ELECTRONIC STRUCTURE OF FERROMAGNETIC SEMICONDUCTORS EuX (X=O, S, Se, Te) PROBED BY X-RAY MAGNETIC CIRCULAR DICHOISM UNDER HIGH PRESSURE

Narcizo M. Souza-Neto[1], Daniel Haskel[1], Yuan-Chieh Tseng[1,2], and Gerard Lapertot[3]
[1]X-ray Science Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439; [2]Department of Materials Science and Engineering, Northwestern University, Evanston, IL 60201; [3]Département de Recherche Fondamentale sur la Matière Condensée, SPSMS, CEA, 38054 Grenoble, France

INTRODUCTION

Ferromagnetic semiconductors have become a subject of great technological interest due to their potential use in spintronics. The important class of Eu^{2+} monochalcogenides EuX (X= O, S, Se, Te) has attracted attention in this respect, but their low ordering temperatures together with complex indirect exchange interactions between Eu 4f moments in these semiconducting materials presents a challenge. A critical issue is the role of f-d and f-p(anion) hybridization, which regulates indirect- and superexchange-interactions.
Strain present in EuX-based nanostructures is known to strongly affect the electronic structure and magnetism. Similarly, contracting the lattice by changing anion type (chemical pressure) or applying pressure enhances the ferromagnetic ordering temperatures, T_C up to 200 K (1). A direct measurement of the changes that take place in electronic structure with anion substitution or pressure - a critical ingredient needed for theoretical models - is still missing.

EXPERIMENTAL

In this work we compare the effect of chemical (anion substitution) and physical (externally applied) pressures upon the electronic and magnetic properties of these bulk FM insulators. The atomic selectivity of XMCD (x-ray magnetic circular dichroism) coupled with the high pressures attainable in a diamond anvil cell (DAC) enables directly probing the magnetism and electronic structure of the 4f (valence) and 5d (conduction) band of Eu atoms under extreme pressure conditions.

RESULTS

We present results from XMCD experiments on EuX samples at ambient and high-pressure (15 GPa) conditions together with ab-initio, density functional theory (DFT) simulations to show that indirect f-d exchange dictates the magnetic properties of these systems under pressure. Also, the processes that determine the highest ordering temperature under pressure (T_C=200 K) are revisited with the hope that related ferromagnetic semiconducting/insulating systems could be found with even higher T_C.

REFERENCES

1. Goncharenko, I.N. and Mirebeau, I., Physical Review Letters 80, 1082 (1998)

ACKNOWLEDGMENTS

Work at Argonne is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No. DE-AC-02-06CH11357.