Characterization of high thermal conductivity cuprates thin films using MeV Ion Beam Analysis techniques

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Transition metal oxides (TMOs) exhibit a rich variety of novel properties which can be exploited for a wide range of applications including ultra-high-density magnetic data storage, spintronics, quantum computing and more recently thermal management applications. The discovery of high thermal conductivity in cuprates has increased in recent years the interest for low-dimensional Heisenberg magnetic systems. Specifically, it has been demonstrated that, in addition to electrons and phonons, heat can also be transported by magnetic excitations (magnons or spinons) in quasi low-dimensional electrically-insulating quantum magnets . The magnetic heat conduction is highly anisotropic, outweighs the lattice contribution and has mainly been studied in novel complex transition metal oxides with quasi 1D spin structures such as the "two-leg ladder" compound $(La,Sr,Ca)_{14}Cu_{24}O_{41}$. It is noteworthy that the room-temperature magnetic thermal conductivity (of the order of 100 $Wm^{?1}K^{?1}$) is as high as in metals [1]. Nevertheless, the fabrication of such compounds in a more technological relevant form, i. e. thin films, has proven to be rather challenging due to the complexity of the structure.

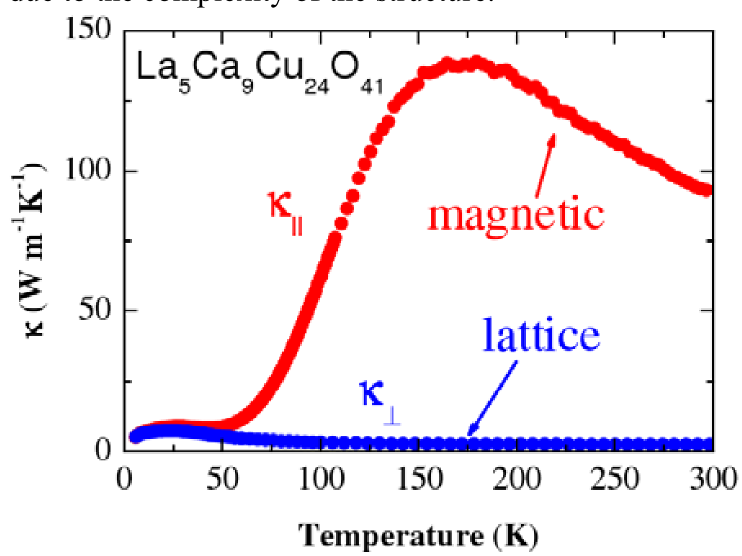

Figure 1. *Thermal conductivity of the spin ladder material La5Ca9Cu24O41 (LCCO), measured parallel (κ||) and perpendicular (κ?) to the ladders. Data from [1].*

We have explored pulsed laser deposition (PLD) as a sequential high-deposition rate process for the preparation of $La_5Ca_9Cu_{24}O_{41}$ thin films grown on $SrTiO_3$, $Gd_3Ga_5O_{12}$ and $SrLaAlO_4$ substrates and we extensively studied the influence of the PLD growth parameters, substrate nature and crystallographic orientation on the films epitaxial nature and stoichiometry. Preliminary results based on X-ray photo-electron spectroscopy (XPS), X-ray diffraction (XRD) and high-resolution transmission electron microscopy (HR-TEM) studies suggest that the films are slightly non-stoichiometric; there is a Ca-deficiency. However, such materials are not easy to profile: sputtering techniques (Auger electron or X-ray photo-electron spectroscopy, or SIMS) are plagued by artefacts including those of interfaces, and SIMS is not quantitative because of the large matrix effects. Analytical methods such as SEM-EDS (energy dispersive X-ray spectrometry on the scanning electron microscope) have little or no depth resolution and do not work well for these thin films.

Our intention is to characterize such films using accurate thin film depth profiling by a self-consistent analysis of simultaneously collected spectra from MeV ion backscattering together with the stimulated photon emission.

We need 3 days (9 shifts) at the 3 MV Tandetron accelerator.

References:

[1] C. Hess, *et al.*, Phys. Rev. B **64**, 184305 (2001)