	Experiment title: Low thermal expansion anomaly and superconductivity in diborides	**Experiment number**: HS-2276
Beamline: ID31	**Date of experiment**: from: 19-september-03 to: 22-September-03	**Date of report**: 1-March-2004
Shifts: 9	**Local contact(s)**: Andy Fitch	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Stefano Agrestini*, Antonio Bianconi*, Gaetano Campi***,** Matteo Filippi*, Naurang L. Saini*

Unità INFM and Dipartimento di Fisica, Università La Sapienza, Piazzale Aldo Moro 2, 00185, Roma (Italy)

Report:

We have performed the study of the low-temperature thermal expansion, using high resolution powder x-ray diffraction, as a function of Mg substitution in the Al1-xMgxB2 system in order to understand correlation between the thermal expansion anomaly close Tc and the superconductivity. During the allocated beam-time we have measured high resolution x-ray diffraction on the $Mg_{1-x}Al_xB_2$, as a function of Al concentration. We could perform the measurements on three samples with x=0.00, 1/6 and 5/6, using the wavelength λ=0.5 Å. All these samples were synthesized by direct reaction of the elemental magnesium, aluminum and boron enclosed in a stoichiometry ratio in tantalum crucibles, sealed by arc welding under argon atmosphere and were well characterized for their superconducting properties. The measurements were made at 25 different temperatures in the range between 4 K and 295 K for all samples. Unfortunately we have been able to get good data for the x=0.00, 1/6 samples. In figure 1 we report the variation of the a axis normalized to its value at T=300K for the two studied samples. In figure 2 we report the variation of the c axis normalized to its value at T=300K for the two studied samples. The results for the MgB_2 sample for the a-axis shows a negative thermal expansion below T*=60 K with a smaller effect in the c-axis, that

confirms the previous data by neutron diffraction by Jorgensen et al. [1,2]. Moreover we observe a bump in the thermal expansion of the a-axis at T_c in MgB_2 that provides a direct evidence for the coupling of the condensate with the lattice. This effect can be clearly observe in the raw data shown in Figure 1 us commonly assigned to a change of the structural symmetry at short length scale. For the x=1/6 Al-doped sample we have obtained for the first times evidence for a negative thermal expansion below T* much larger than in MgB_2.. This effect could be related to the anomalous temperature and pressure behaviour of the E_{2g} Raman mode of MgB_2 [3] that has been explained in terms of the proximity to an electronic topological transition [4]. In fact a lattice instability is expected approaching the chemical potential to a critical point at zero temperature that for magnesium diboride occurs at the point where the Fermi surface 2D topology of the sigma band change to a 3D topology. In Al doped material the ETT is expected at x=0.33 [5], therefore the lattice instability is expected to increase with Al doping. The results in Figure 1 and 2 show that the anomalous negative thermal expansion at T<T* increases with Al doping, confirming the expected scenario. The results require to be extended to several Al doping concentrations.

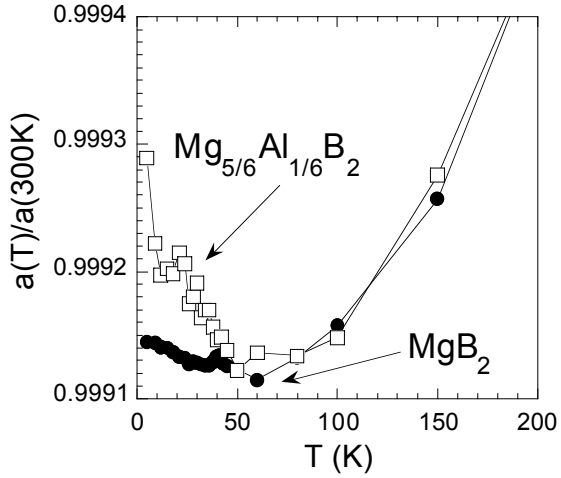

Fig.1 Thermal expansion of the *a*-axis, normalized to its value at T=300K.

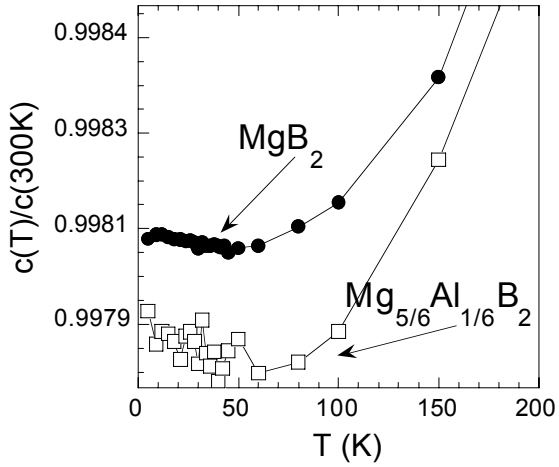

Fig. 2 Thermal expansion of the *c*-axis, normalized to its value at T=300K

1. J. D. Jorgensen, D. G. Hinks, S. Short, Phys. Rev. B 63 , 224522 (2001)

2. J. D. Jorgensen,et al. cond-mat/0205486

3. A. F. Goncharov, V. V. Struzhkin Physica C 385 117–130 (2003).

4. I. M. Lifshitz Soviet Physics JEPT 11, 1130 (1960).

5. A. Bianconi *et al.*, *Phys. Rev. B* **65**, 174515(2002)