Superconductivity and Structure of Gallium under Nanoconfinement

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Synchrotron radiation x-ray powder diffraction was used to study various structures of crystalline gallium confined to porous glasses with two different pore sizes [1]. Crsytalline modifications formed within pores of the samples were shown to depend on pore sizes. Two new confined gallium structures, labeled ι- and κ-Ga, were identified (Figs. 1 and 2). Other structures under nanoconfinement were ascribed to known bulk modifications, α and δ-Ga. The stable under ambiet conditions α-Ga was found to be strongly disordered. These structural data were then used to find the superonducting transition temperatures for the observed new gallium modifications. The evolution of superconductivity with decreasing the pore filling with gallium was also studied. It was shown that the gallium structure within pores was independent of the filling.

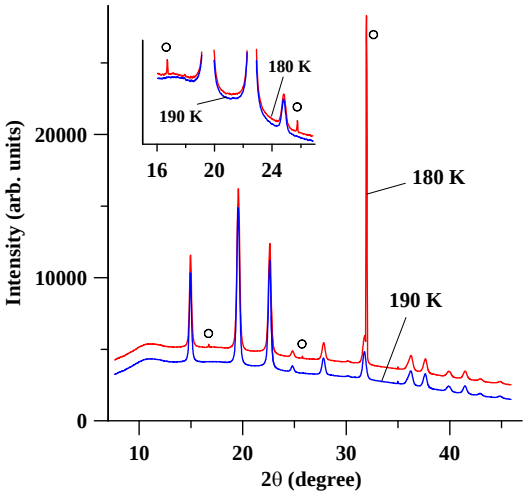

Fig. 1: X-ray patterns of the gallium loaded porous glass with pore size 7 nm at 190 K (blue) and 180 K (red) obtained upon cooling. The patterns are shifted vertically for better visibility. The inset shows scaled patterns at 190 and 180 K. The peaks belonging to ι-Ga are marked by circles.

The temperatures of the superconducting transitions for the new gallium crystalline modifications are listed in Table. They are noticeably higher than the superconducting transition temperature for stable α-Ga.

Table. Temperatures of the superconducting transition

phase	ι-Ga	κ-Ga
T_c (K)	7.1	6.7

Two samples of porous glasses with mean pore diameters of 7.0±0.5 and 3.5±0.5 nm were used as nanoporous templates for gallium. They were made from phase separated soda borosilicate glasses with pore structure produced by acid leaching. The pore size and pore size distribution were determined by mercury porosimetry and electron microscopy. The volume fraction of pores for the samples under study was about 17 and 12 %, respectively. The sample volumes were 4.1 and 18 mm^3. The liquid gallium was embedded into pores under pressure up to 9 kbar. The initial filling of the total void volume was near 85% for both samples and then was gradually reduced by heat treatment to 50 and 55 % for the samples with 7 and 3.5 nm pores, respectively

During x-ray measurements, temperature was changed within a range of 320 to 180 K and from 320 to 70 K for the porous glasses with 7 and 3.5 nm pores, respectively.

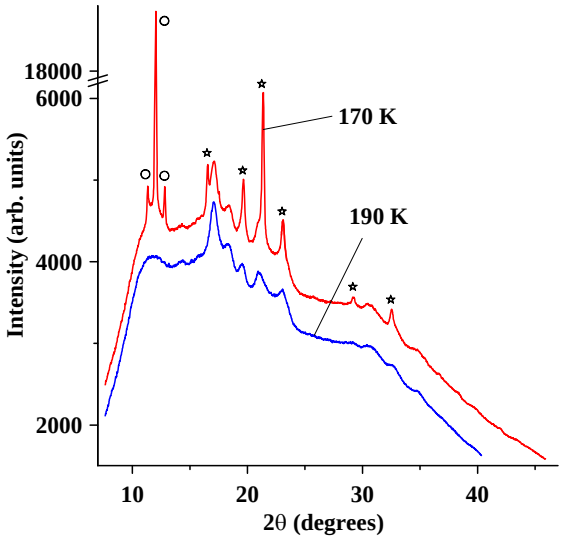

Fig. 2: X-ray patterns of the gallium loaded porous glass with pore size 3.5 nm at 170 K (red) and 190 K (blue) obtained upon warming from 70 K. The patterns are shifted vertically for better visibility. The pattern at 190 K shows only peaks corresponding to δ-Ga. The peaks belonging certainly to κ-Ga and other narrow peaks at 170 K are marked by circles and asterisks, respectively.

Reference

[1] E. V. Charnaya, C. Tien, M. K. Lee, and Y. A. Kumzerov, J. Phys.: Condens. Matter **21**, 455304 (2009).