per stage can be determined.

To mechanize the process, a simple polishing machine consisting essentially of two reciprocating polishing plates is being developed.

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[1] J. L. Carter, E. V. Edwards, and I. Reingold, "Ferrite sphere grinding technique," *Rev. Sci. Instr.*, vol. 30, pp. 946–947; October, 1959.

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[3] J. Masters, B. Capone, and P. Gianino, "Measurement technique for narrow linewidth ferromagnets," IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, this issue, p. 330.

Tunable Two-Mode Cavity with Capacitative Loading*

A cavity with two independently tunable modes in the 4- to 9-kMc frequency range was needed for experiments in paramagnetic relaxation. It had to be small enough to fit inside a liquid helium dewar and had to possess a region of approximately uniform RF magnetic field common to both modes over part of its volume.

To meet these requirements a box shaped copper cavity of inside dimensions 0.670 inch×0.670 inch×0.866 inch was built, and its natural resonant frequencies were lowered into the required range by means of copper blocks mounted in the central region. If the cavity is regarded as the limiting case of an LC resonant circuit, the effect of such loading is to increase the capacity. The fundamental unloaded frequencies were 11.18 kMc in the two modes which were used and 12.48 kMc in the third mode. The 11.18-kMc modes were shifted to frequencies in the range from 4 to 9 kMc by an appropriate choice of loading block. The third mode was damped out by the joint in the cavity wall and by the brass rod used to support the center block. The cavity was tuned by moving dielectric plungers in and out of the region of the strong electric field. In most of the geometries tested, these regions were distinct for each mode so that changes in the tuning of one had comparatively little effect on the other.

The cavity was made in two parts joined along a central plane as shown in Fig. 1.

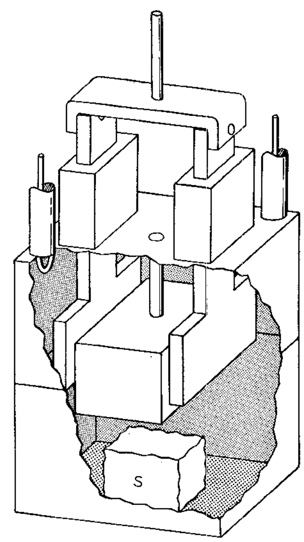

Fig. 1—Cutaway view of loaded cavity. In magnetic resonance experiments the sample (*S*) may be placed in the space below the loading block. For clarity, only one pair of dielectric tuning plungers are shown.

Dielectric plungers, loading blocks, and coupling loops were mounted in the upper part, the lower part being left for accommodation of the specimen. The plungers were made of SC24 ceramic (relative dielectric constant 9) and connected in pairs by brass brackets outside the cavity so that each

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