# CAREER PROJECT SUMMARY EXAMPLE
# AWARDED 2006

**SECTION A- SUMMARY:** This five year career-development plan (CDP) is an integrated research, education, and outreach program that focuses on the study of spin-dependent phenomena in semiconductors at multiple length scales. This CDP has four main goals:

1. To develop a theory of spin transport and accumulation in spin-orbit coupled systems where spin manipulation is possible solely by electrical means. This study, which encompasses the spin-Hall effect, will address key issues such as disorder scattering, generalized drift-diffusion equations, and interaction effects. Several approaches combining analytical and computational techniques at different length scales will be utilized;
2. To obtain a systematic theory of the anomalous Hall effect and anomalous transport that treats on an equal footing both extrinsic and intrinsic mechanisms responsible for the effect. This study will also merge different approaches to resolve the contradictory results obtained through microscopic and phenomenological approaches which ultimately should be linked, forming a consistent theory;
3. To further extend the theory of magneto-transport and magneto-optics in diluted magnetic semiconductors (DMS) to include nano-structures and hybrid systems and explore new phenomena such as tunneling anisotropic magneto-resistance;
4. To implement an educational plan which incorporates and develops a new teaching initiative in the upper-division undergraduate curriculum, involves undergraduates in research, promotes student international collaborative research, exposes the field of spintronics to the general public, and provides a resource web-site for DMS studies.

**Intellectual merit of the proposed activity:** The proposed research plan addresses fundamental questions essential to advancements in the semiconductor spintronics field (SeS). We propose to develop a spin-transport theory for systems with intrinsic and extrinsic spin-orbit coupling using a variety of models and approaches at multiple length scales in order to connect the physical insights obtained through each approach into a unified cohesive picture of spin-transport in semiconductors. At the nanoscale it is possible to explicitly address the effects of disorder on decoherence and spin-accumulation. This microscopic approach must ultimately be linked to the macroscopic length scale as it was done successfully in charge transport theory. Some of these approaches will involve non-equilibrium Green's function calculations, phenomenological model calculations, and first principles calculations. The PI has ongoing collaborations with leading experimental groups at Hitachi-Cambridge, SUNY Buffalo, U. of Würzburg, and U. of Nottingham. This CDP extends naturally a highly fertile line of leading research by the PI which has generated many publications by his group in top ranked journals and has been featured in wider audience journals (Physics Today, February 2005).

**Broader impact of the proposed activity:** The greater tunability of materials properties in semiconductors gives SeS devices richer scientific and technological possibilities than their metallic counterparts and may resolve current obstacles such as dissipation of heat at the nanoscale. This CDP evaluates SeS systems as a technological alternative.

The educational and outreach component of this CDP focuses on four segments: (1) Incorporation, further development, and assessment of several Paradigms of Physics (PP) module courses at Texas A&M University (TAMU) in coordination with their developers at Oregon State University. The PP program consists of several short module-like-courses, taught during the junior year, that focus on key paradigms that cut across several branches of physics. This allows students to better connect many interwoven ideas in different subfields. (2) Direct undergraduate involvement in the group's research projects. (3) Enhancement of graduate education, through student participation in international collaborative research including visits to international experimental groups. (4) Outreach activities to increase public awareness of spintronics and its broad impact in society, including public lectures and the development of a website describing spintronics research at TAMU at a general level. In addition a website dedicated to the specialized DMS research community will be further developed. The PI believes strongly in mentoring underrepresented students and diversity will be encouraged in the research group. The PI is currently advising two Hispanic graduate students and two undergraduate students.