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Lawrence Livermore Laboratory

MASTER

DT FUSION NEUTRON IRRADIATION OF BNL-LASL SUPERCONDUCTOR WIRES, LASL SPINEL, Al_2O_3
AND YAG, NRL GeO_2 CRYSTALS, AND LASL-IIT MgO , YAG, SPINEL AND Al_2O_3 - NOVEMBER 9, 1977

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For efficiency, samples from several experimenters were stacked together for the LLL Rotating Target Neutron Source (RTNS) irradiation of August 30, 1977.

Dr. C. L. Snead, Jr. of Brookhaven National Laboratory (BNL) and Dr. Don M. Parkin of Los Alamos Scientific Laboratory (LASL) requested a fluence of 10^{18} neutrons/cm² for eleven superconductor wires. The wires measured 19 to 28 mm long, were arranged in a single layer, and were wrapped in aluminum foil. This sample package had been irradiated July 26-29, 1976, September 27 through October 1, 1976, November 17 through December 2, 1976, January 3-7, 1977, January 17-21, 1977, March 14-15, 1977, and August 15-19, 1977. Nine of the wires included in the package (three pieces of Nb₃Sn single core, three pieces V₃Ga single core, two pieces NbTi Supercon 402, and one piece NbTi cupronickel jacketed) had received 8×10^{17} neutrons/cm² from RTNS irradiations prior to the current accumulation. The remaining two samples, 19-core Nb₃Sn multifilament wires, had 1.8×10^{18} neutrons/cm² from previous RTNS irradiations.

Dr. James M. Bunch of LASL supplied two crystal samples each of Spinel, Al₂O₃ and YAG. They were wrapped in aluminum foil and each measured approximately 10 × 20 × 5.5 mm. He requested a fluence of approximately 3×10^{16} neutrons/cm² on the front of the first set of samples, and 3×10^{15} neutrons/cm² on the front of the second set.

Dr. Bruce D. Evans of the Naval Research Laboratory shipped six samples of five 9's crystalline, tetragonal GeO₂ to be included in the irradiation. The crystals were irregular in shape and measured approximately 1 to 5 mm on a side.

Four high purity single crystal samples had been received from Dr. George F. Hurley of LASL and Dr. Harold Weinstock of Illinois Institute of Technology (IIT). The samples, YAG, Spinel, Al₂O₃ and MgO, all measured approximately 4 × 4 × 4 mm. They were individually wrapped in aluminum foil and labeled on one side. The desired dose of 10^{17} neutrons/cm² was being accumulated half on the labeled faces of the crystals and half on the opposite faces. The samples had been irradiated October 11-15, 1976, November 17-24, 1976 and January 17-21, 1977.

The samples were all stacked with niobium dosimetry foils. The superconductor wires were sandwiched between two 12 mm diameter, 0.03 mm thick foils. The remaining niobium foils were all 0.14 mm thick. The large LASL crystals each had three dosimetry foils (6 × 10 mm) on the front and three

dosimetry foils on the back. The small LASL-IIT crystals had individual dosimetry foils (4 × 4 mm) on the front and back.

The LASL crystals were arranged side by side, left to right as seen from the direction of the beam, YAG, Al_2O_3 , Spinel. The labels were forward with the numbers (1 or 2) at the top. The NRI GeO_2 crystals were taped across the upper edge of the Al-1 and Al-2 crystals: the two largest crystals on Al-1, the four smallest crystals on Al-2. See Figure 1.

The superconductor wires were centered on the front of the LASL Al-1. The four LASL-IIT single crystals were centered on the back of LASL-Al-1 with the labeled sides forward. The order of stacking, beginning with the material nearest the neutron source, was as follows:

Front Sample Holder

Nb-869

Superconductor wires in Al foil

Nb-870

Nb-871	Nb-874	Nb-877
Nb-872	Nb-875	Nb-878
Nb-873	Nb-876	Nb-879
YAG-1	Al-1	Sp-1

Two large GeO_2 crystals on top

Nb-880	Nb-883	Nb-886
Nb-881	Nb-884	Nb-887
Nb-882	Nb-885	Nb-888

Nb-890	Nb-891
YAG	Al_2O_3
Nb-894	Nb-895
Nb-892	Nb-893
MgO	Spinel
Nb-896	Nb-897

Second Sample Holder

Nb-898	Nb-901	Nb-904
Nb-899	Nb-902	Nb-905
Nb-900	Nb-903	Nb-906
YAG-2	Al-2	Sp-2
Four Small GeO_2 Crystals on Top		
Nb-907	Nb-910	Nb-913
Nb-908	Nb-911	Nb-914
Nb-909	Nb-912	Nb-915

The distances between samples were as listed below:

<u>Sample</u>	<u>Thickness (mm)</u>
Tape	0.25
Nb-869	.030
Superconductor Wires	.660
Nb-870	.030
Tape	.050
Nb-875	.140
Al-1	5.080
Nb-884	.140
Tape	.050
Nb-890-893	.140
Hurley's crystals	4.013
Nb-894-897	.140
Tape	.025
Air gap	3.556
Tape	.025
Nb-902	.140
Al-2	5.105
Nb-911	.140
Tape	.025

The neutron irradiation was carried out by the LLL E Division Acceleration Staff on August 30, 1977. Beam-on time was 14.9 hours. Neutron

production was monitored continuously with a proton recoil counter and recorded each hour. The dose record is attached.

Following the irradiation, the sample packages were stored for several days to allow for decay of short-lived isotopes. The dosimetry foils were delivered to Ruth Anderson in the LLL Nuclear Chemistry Division for gamma ray counting. The samples were retained for further irradiation.

The average fluence on each dosimetry foil was calculated using the method described in UCRL-51393, Rev. 1. However, the cross section used for the activation of the 10.16 day isomer of niobium by 14.8 MeV neutrons was changed to 463 millibarns (UCRL-80097). The results were as follows:

<u>Dosimetry Foil</u>	<u>Fluence (neutrons/cm²)</u>
Nb-869	1.87×10^{16}
Nb-870	1.44×10^{16}
Nb-871	5.04×10^{15}
Nb-872	7.62×10^{15}
Nb-873	7.14×10^{15}
Nb-874	8.66×10^{15}
Nb-875	1.57×10^{16}
Nb-876	1.32×10^{16}
Nb-877	4.81×10^{15}
Nb-878	7.29×10^{15}
Nb-879	6.82×10^{15}
Nb-880	2.99×10^{15}
Nb-881	3.91×10^{15}
Nb-882	3.75×10^{15}
Nb-883	4.08×10^{15}
Nb-884	5.93×10^{15}
Nb-885	5.48×10^{15}
Nb-886	2.94×10^{15}
Nb-887	3.88×10^{15}
Nb-888	3.72×10^{15}
Nb-890	5.07×10^{15}
Nb-891	5.14×10^{15}
Nb-892	5.88×10^{15}
Nb-893	5.88×10^{15}

Dosimetry FoilFluence (neutrons/cm²)

Nb-894	3.27×10^{15}
Nb-895	3.20×10^{15}
Nb-896	3.47×10^{15}
Nb-897	3.53×10^{15}
Nb-898	1.76×10^{15}
Nb-899	2.03×10^{15}
Nb-900	1.92×10^{15}
Nb-901	2.01×10^{15}
Nb-902	2.32×10^{15}
Nb-903	2.39×10^{15}
Nb-904	1.72×10^{15}
Nb-905	1.97×10^{15}
Nb-906	1.95×10^{15}
Nb-907	1.16×10^{15}
Nb-908	1.28×10^{15}
Nb-909	1.27×10^{15}
Nb-910	1.28×10^{15}
Nb-911	1.43×10^{15}
Nb-912	1.44×10^{15}
Nb-913	1.17×10^{15}
Nb-914	1.28×10^{15}
Nb-915	1.27×10^{15}

The estimated overall uncertainty of these results is $\pm 7.5\%$. The relative uncertainty between any two values is about $\pm 2\%$. The fluences given here represent average fluences over the volume of each dosimetry foil.

FIGURE I

RTNS IRRADIATION OF AUGUST 30, 1977

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FIGURE II