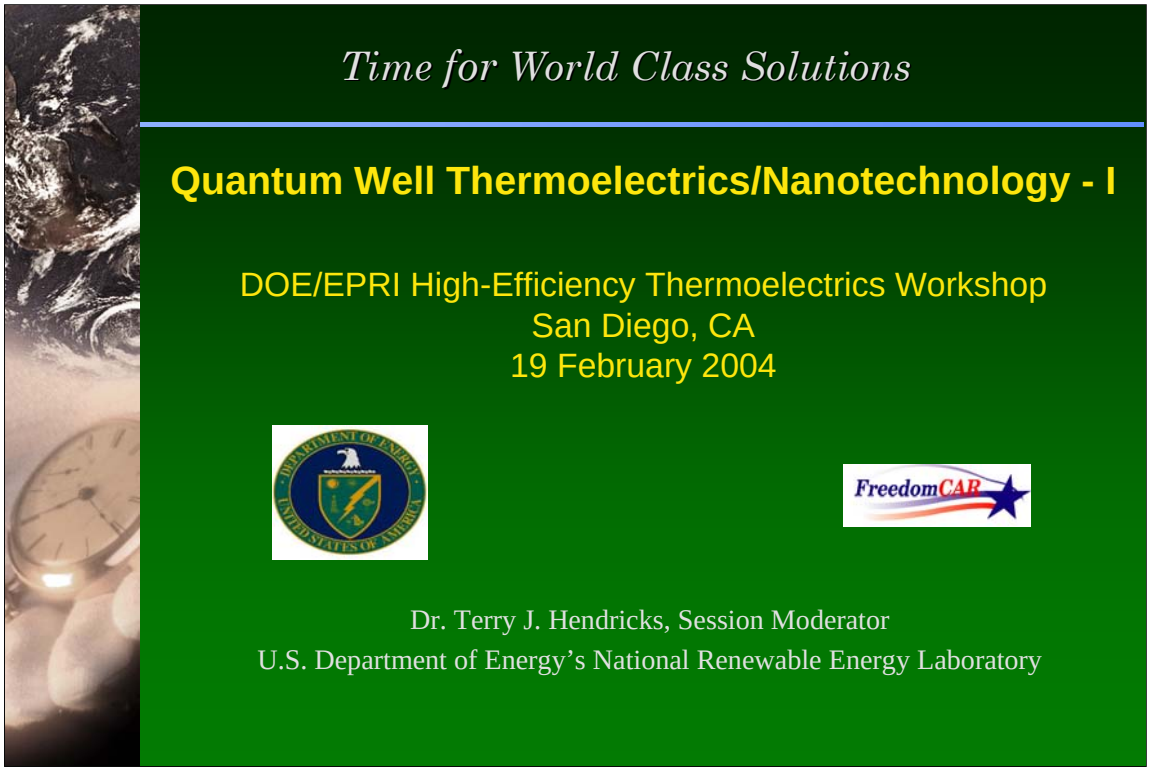

Opening Session Remarks

We live in some amazing times right now and have experienced some amazing technological developments in the last 30-40 years. Many of us experienced as small children, with amazement, man reaching out to the frontiers of space and the heavens to our first landings on the moon. We experienced (at that time) far-reaching vehicles and technologies that man used for that achievement. We live in an age of Space Stations and Space Shuttles, making relatively regular visits to space. We have seen man send spacecraft to investigate Venus and many of our outer planets, and even comets now. We have incredibly sophisticated spacecraft and rover technologies on the surface of Mars as we speak today.

Turning inward to much smaller scales, we have experienced the discoveries and developments in superconductivity, with all of its potential for our society. We all regularly deal with the amazing technological advancements in semiconductors and electronics that have brought us super-fast, Giga-Hertz computers; vast, world-wide computer networks; and the INTERNET.

We are now turning our focus more inward to even more exciting frontiers of Nanotechnology, with ultra-tiny materials that are only tenths to tens of nanometers across. Typically, this dimension contains only a few to tens of atoms. The impact of these new nanotechnologies is certainly opening up new frontiers in Thermoelectrics. We have some great presentations in this session, Let's read on in yet more amazement.

NanoTechnology

- **Materials & Structures Where Length Scales Become Comparable to:**
  - Mean Free Path
  - Domain Sizes
  - Coherence Length of Phonons
  - Correlation Lengths of Collective Ground States Like Superconductivity
- **Not Just Next Step in Miniaturization Beyond Micro-Scale Technologies (MEMS)**
- **Qualitatively A New Scale With New Behaviors**
  - Quantum Mechanics Phenomena Manifest Themselves
  - Quantum Phenomena Are Relevant & Measurable
- **Many New & Exciting Challenges**
  - Sensors – How Do We Measure
  - Modeling & Simulation
- **Remarkably Little Experience or Intuition for Expected Phenomena & Behaviors**

Nanotechnology materials and structures are new materials that have characteristics length scales that are comparable to such quantities as mean free paths, domain sites in ferromagnets and ferroelectrics, coherence lengths of phonons, and correlation lengths of collective ground states like superconductivity. The main point is that nanotechnologies are not just the next step in miniaturization beyond micro-scale technologies such as micro-electro-mechanical systems. Nanotechnologies instead represent a qualitatively new scale of materials where quantum mechanics phenomena manifest themselves in significantly new behaviors. These new nanotechnology materials have exciting new properties and characteristics that hold the promise to impact all the applications and technologies discussed on the previous chart and create exciting new technologies and advancements. These materials also hold many new and exciting challenges however, as we have remarkably little experience or intuition for what phenomena and behaviors to expect in these new materials.

Just a Few NanoTechnology Possibilities

- Nanolayered Materials for Advanced Permanent Magnets
- New Optical Properties Through Fabricating Photonic Band Gap Superlattices
- Tailored Surfaces With Extraordinary Wear Characteristics
  - Al2O3 Nano particles in Al – Wear Resistance Qualities Comparable to Steel
- Layered Quantum Well Structures for Highly-Efficient Light Sources & Photovoltaic Cells
- Novel Optical Properties in Semiconducting Nano Crystals
  - Tracking Molecular Processes in Living Cells
- Unique Thermo-Mechanical Devices
  - Thermal & Structural Properties
- New Quantum Well Thermoelectric Material
  - Quantum Dots, 1-D Quantum Wires, 2-D Thin Film Superlattices

This list is just a few possibilities for nanotechnologies at the current time. There will undoubtedly be more as time progresses and our research and development experience with current and even newer nanotechnologies deepens and broadens. One of the current areas of nanotechnology that seems to hold great promise is the subject of this first session of the 2004 DOE/EPRI High-Efficiency Thermoelectrics Workshop – new quantum-well-based thermoelectric materials.