Nanotechnology Opportunities: Enhance the utilization of lignocellulosic/wood biopolymers as a high-performance, renewable biomass resource for a broad range of applications in biomaterials, biosystem-based electronics, transportation, health, energy, construction, agriculture, and the environment.

**Smart Paper/Packaging**
- Responsive to emf signal, tunable hydrophobic/hydrophilic properties
- Electronic paper with electric and magnetic properties
- Physical stress response, self-cleaning/healing, temperature/moisture indicator, audio response
- Security/anti-counterfeiting, environmental barriers/control
- Lightweight printing paper and paperboard, enhanced recycling properties
- Active defenses against bacteria/fungal infiltration

**Wood Composites**
- Healthy building material generating less VOC
- Stronger light weight wood composites
- Environmental/Biological stability
- Stronger than steel and more durable

**Renewable BioComposites**
- Programmable lifecycle biocomposites employing Nanocellulose fibers, nanohemicellulose, nanolignin particles
- Polylactic acid (PLA), Polyhydroxybuturate (PHB), etc.
- Enhanced strength/performance properties, reduced weight
- Recyclable, Biodegradable,

**Fundamental Research Needs/Opportunities**
- Understanding of tree genetics, cellular biology biochemistry/biophysics facilitating new bio-versions of “carbon tubes”
- Multifunctional self assembling biopolymers yielding unique nanomaterials, nanotemplates and nanodevices
- Convergence of lignocellulosic biopolymer nanostructures with silicon IT, computer in a tree
- Morphology, dimensionality performance, self-shaping/assembling of lignocellulosic nanostructures
- Instrumentation and analytical technologies for characterization of rough/soft nanolignocellulosic structures
- Nanomechanics of wood and force convergence on natural biopolymers
- Efficient chemo-enzymatic synthesis of nanolignocellulosic structures such as nanocellulose whiskers, balls, etc...
- Synthesis of lignin and hemicellulose nanoparticles
- Adaptation of nanomanufacturing technologies to molecularly “rough/soft” surfaces and materials
- Utilization of solar energy for paradigm changes in efficient energy conversion for renewable biofuels and biochemicals
- Molecular interaction and systems architecture of nanostructures with lignocellulosics materials
- Health and environmental impact of nanolignocellulosics
- Societal, K-12, Undergraduate and Graduate Educational Needs

**Current Forest Products Portfolio**
- 41 million tons of paper
- 47 million tons of packaging paper/board
- 7 million tons of tissue/towel/hygiene products
- 21.7 Billion ft³ of oriented strandboard
- 21.6 Billion ft³ of plywood
- 19.8 Billion ft³ of Particleboard/MDF
- 67.7 Billion Board feet of lumber

**Nanotechnology Forest Products Initiative**
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