Interplay of Superconductivity and Magnetism in Oxy-Chalcogen Cuprates $YBaSrCu_3O_xSe_y$

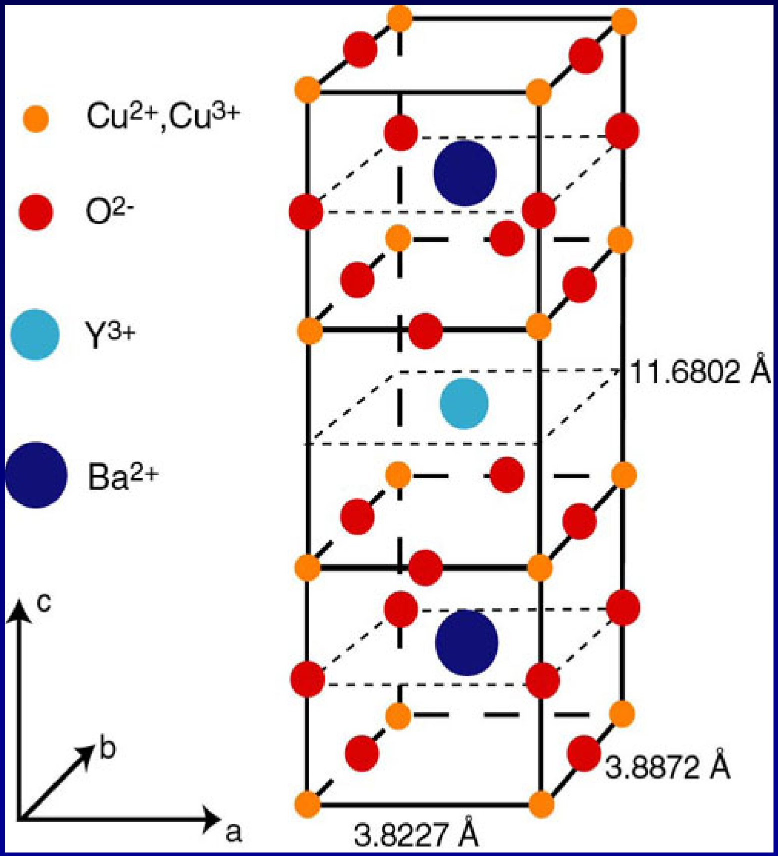
Armen Gulian, presenter
Chapman University, Institute for Quantum Studies,
Advanced Physics Laboratory, Burtonsville, MD 20866, USA

Vahan Nikoghosyan
Chapman University, Institute for Quantum Studies,
Advanced Physics Laboratory, Burtonsville, MD 20866, USA
Also: Physics Research Institute, National Academy of Sciences, Ashtarak, 0203, Armenia

Vadim Grinenko
Leibniz Institute IFW-Dresden, PF 270116, Dresden D-01171, Germany

March Meeting of the American Physical Society, Baltimore, March 14-18, 2016 . Session B25, March 14

Motivation:



Belief:

Exploration of the oxychalcogens is a valuable step towards testing the proposed theories of HTSC

[Yee C.-H., Birol T., and Kotliar G. Guided design of copper oxysulfide superconductors. *Europhys. Lett.*, **111**, 17002 (2015).]

Intention:

Replace in $YBa_2Cu_3O_7$ superconductors:

1) one atom of Ba by Sr
2) one oxygen atom by Se.

Outcome:

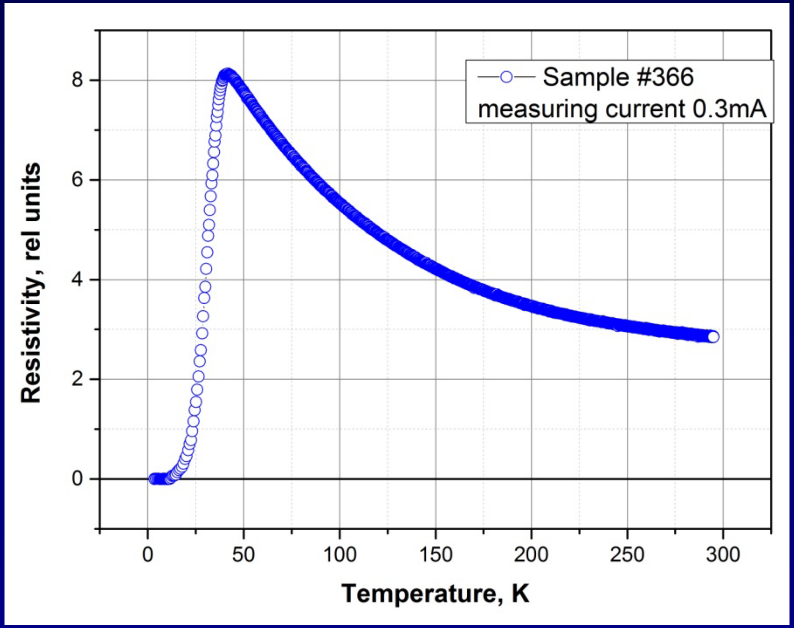
This double substitution results in:

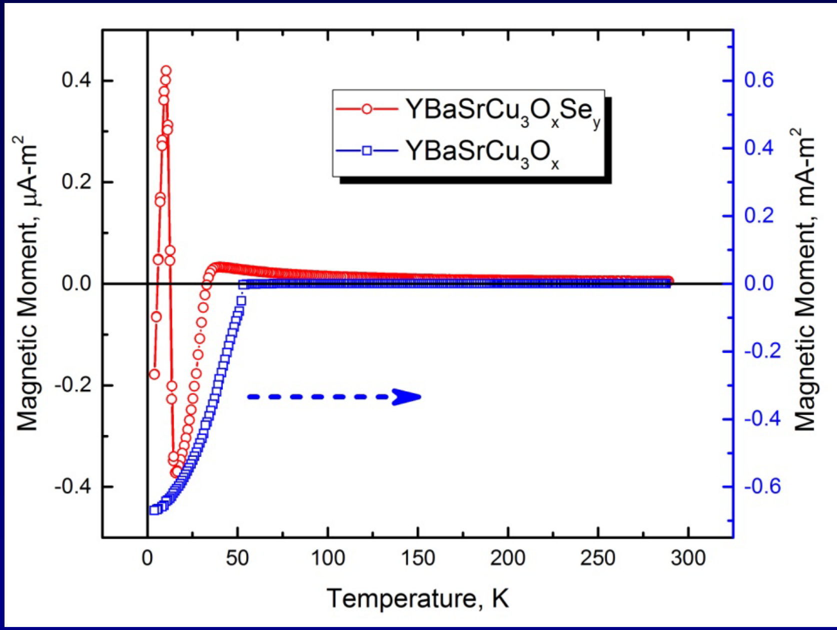
1. two SC transitions: at 34K and and18K;
2. the re-entrant Wohlleben effect;
3. setting up of ferromagnetic interaction at 4K.

Standard Synthesis Routes

Y_2O_3, $SrCO_3$, $BaCO_3$, and SrSe in stoichiometric proportions for $YBaSrCu_3O_xSe$ composition. Calcinating at 900°C for 100 min. Re-grinding, pelletizing, baking at 950°C for 30 min. Continued at 650°C for 80 minutes.

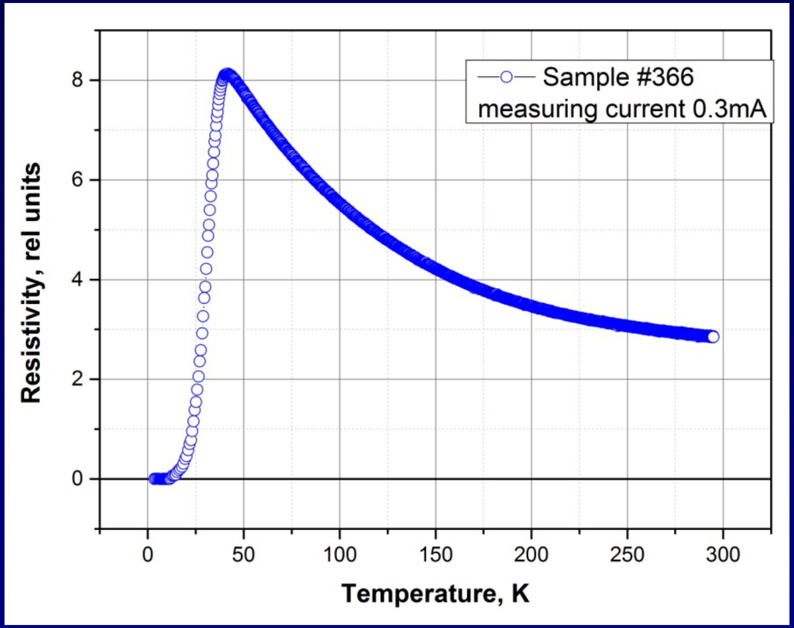
Initial Findings: Doubly Re-entrant Magnetization

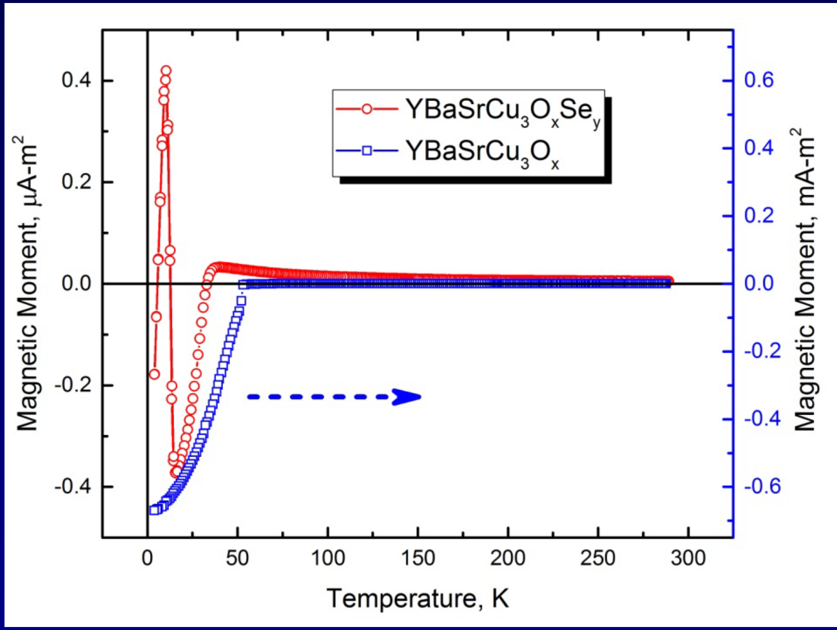




While resistive transition takes place at ~35K, diamagnetic transition which started at the same T is suppressed by the re-entrant paramagnetism at cooling down, which itself is suppressed by the re-entrant diamagnetism at further cooling down!

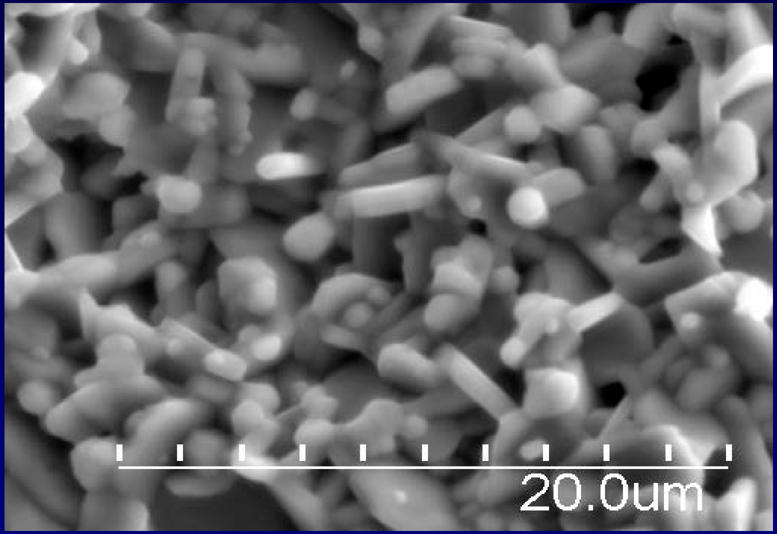
What is going on?

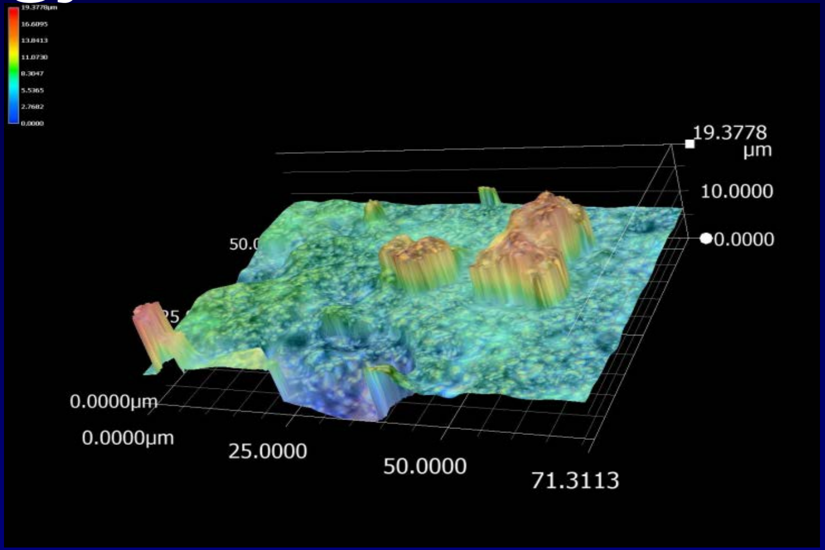


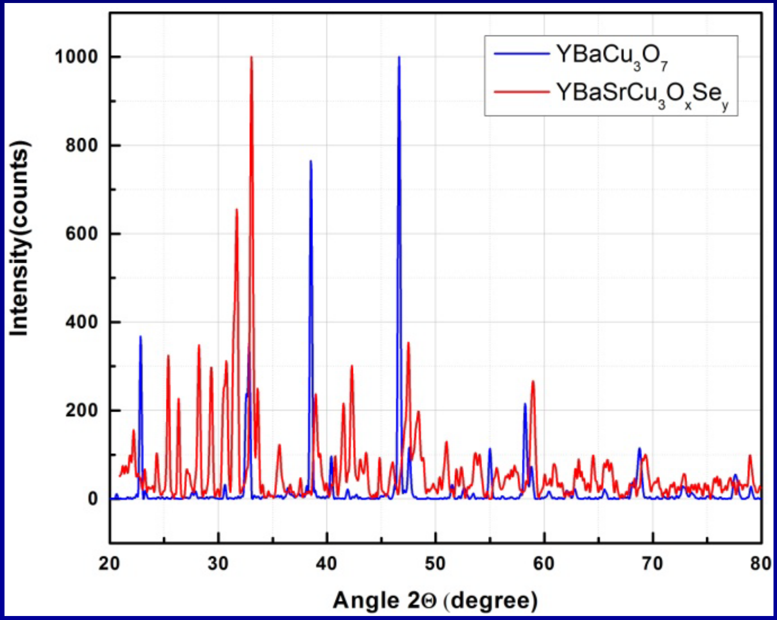


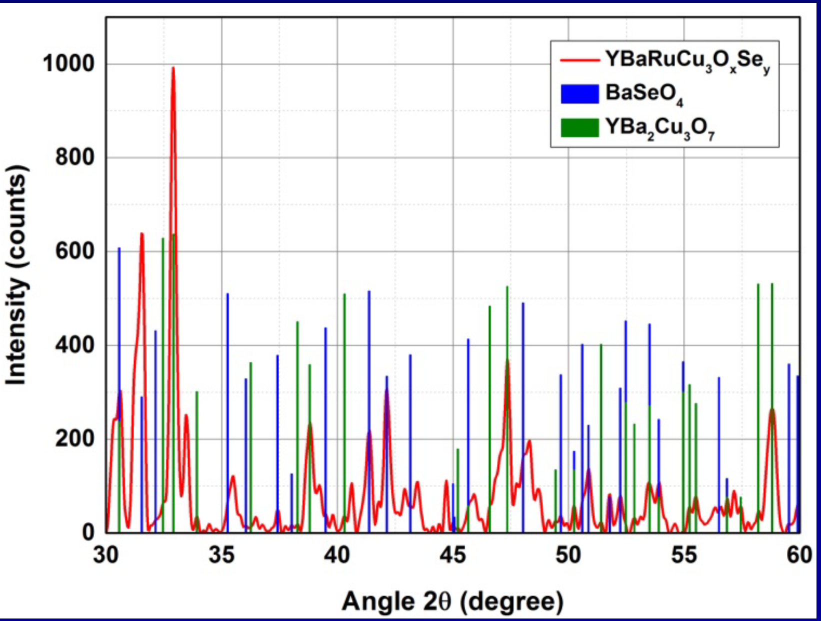
1) **How many phase transitions?**
2) **What is causing the jumps?**
3) **Any effect on resistivity?**
4) **Crystalline structure**
5) **Composition**

Surface morphology and Structure

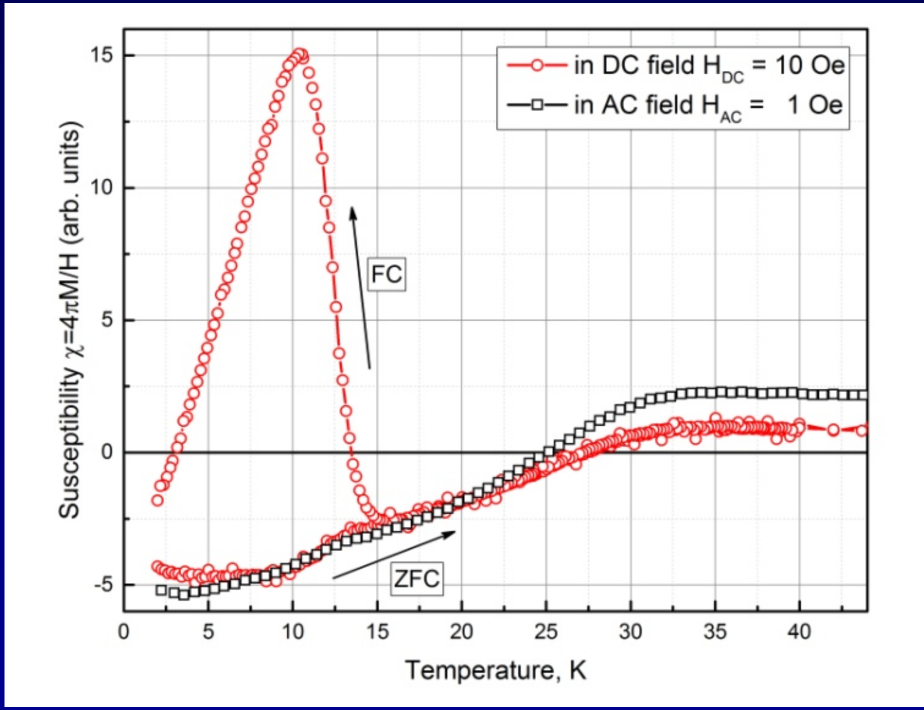


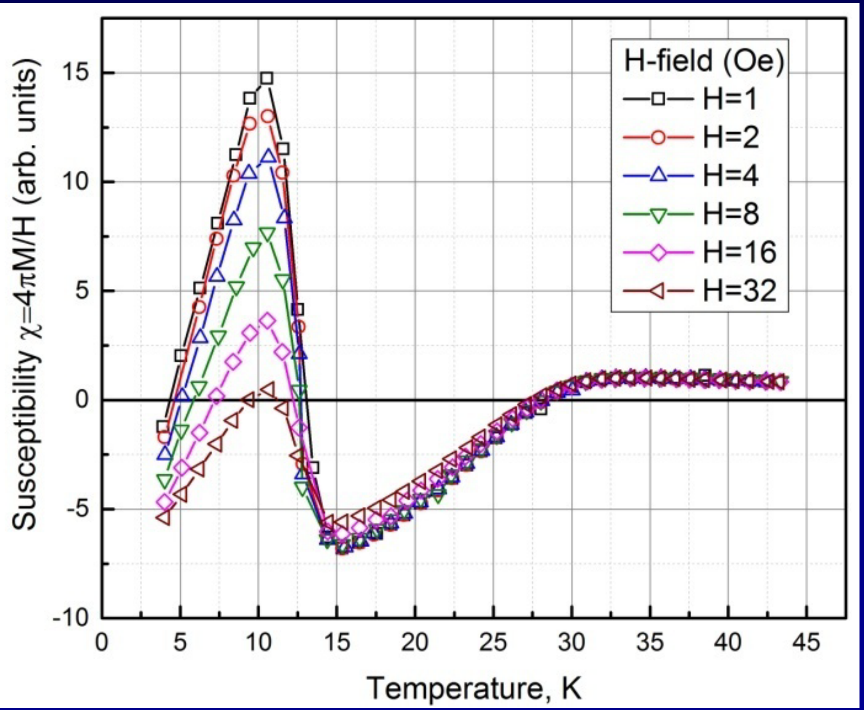




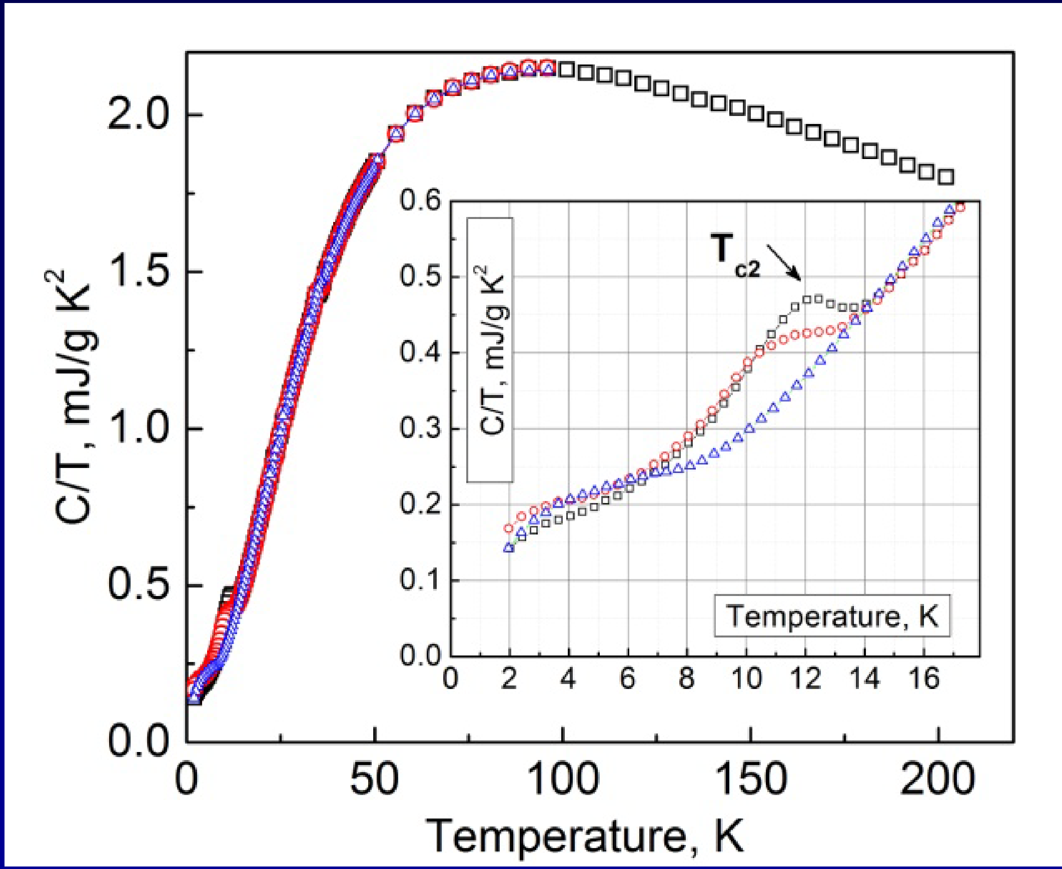


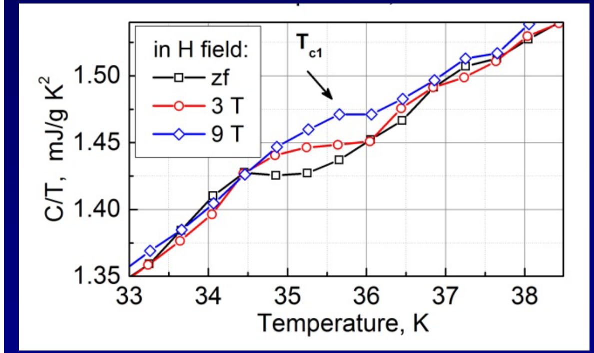
Wohlleben Effect (PME)





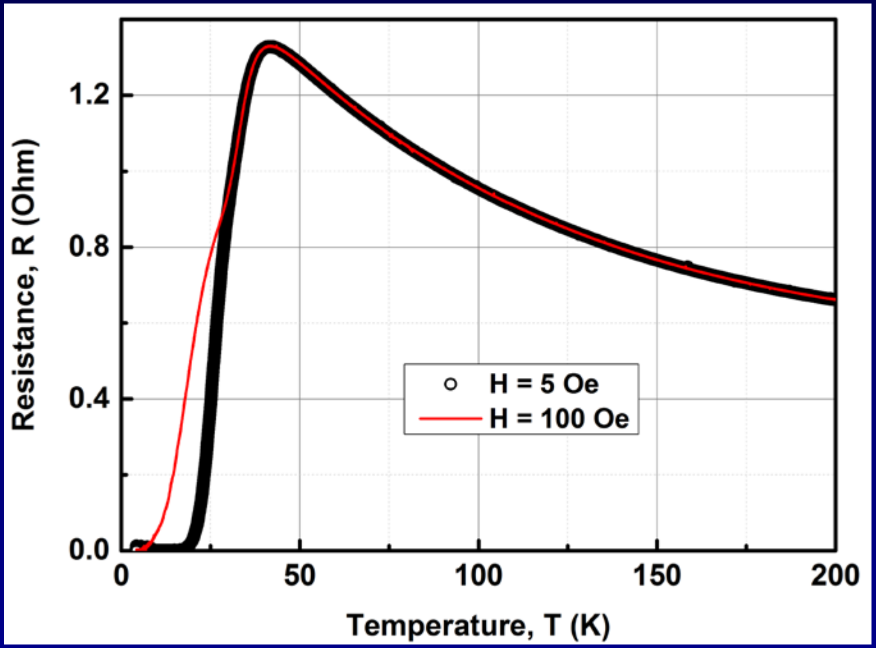
Two SC transitions as indicated by heat capacity

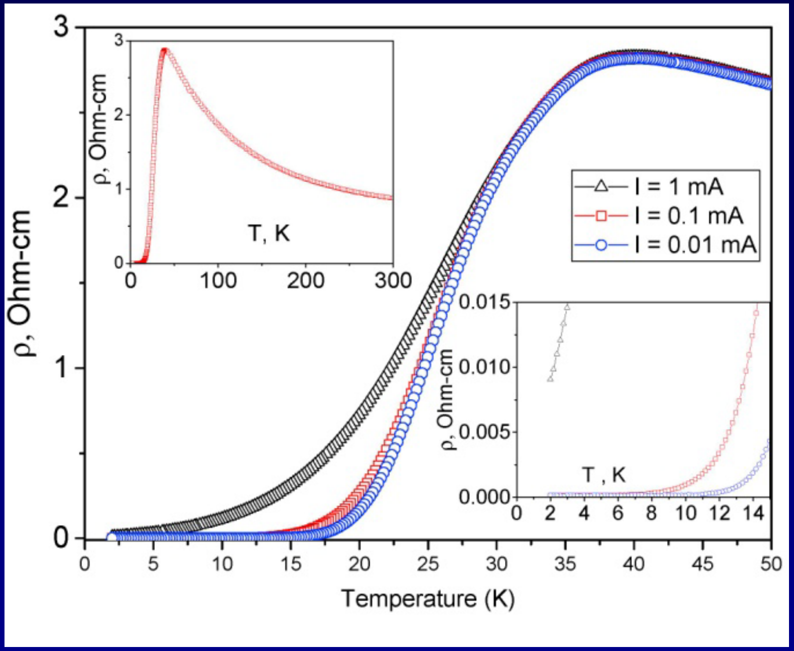




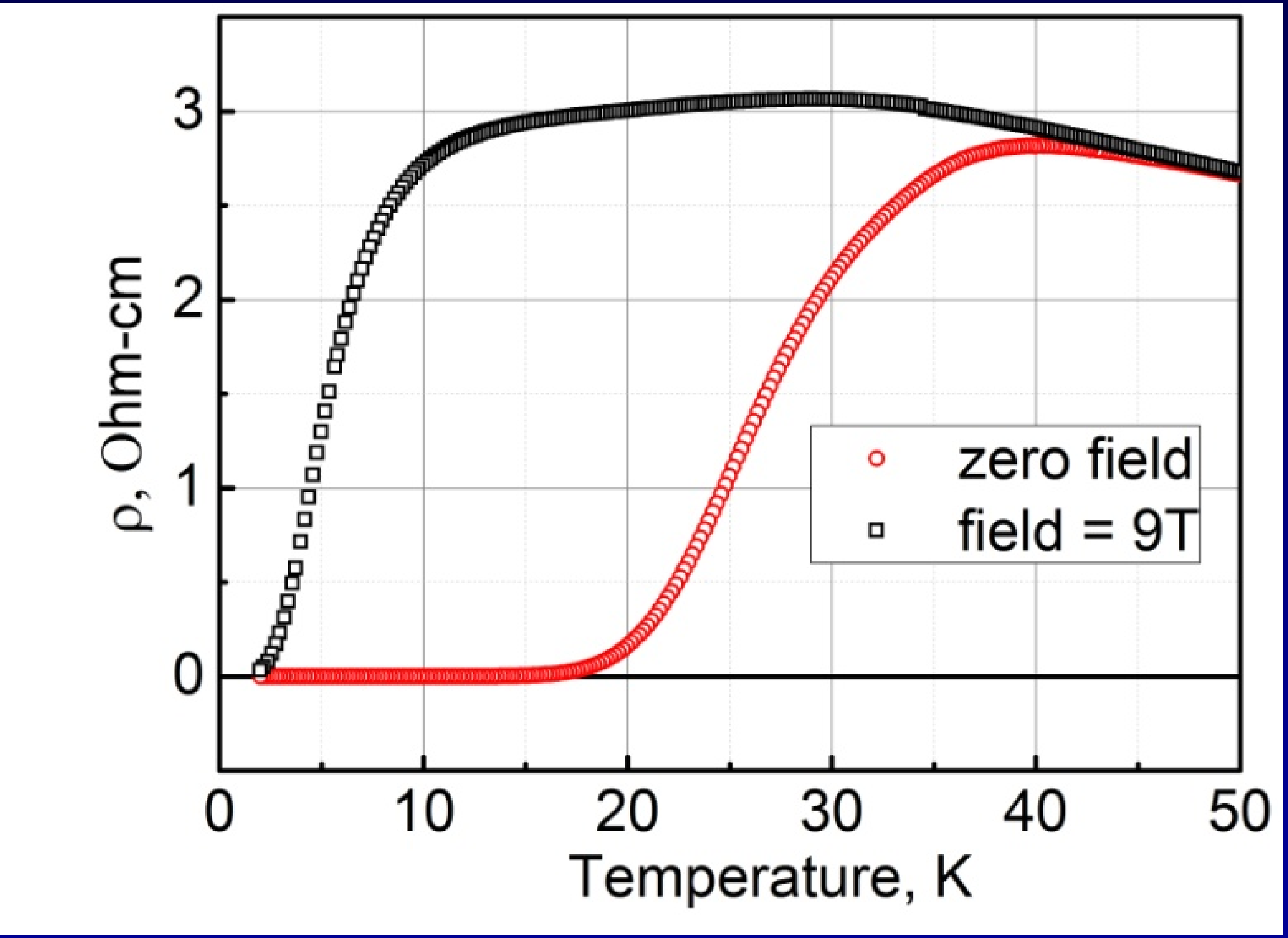
March Meeting of the American Physical Society, Baltimore, March 14-18, 2016 . Session B25, March 14

Two SC phases in resistivity?

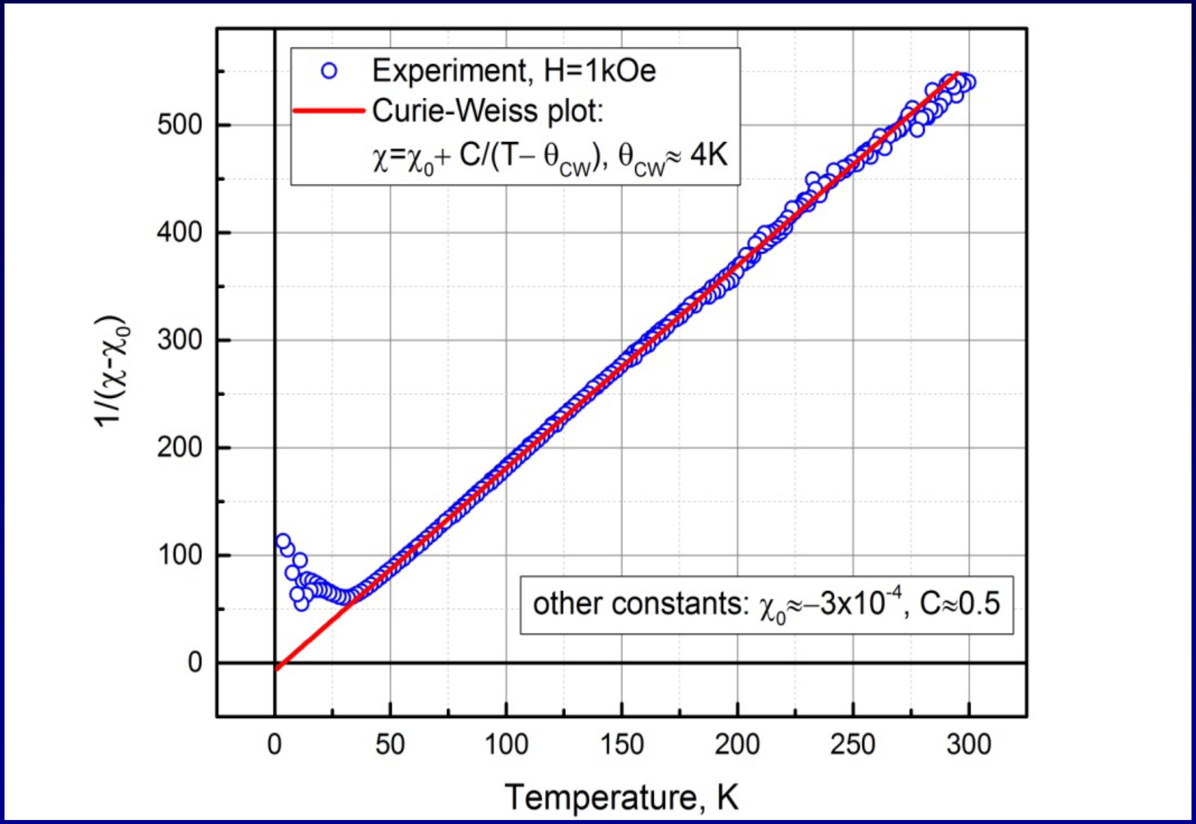




Two SC phases in resistivity?

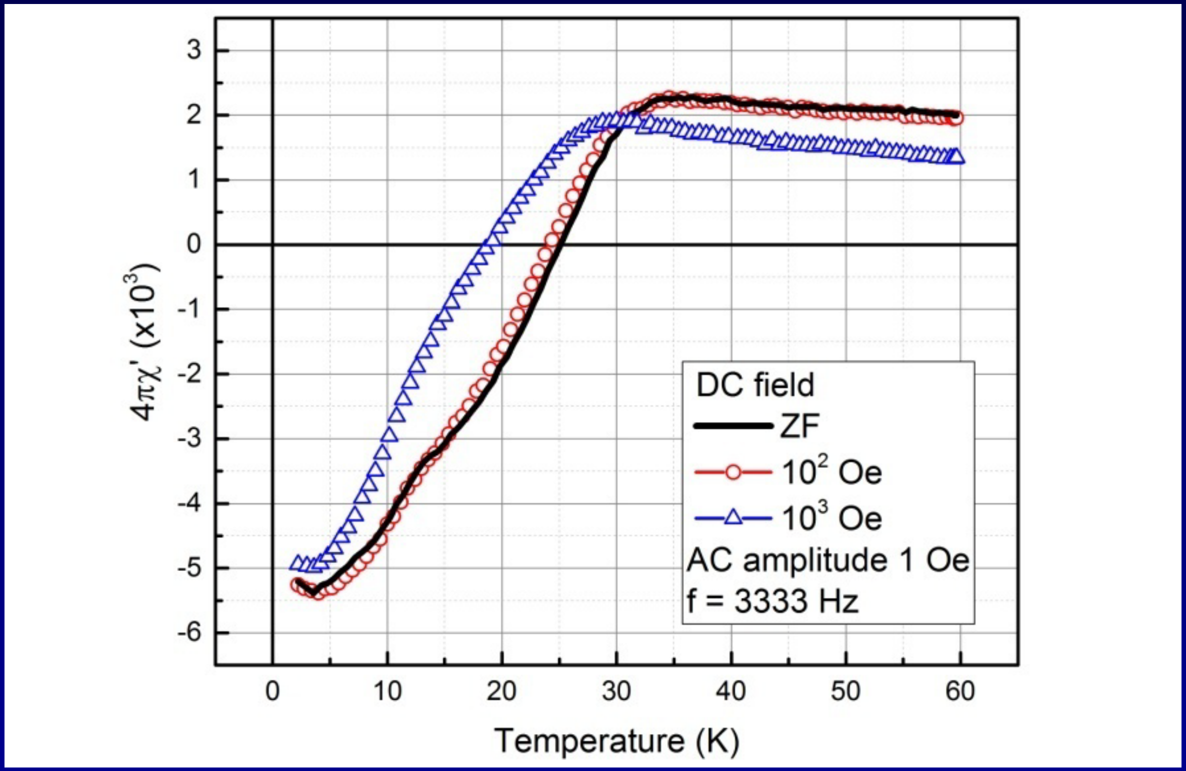


Fitting by the Curie-Weiss law



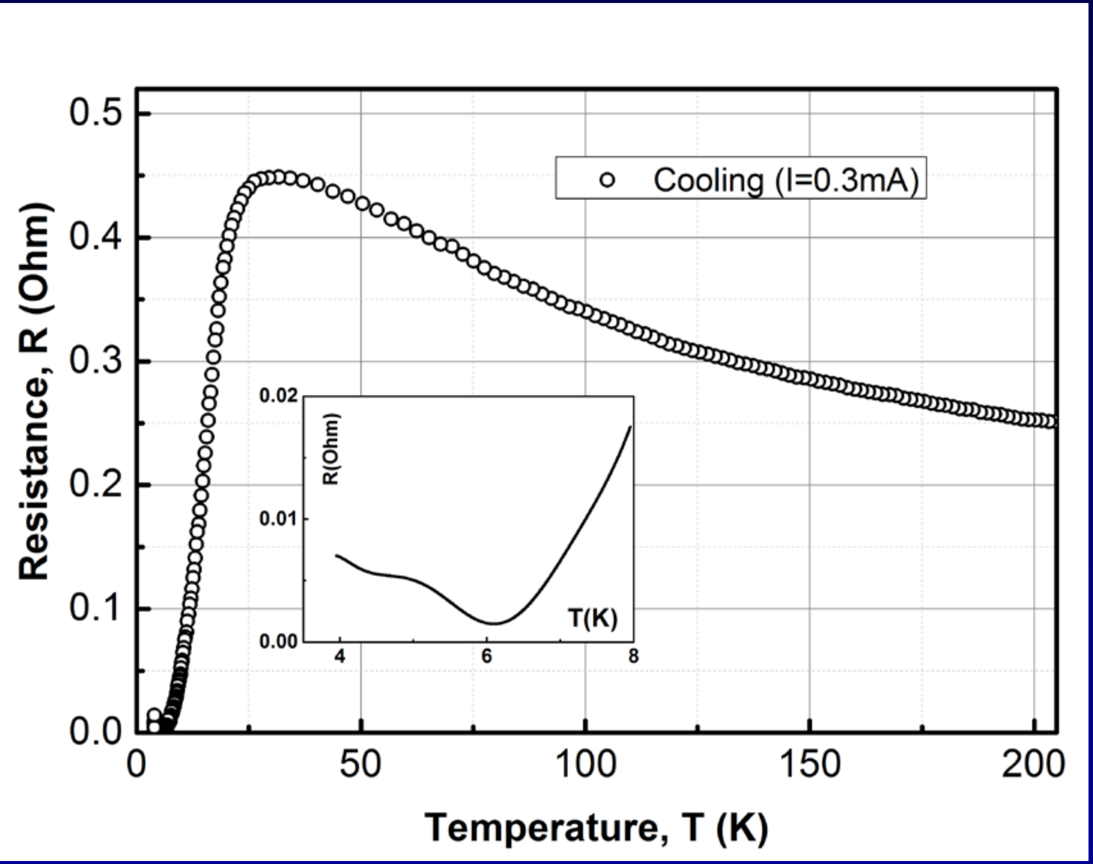
- μ_{eff}~2/3 μ_B per Cu atom
- Enhanced correlations are responsible for magnetism.

Upturn in the AC-susceptibility



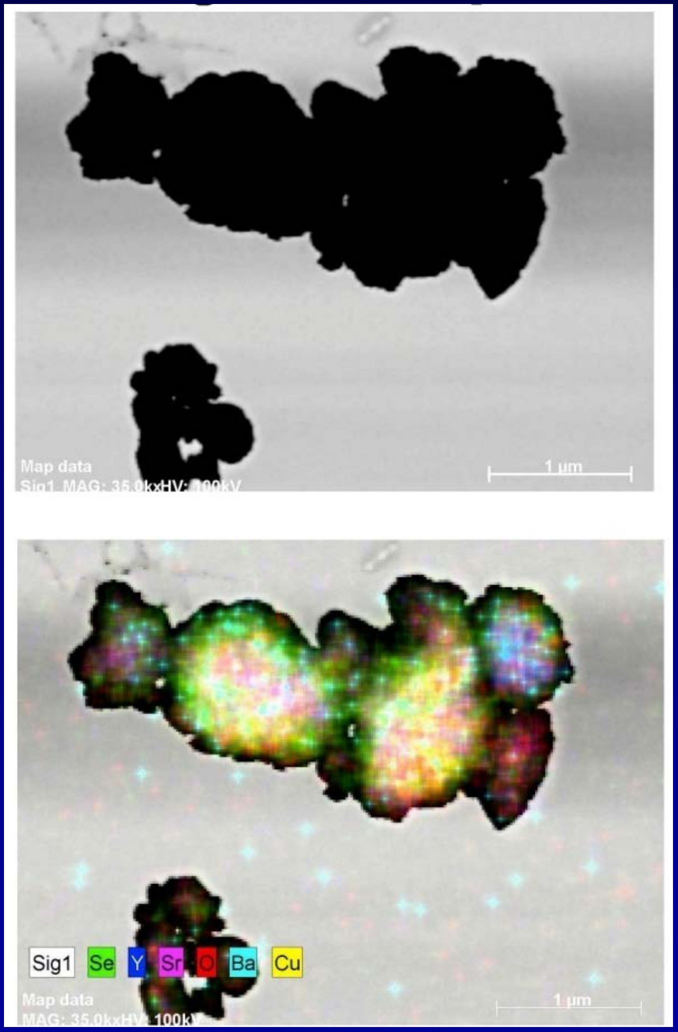
- Various magnetic fields: H=0, 100 Oe, 1000 Oe
- f=3333Hz ; measurements at other frequencies yielded similar results.

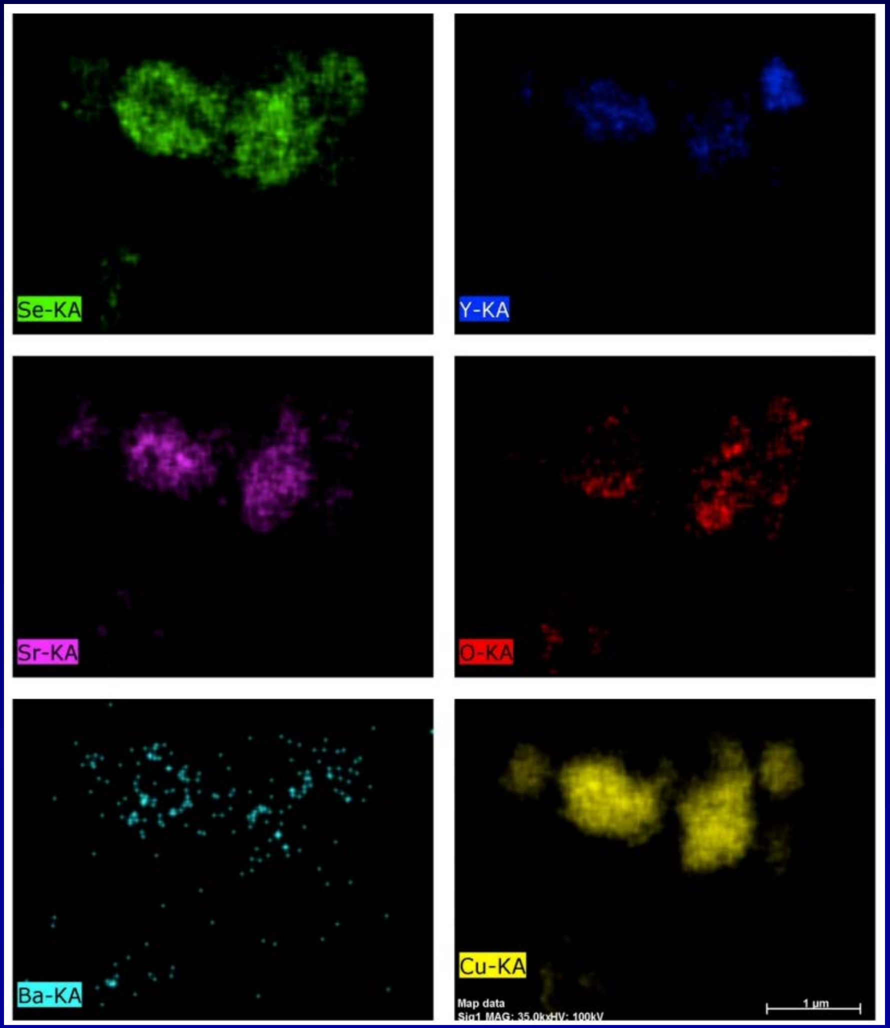
Re-entrant resistive state



In some samples only

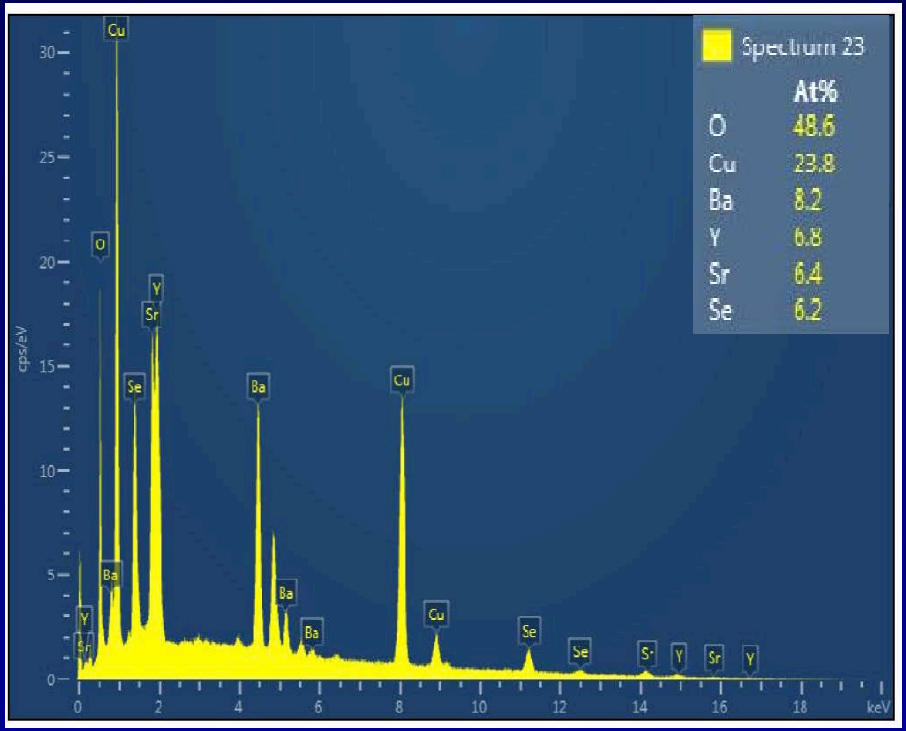
Does Se stay in composition?

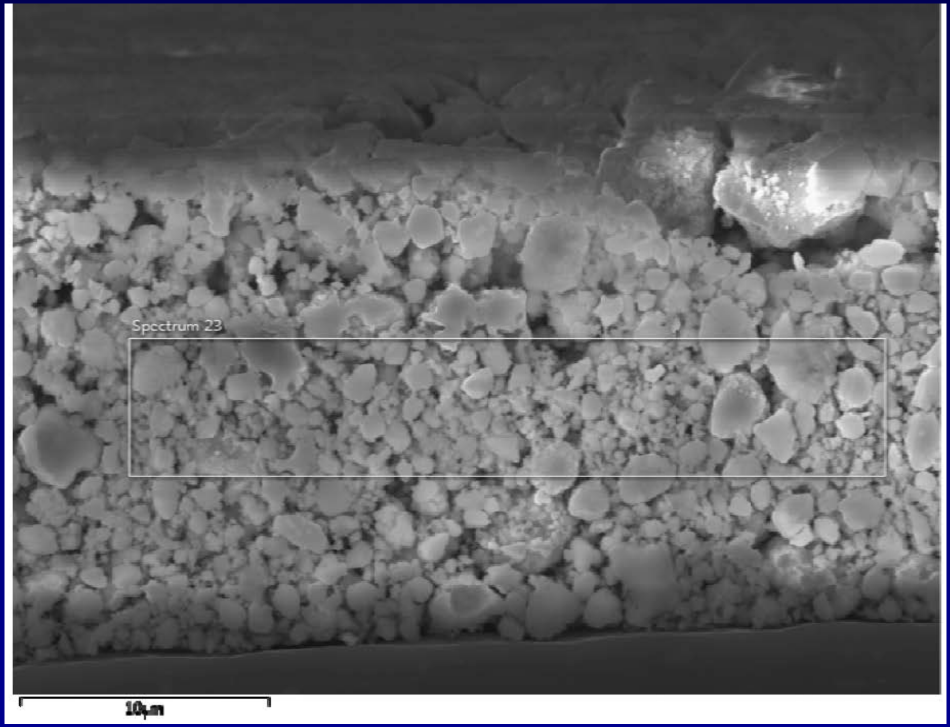




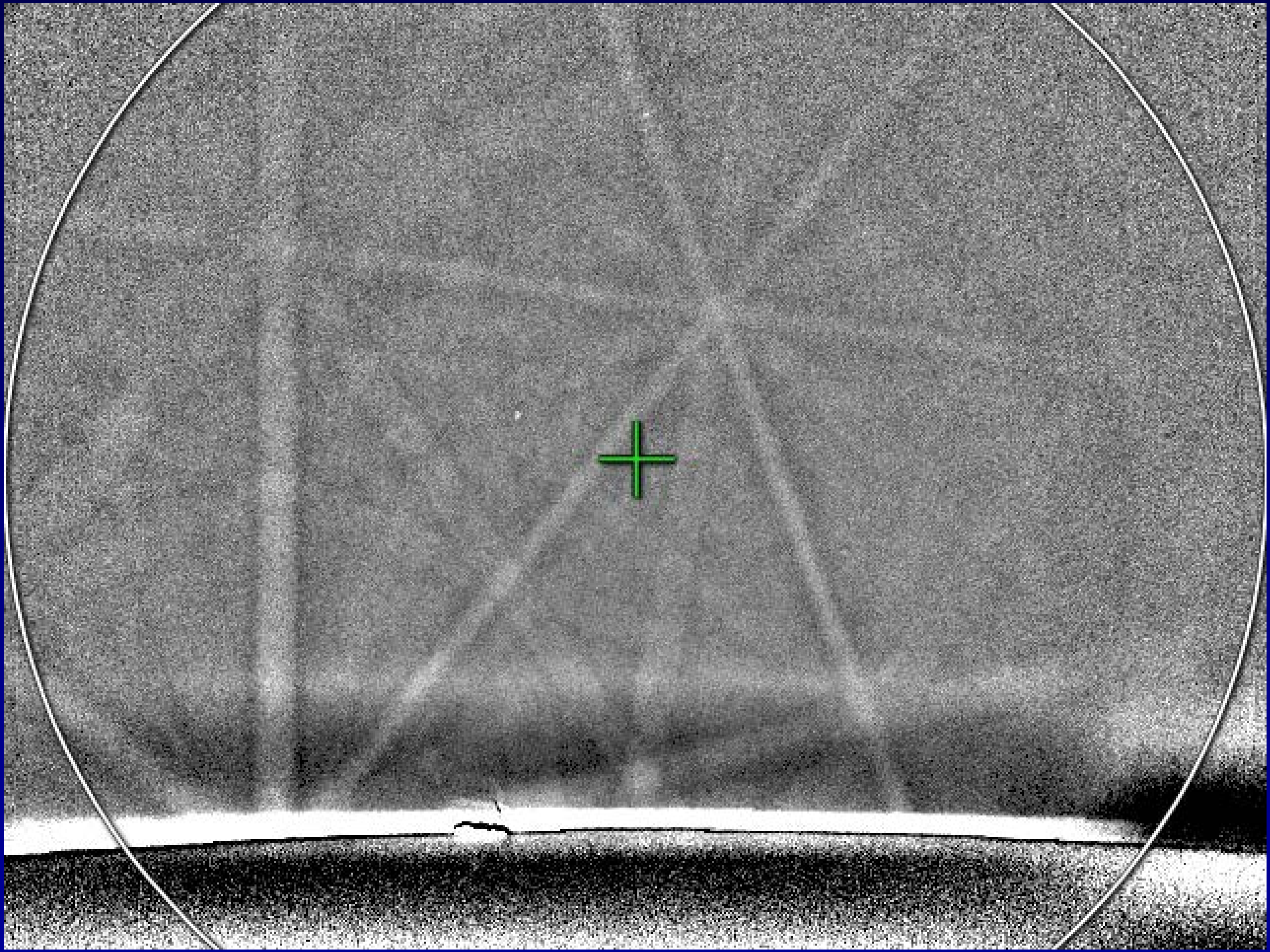
TEM analysis (Hitachi-USA)

Quantitatively?





In the lattice?



Kikkuchi pattern with simultaneous EDX

Acknowledgement

- This work is supported in part by the US Office of Naval Research
- Collaborative support of Hitachi-USA (S. Nozaki, A. Muto, J. Clark, and J. Kilcrease) is very appreciated

Many thanks for your attention!