Abstract of Presentation

IRON BASED SUPERCONDUCTORS: EFFECT OF DOPING, CHEMICAL PRESSURE, STRESS, MAGNETIC AND NOT MAGNETIC IMPURITIES

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Abstract :

The recent discovery of Fe-based superconductors has opened several perspectives: more fundamental, as the understanding of the basic mechanisms responsible for superconductivity and more practical, as the optimization of the material synthesis for improving the superconducting properties and the exploring of their potential for applications. The current activity of the CNR-SPIN laboratory of Genova, Italy on Fe-based superconductors addresses these different fields:

1)Role of substitutions in 1111 compounds: Since it has been suggested that superconductivity in pnictides may be mediated by magnetic excitations, the interplay between superconductivity and magnetism can be investigated by varying magnetic and superconducting properties of the compounds through suitable substitutions, nevertheless results from several substitutions pointed out on the difficulty to separate the effect of disorder, doping and magnetism on the properties of pnictides. To enucleate the effect of disorder we substituted isoelectronic Ru at the Fe site in optimally doped Sm-1111 phase: indeed ab-initio calculations show that substitution Ru does not strongly modify electronic properties, whereas it frustrates the magnetic moment of Fe and act as not magnetic impurities.We were able to completely suppress the superconductivity for Ru content higher than 56%1. Since the La system presents the lowest Tc within the 1111 family likely due to the large ionic radius of La, La-1111 is one of the best systems to investigate the effects of chemical pressure on Tc through smaller ion size substitution on La site. We partially substituted yttrium at the lanthanum site of the undoped LaFeAsO and superconducting LaFeAsO0.85F0.15 compounds and we studied its effect on the structural, magnetic and superconducting properties. Increasing2 the Y content, the SDW ordering temperature in the undoped compounds progressively shifts to lower temperature while superconductivity does not occur. In the 15%-doped samples, Tc progressively grows from 24 to 40 K with increasing y from 0 to 0.5 and then decreases probably for some crystallographic disorder introduced by the smaller Y size compared to La. These results suggest that smaller TSDW in the undoped compounds favours higher Tc in the F-doped one. Similar evolution of TSDW and Tc has been also observed as a function of external pressure, indicating that external and chemical pressure play a very similar role.

2) Thin films grown. Similar effect in the Tc increase can be produced in FeSe0.5Te0.5

Abstract of Presentation

thin film by compressive in plane stress. We demonstrated3 that, in strained thin films, Tc can be enhanced up to 21K, 5 K higher in respect to the bulk value!

All these data on different systems will be discussed in term of the chalcogen eight and thetraedical bond angle values.

3) To enucleate the role of magnetic impurities the study of the Fe excess in FeySexTe1+x seems promising to help in the understanding the role of the magnetic order in the Fe planes in inducing superconductivity. We present a systematic study by means of transport measurements on polycrystalline samples by varying both Se content and Fe excess (y=0.9, 1, 1.1). Our results give strong indications in favour of a multiband character of this compound and they shed a light on the role of iron excess on the normal and superconducting state properties.

4) Optimization of the synthesis of polycrystalline samples It has been shown4 that polycrystalline samples exhibit electromagnetic granular behavior, perhaps in an analogous way to that seen now to be intrinsic to the HTS cuprates. Meanwhile it appears that polycrystalline oxypnictides are multi-phase. In collaboration with Florida State University (D Larbalestier) and Tokyo University (A. Yamamoto) we synthesize more single phase polycrystalline 1111 samples that are densified by employing HIP. Using remanent magnetization analysis, magneto-optical imaging and detailed microstructural analysis we study intergranular current flow in samples synthesized at different temperature and pressure.

References

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