Patent Claims

NANOWIRES FORMED OF ELR MATERIALS
JOSEPHSON JUNCTIONS FORMED OF ELR MATERIALS
QUIDS FORMED OF ELR MATERIALS
MEDICAL DEVICES FORMED OF ELR MATERIALS
CAPACITORS FORMED OF ELR MATERIALS
INDUCTROS FORMED OF ELR MATERIALS
TRANSISTORS FORMED OF ELR MATERIALS
INTEGRATED CIRCUITS FORMED OF ELR MATERIALS
ROTATING MACHINES FORMED OF ELR MATERIALS
BEARINGS FORMED OF ELR MATERIALS
SENSORS OF ELR MATERIALS
    Position, Displacement, and Level Sensors
    Occupancy and Motion Sensors
    Velocity and Acceleration Sensors
    Force, Strain and Tactile Sensors
    Pressure Sensors
    Flow Sensors
    Acoustic Sensors and Microphones
    Humidity and Moisture Sensors
    Radiation and Particle Detectors
    Temperature Detectors
    Chemical Sensors
    Light Sensors
    Dust, Smoke, and other Particle Sensors
    Electrical and Electromagnetic Sensors
    Other Sensors
ACTUATORS FORMED OF ELR MATERIALS
FILTERS FORMED OF ELR MATERIALS
ANTENNAS FORMED OF ELR MATERIALS
ENERGY STORAGE DEVICES FORMED OF ELR MATERIALS
FAULT CURRENT LIMITERS FORMED OF ELR MATERIALS
TRANSMISSION LINES FORMED OF ELR MATERIALS

Nanowires Formed of ELR Materials

Although there is at least one commercially available quantum computer in existence (D---Wave in Canada). It is probable that when quantum computers do become more widely available they will change computer science as we know it with processing speeds many orders of magnitude higher.

The patent describes how the ELR material can be formed into nanowires that can be as thin as 40 nanometres. This has implications for quantum computing and integrated circuits in general.

Josephson Junctions Formed of ELR Materials

Josephson junctions are based on an effect first noticed by Josephson in 1962 and for which he subsequently won a Nobel Prize for Physics. The junction consists of two layers or superconductor material that are separated by a layer of insulator, superconductor---insulator---superconductor ("SIS"); superconductor---normal conductor---superconductor ("SNS"); superconductor---ferromagnetic metal---superconductor ("SFS"); superconductor---insulator---normal conductor---insulator---superconductor ("SINIS"); superconductor---insulator---normal conductor---superconductor ("SINS"); superconductor---constriction--- superconductor ("SCS").

The patent describes new ways of creating Josephson Junctions in which the barrier separating the superconductors could vary from as thin as 30 Angstroms to as thick as several microns. Josephson Junctions are used in very sensitive detectors of magnetic fields. They are used in SQUIDs (Superconducting Quantum Interference Device), and single electron transistors in fields such as quantum computings, meterology, and are used to make more sensitive NMR’s.

QUIDS Formed of ELR Materials

SQUIDS (Superconducting Quantum Interference Devices) are used for very sensitive magnetometers that can be used for submarine navigation, scientific research, medical imaging and astronomy. The patent describes a SQUID fabricated from ELR material referred to as a 'One unctionJ QUID' or an RF QUID.

The RF QUIDS are of particular significance as they can be used in greatly increasing the sharpness and sensitivity (usually these two qualities are mutually exclusive) and because of this are able to greatly increase the required distance between towers. The Q factors increase by at least eight fold which means the cell towers can be at least twice or three times as distant.

This in turn means that the number of towers required can be reduced by a factor of four to nine (the square of the above multiples. When one considers that the cost of installing a cell tower is generally approximately $250,000 per tower then the economic saving resulting from this technology could be very significant.

Medical Devices formed of ELR Materials

The patent describes how wrapping the ELR materials in torroidal or helical arrangements can create small powerful magnets to use in these machines. Sensitive SQUID based medical devices can improve the existing NMR's by making them more sensitive and much smaller so that they could eventually even be available in doctor's offices or even in portable forms, but they can also be used to partially replace other imaging technologies based on X---rays and CAT scans. These magemets can also be used in very sensitive electro---encephelagraphs that could revolutionize neurophysiology and the diagnosis and treatment of mental disorders.

Capacitors formed of ELR Materials

This section describes how superconducting materials provide the potential to greatly increase the efficiency, capacity and rate of discharge of capacitors using various dielectric materials and also no material (a vacuum).

Inductors formed of ELR Materials

This section describes how ELR materials can be used to create much more efficient inductors with air or metal cores to significantly reduce core losses particularly at high frequencies. The ELR materials formed as wires, nanowires, tapes and foils are used to create coils of varying length, cross---section, turns and flexibility.

Transistors Formed of ELR Materials

ELR and captured ELR materials can be used with semiconductors to create transistors with properties quite distinct from traditional transistors. These transistors can perform faster and more reliably than conventional transistors and may require fewer components. For example, devices that may utilize such an ELR element---semiconductor junction include Josephson junctions, bipolar junction transistors, field effect transistors (FETs), amplifiers, switches, logic gates, microprocessor elements, microprocessors etc, The Josephson junction may be used in Rapid Single Flux Quantum (RSFQ) components as qubits, in Superconducting Tunnel Junction (ST J) Detectors as detectioncomponents, as well as other applications

Integrated Circuits Formed of ELR Materials

Superconductivity solves one of the major restraints on increasing the power of integrated circuits– the limitation of distance. This derives from the fundamental limitation of the speed of light. A 5 GegHz chip cycles in 0.2 nanoseconds during which time light (and an electrical signal) can only travel 6 cms. So to synchronize processors they have to be within 6 cms which in turn leads to problems of heat dissipation. In addition signals propagate through ELR materials in a manner similar to a waveguide that reducing any latency and maximizing performance within the speed of light constraint. Superconducting components do not have resistance (or have very low resistance) and so the heat generated is much less. This means many more processors can be packed into the 6cm range thus greatly increasing the computing power. Other factors can also contribute to gains in the efficiency of integrated circuits such as the behavior of semiconductors in superconducting environments. Some of the materials covered in this patent exhibit what would seem to be mixed state behavior at temperatures as high as220 degrees Kelvin. If confirmed, this would enable superconducting applications that would require very little, if any, cooling making superconducting applications feasible, practicable and relatively inexpensive not just in integrated circuits but also across a broad range of applications.

The patents describe the application of new technology based on superconductivity and EL for devices that include MEMS, RF, circuit routing, and SiP (System in Package) devices.

Rotating Machines Formed of ELR Materials

Both generators and motors are based on coils that make up the armature and field coils. Much energy is lost due to the resistance of these coils. Using superconducting materials will greatly reduce these losses thus making more power available locally or for the grid in the case of generators and to power the processes in the case of motors. This could result in significant improvements in industrial efficiency as well as reducing the overall carbon footprint involved in the generation of electricity. The portfolio deals with many aspects of how ELR materials can be used in the creation of coils for superconducting based rotating machines. In addition to the efficiency improvements superconducting rotating machines are significantly smaller and lighter even when you consider the overhead associated with the cooling systems.

Bearings Formed of ELR Materials

It is possible to use the properties of superconductors to levitate a rotor with respect to the bearings to eliminate friction. This section deals with many ways in which such bearings can be formed from ELR materials and how such materials can be manufactured to produce the desired properties.

Sensors of ELR Materials

Sensors can be made that are orders of magnitude more sensitive than conventional sensors. Superconductivity reduces the noise and thus the signal to noise ratio enabling far greater sensitivity. The analysis of this data has implications for almost every industry from health care to oil and gas. Sensors are proliferating as ever more monitoring both reduces the need for human monitoring and provides valuable data both individually and in aggregate. The aggregation of data and the range of parameters that can be measured by the sensors are substantial and include:

Sensor Parameters

Acoustic
Biological
Chemical
Charge, current
Potential, voltage
Electric field (amplitude, phase, polarization, spectrum)
Conductivity
Permittivity
Magnetic field (amplitude, phase, polarization, spectrum)
Magnetic flux
Permeability
Wave amplitude, phase, polarization
Spectrum
Wave velocity
Biomass (types, concentration, states)
Components (identities, concentration, states)
Optical
Mechanical
Radiation
Thermal
Wave amplitude, phase, polarization, spectrum
Refractive index
Emissivity, reflectivity, absorption
Position (linear, angular)
Acceleration
Force
Stress, pressure
Strain
Mass, density
Moment, torque
Speed of flow, rate of mass transport
Shape, roughness, orientation
Stiffness, compliance
Viscosity
Crystallinity, structural integrity
Type
Energy
Intensity
Temperature
Flux
Specific heat
Thermal conductivity

Wave velocity

In addition superconducting sensors can detect the following types of energy conversion with great sensitivity:

Sensor Energy Conversions	
Thermoelectric	Electrochemical process
Electroelastic	Photoelectric
Thermooptic	Thermomagnetic
Photoelastic	Magnetoelectric
Photomagnetic	Electromagnetic
Spectroscopy	Thermoelastic
Physical transformation	Biochemical transformation
Chemical transformation	Electrochemical process

Position, Displacement, and Level Sensors

Sensors may be configured to provide an output signal that is indicative of the position or displacement of a physical object or the level of a fluid that is proximate to the sensor. Indicating "position" means indicating the angular or linear coordinates of an object with respect to a particular reference while indicating a "displacement" means indicating a movement of an object from a reference position.

This can be accomplished with:

- Resistance---Based Level Sensors
- Capacitive Displacement Sensors
- Magnetoresistive Position Sensors
- Magnetostrictive Position Sensors
- Radar Position Sensors
- Optical proximity
- Optical bridge sensors
- Optical proximity detectors that use polarized light
- Fiber---optic sensors
- Fabry---Perot sensors
- Grating sensors
- Linear optical sensors
- Ultrasonic position, displacement, and level sensors;
- Thickness and ablation sensors including (e.g., break---wire gauges, radiation transducer sensors, light pipe sensors, capacitive or resonant ablation gauges and thin film thickness gauging sensor such as capacitive sensors employing electrodes, and optical sensors
- Level sensors including resistive level sensors
- Optical level sensors
- Magnetic level sensors
- Capacitive level sensors
- Transmission line level sensors

- Pointing devices (optical and magnetic)
- Inertial and gyroscopic pointing devices
- Satellite navigation systems such as GPS and global navigation satellite systems (GNSS)

Occupancy and Motion Sensors

The portfolio also makes claims related to sensors that may be configured to provide an output signal that is indicative of the presence of people or animals in a monitored area ("occupancy") or the motion of an object. Such sensors may be used in toys, consumer electronics, security systems, surveillance systems, energy management systems, personal safety systems, appliances, and many other types of systems. These are based on the following technologies:

- Capacitive Occupancy/Motion Sensors
- Triboelectric Detectors
- Optoelectric Motion Sensors
- Optical Presence Sensors
- Pressure Motion Sensors
- Air pressure/pressure---gradient sensors
- Acoustic sensors
- Photoelectric sensors that detect an interrupted light beam, pressure mats or other Pressure sensitive surfaces
- Stress or strain detectors embedded in a protected area
- Switch sensors including magnetic switches
- Vibration detectors
- Infrared motion detectors
- Ultrasonic detectors
- Videomotion detectors
- Face recognition systems
- Laser detectors
- Alarm sensors
- Reed switches
- Stud finders
- Triangulation sensors
- Wired gloves
- Doppler radar sensors

Velocity and Acceleration Sensors

The Ambature patent portfolio includes descriptions of single--- and multi---axis velocity sensors and accelerometers. A velocity sensor may measure the linear or angular speed or rate of motion of an object. An accelerometer may measure the coordinate acceleration or proper acceleration of an object, e.g., by measuring weight per unit of test mass or specific force. Accelerometers are used to determine, orientation, coordinate acceleration (i.e., change of velocity of an object in space),vibration, shock, and falling. Multiple accelerometers may be used to detect differences in acceleration, e.g., as gradiometers.

Velocity sensors or accelerometers may be used in numerous applications, including automobiles, trains, vulcanology, commercial or industrial equipment, vibration measurements/monitoring, seismic activity measurements, inclination measurements, gravimeters, machinery health monitoring, aircraft/avionics equipment, inertial navigation and guidance systems, medical equipment, and consumer products, including video game systems, sports equipment, and other portable electronics, such as mobile phones, camcorders and cameras (e.g., for image stabilization and/or orientation determinations), smart phones, audio players, tablet computers, laptop computers, personal digital assistants, and other mobile computers. The following kinds of sensors are described:

- Accelerometers Having Proof Masses
- Capacitive Accelerometers
- Piezoresistive Accelerometers
- Piezoelectric Accelerometers
- Heated Plate Accelerometers
- Gravimeters that use a magnetically levitated sphere,
- Free fall sensors
- Inclinometers
- Laser rangefinders
- Linear encoders
- Liquid capacitive inclinometers
- Odometers
- Rotary encoders
- Selsyn sensors;
- Sudden motion sensors
- Tachometers
- Ultrasonic thickness gauges
- SONAR sensors

Force, Strain and Tactile Sensors

These sensors are configured to provide an output signal that is indicative of a force, strain, or touch applied to an object. As with other types of sensors, force or strain sensorscomprising ELR material may be quantitative or qualitative. These sensors include:

- Piezoelectric Cables
- Complex Force Sensors (Including Load Cells)
- Strain Gauges
- Switch Tactile Sensors
- Piezoresistive Tactile Sensors
- Capacitive Tactile Sensors
- Pressure---sensitive mats
- Sensors that balance an unknown force against gravitational force of a known mass
- Sensors that determine acceleration of a known mass to which an unknown force is applied,
  Sensors that balance an unknown force against an electromagnetically generated force
- Sensors that transduce an unknown force into a fluid pressure
- Piezoelectric tactile sensors (active ultrasonic coupling touch sensors, passive piezoelectric strips

- MEMS sensors, including MEMS threshold tactile sensors that are formed from silicon materials and have a mechanical hysteresis
- Acoustic touch sensors
- Optical sensors, including those that use LEDs and photodetectors to detect changes in light intensity that result from a touch event
- Piezoelectric force sensors
- Bhangmeters
- Hydrometers
- Magnetic level gauges
- Nuclear density gauges
- Torque sensors
- Visco meters

Pressure Sensors

The patent portfolio describes the use of ELR materials in pressure sensors that include:

- Complex Pressure Sensors use a variety of elements potentially including deformable elements such as diaphragms and a displacement sensor
- Pressure Sensors
- Variable Reluctance Pressure Sensors
- Mercury pressure sensor
- Complex pressure sensors, such as silicon diaphragm
- Capacitive pressure sensors, that use a pressure---to---displacement sensor
- Optoelectronic pressure sensors
- Indirect pressure sensors
- Vacuum sensors (Pirani gauges, ionization gauges, gas drag gauges, and membrane vacuum sensors)
- Barographs
- Barometers
- Boost gauges
- Hot filament
- Ionization gauges
- McLeod gauges
- Permanent downhole gauges
- Time pressure gauges

Flow Sensors

The patent portfolio also describe flow sensors that include;

- Pressure Gradient Flow Sensors
- Thermal Transport Flow Sensors
- Ultrasonic Flow Sensors

- Transport sensors that detect the movement of a marker (e.g., a float, a radioactive element, a dye introduced into the flowing fluid whose flow rate is being sensed
- DC and AC electromagnetic flow sensors that register a voltage across pick---up electrodes in response to a conductive fluid crossing magnetic flux lines
- Breeze sensors that detect changes in the velocity of a gas
- Coriolis mass flow sensors for measuring mass flow rate directly
- Drag force sensors that measure a fluid flow using a drag element coupled to a rigid base
- Mechanical flow meters
- Pressure---based flow meters, such as Venturi meters, orifice plates, Dall tubes, Pitot tubes, and multi---hole pressure probes
- Optical flow meters
- Sensors using open channel flow methods, such as level to flow, area/velocity, dye testing, and acoustic Doppler velocimetry
- Thermal mass flow meters
- Electromagnetic, ultrasonic, and Coriolis flow
- Cryogenic flow sensors
- Air flow meters
- Gas meters,
- Water meters
- Sensors using laser Doppler flow measurement

Acoustic Sensors and Microphones

Most acoustic sensors use a moving diaphragm and a displacement transducer to produce an electrical signal indicative of the deflection of the diaphragm in response to an acoustic input. The displacement transducer or other components in an acoustic sensor may comprise ELR material. These are used in hearing aids, recorders, karaoke systems, VOIP systems, motion picture production, telephones (including mobile phones), audio engineering, portable computers, speech recognition systems, complex sensors, microbalances, SAW devices, and vibration sensing. Technologies include:

- Condenser Microphones
- Electret Microphones
- Dynamic Microphones
- Solid---State Acoustic Detectors
- Resistive microphones, including carbon microphones and piezoresistivemicrophones,
- Piezoresistive transducers (e.g., stress---sensitive resistors in a micromachined diaphragm pressure sensor or a powder whose bulk resistivity is sensitive to pressure) configured to transduce an acoustic signal into an electrical output signal
- Fiber---optic microphones which may be used in applications having hostile environments or requiring EMI/RFI immunity, such as structural acoustic tests, industrial turbines, turbo jets or rocket engines, industrial and surveillance acoustic monitoring, MRI and jet noise abatement
- Laser microphones that aim a laser at particulates or the surface of a window or other plane surface that respond to acoustical pressures with a vibration, and then analyze the reflected light
- Piezoelectric microphones that use a piezoelectric element (e.g., a piezoelectric crystal,
- Piezoelectric ceramic disk, or piezoelectric film) to directly transduce an acoustical
- Pressure or other mechanical stress into an electrical signal indicative of an acoustical

- Signal, and may be used for, e.g., voice---activated devices, blood---pressure
- Measurements, underwater sound measurements, contact microphones, and acoustic
- Pickups in instruments
- MEMS sensors, which may include a diaphragm formed from Silicon, and may be configured to use the same orsimilar displacement sensing
- Principles of a condenser microphone
- Geophones
- Hydrophones
- Seismometers
- Ultrasonic sensors
- SONAR sensors

Humidity and Moisture Sensors

The patent portfolio describes use of ELR materials for this important class of sensors hat can greatly contribute to the efficient use of water in applications ranging from irrigation to residential. The types of sensors described in this category include:

- Capacitive Humidity and Moisture Sensors
- Electrical Conductivity Humidity and Moisture Sensors
- Other Humidity and Moisture Sensors
- Thermal conductivity sensors that measure thermal conductivity of a gas and/or utilize thermistor---based sensors and that may include thermistors or other components formed in whole or in part from ELR materials
- Optical hygrometers that detect the dewpoint temperature of a gas
- Oscillating hygrometers
- Gravimetric hygrometers
- Psychrometers

Radiation and Particle Detectors

Superconducting technology is already broadly implemented in science and medicalrelated applications related to radiation and ionization detection. The portfolio describes applications for:

- Scintillating Detectors
- Ionization Detectors
- Semiconductor or solid---state radiation and particle detectors, such as diamond
- Detectors, silicon diodes, avalanche detectors, and germanium detectors
- Cloud and bubble chambers
- Dosimeters (including, e.g., quartz fiber dosimeters, film badge dosimeters
- Thermoluminescent dosimeters, and solid state dosimeters
- Microchannel plates
- Solid---state nuclear track detectors
- Spark chambers

- Neutron detectors
- Superconducting tunnel junction sensors
- Microcalorimeters

Temperature Detectors

Various temperature detectors are described including:
- Thermoresistive Sensors
- Resistance temperature detectors
- Pn---junction detectors
- silicon resistive positive temperature coefficient (PTC) sensors
- Thermistors
- Thermocouples and thermopiles
- Optical temperature sensors, such as fluoroptic sensors that use phosphor compounds
- Infrared optical sensors
- Interferometric sensors
- Thermochromic solution sensors
- Acoustic temperature sensors (including SAW and plate wave temperature sensors)
- Coulomb blockade temperature sensors
- Silicon bandgap temperature sensors
- Temperature sensors used in calorimeters
- Piezoelectric temperature sensors
- Exhaust gas temperature gauges
- Gardon gauges
- Heat flux sensors
- Microwave radiometers
- Net radiometers

Chemical Sensors

The patent portfolio describe a broad range of sensors that may be used in oxygen monitoring, exhaust systems, glucose monitoring, carbon dioxide monitoring, analytical equipment, monitoring industrial processes, quality control, environmental monitoring of workers, detection of explosives or VOCs, electronic noses, medical monitoring of oxygen and trace gas content, breathalyzers, detection of warfare agents, detection of environmental contaminants, and detection of hydrocarbon fuel leaks. These include:
- Electrical and Electrochemical Sensors
- Metal---Oxide Semiconductor Chemical Sensors
- Electrochemical Sensors
- Elastomer chemiresistors
- Chemicapacitive sensors that have capacitive elements
- ChemFETs (including ISFETs, MEMFETs, SURFETs, and ENFETS) that include a field effect transistor (FET) whose gate is replaced by and/or coated by one or more layers of chemically---

selective materials (such as gas---selective membranes, ion---selective membranes, or enzyme membranes), so that the FET responds differently

- In the presence of selected target species such as target gases, target ions, or target enzymes
- Photoionization detectors that may use High---energy UV light to ionize molecules and an electrometer to measure a small current
- Produced by the ionization
- Acoustic wave devices (including quartz crystal or other microbalance sensors, SAW sensors, acoustic plate mode sensors, and flexural platewave, other mass or gravimetric sensors, and microcantilevers, which detect changes in the mechanical properties of a structure
- Ion mobility spectrometers, that may use an electric deflection field to separate ions having different ion mobilities
- Thermal chemical sensors that use temperature sensors (e.g., thermistors) coated with a chemically---sensitive material
- Spectroscopic systems
- Fiber---optic transducers thatBiosensors that detect organisms, membranes, tissues, cells, organelles, nucleic acids
- enzymes, receptors, proteins, and/or antibodies
- Sensors (e.g., thermal, electrochemical, or optical) that comprise an enzymatic layer
- Piezoelectric
- Disposable chemical sensors and biosensors
- Electronic noses and tongues (i.e., electronic smell and taste sensors
- Breathalyzers
- Carbon dioxide sensors
- Carbon monoxide detectors
- Catalytic bead sensors
- Electrolyte---insulator---semiconductor sensors
- Hydrogen sensors
- Hydrogen sulfide sensors
- Infrared point sensors
- Microwave chemistry sensors
- Nitrogen oxide sensors
- Olfactometers
- Pellistors
- Zinc oxide nanorod sensors
- Nuclear quadrupole resonance (NOR) sensors
- Ion channel switch sensors
- Piezoelectric sensors
- Thermometric sensors
- Magnetic sensors

Light Sensors

Photosensors utilizing ELR materials are described. Such sensors may be used for numerous applications, including mobile devices, cameras, camcorders, portable computers such as tablet computers, mobile phones, medical diagnostics, medical imaging, nuclear and particle physics, astronomy, computed tomography, and image scanners. They include:

- Photocathodes, Phototubes, and Photomultipliers
- Quantum Photosensors
- Thermal Photosensors
- Bolometers
- Colorimeters
- Contact image sensors
- LED as light sensors
- Nichols radiometers
- Fiber optic sensors
- Photoionization detectors
- Photoswitches
- Shack---Hartmann sensors
- Wavefront sensors

Dust, Smoke and other Particle Sensors

The portfolio describes sensors that may be an optical smoke or dust detector that uses a photosensor and interface circuit to measure the scattering of the light produced by a light emitter, such as an LED that use ELR materials. Such uses include Ionization, Dust, Impurity and Smoke Sensors.

Electrical and Electromagnetic Sensors

The portfolio also describe sensors that indicate of characteristics of an electrical, magnetic, or electromagnetic signal and the electromagnetic properties of a circuit, material, medium, or object. These include:

- Ammeters and current sensors (such as galvanometers, D'Arsonval galvanometers, moving iron ammeters, electrodynamic movement ammeter, hot---wire ammeters, digital ammeters, integrating ammeters, milliammeters, microammeters, and picoammeters
- Voltage sensors or voltmeters (e.g., analog voltmeters, amplified voltmeters, digital voltmeters, vacuum tube voltmeters, AC voltmeters and field---effect
- transistor voltmeters
- Oscilloscopes
- Electrical reactance and susceptance sensors (e.g., ohmmeters
- Magnetic flux sensors
- Magnetic field sensors and magnetometers (e.g., fluxgate, superconducting quantum interference device (SQUIDs)
- Atomic spin---exchange relaxation---free, rotating coil, Hall Effect (described herein), proton precession), magnetometers that use Josephson junctions, gradiometers, and optically pumped caesium vapor magnetometers
- Electric field sensors
- Electrical power sensors
- S---matrix meters (e.g., network analyzers)

- Electrical power spectrum sensors (e.g., spectrum analyzers
- Electrical resistance and electrical conductance sensors (e.g., ohmmeters)
- Multimeters
- Metal detectors
- Leaf electroscopes
- Magnetic anomaly detectors
- Phase or phase---shift sensors
- Ohmmeters
- Radio direction finders
- Watt---hour meters
- Inductance sensors
- Capacitance sensors
- Electrical impedance sensors
- Quality factor sensors
- Electrical spectral density sensors
- Electrical phase noise sensors
- Electrical amplitude noise sensors
- Transconductance sensors
- Transimpedance sensors
- Electrical power gain sensors
- Voltage gain sensors
- Current gain sensors
- Frequency sensors
- Electrical charge sensors (e.g., electrometers such as vibrating reed, valve, or solid---state electrometers)
- Duty cycle meters
- Decibel meters
- Diode and transistor characterization sensors (e.g., for measuring drop, current gain, or other diode/transistor parameters)

Other Sensors

Other sensors including ELR materials that have not been mentioned above are described in the patent portfolio and include:

- Bedwetting alarms
- Dew warning alarms
- Fish counters
- Hook gauge evaporimeters
- Pyranometers
- Pyrgeometers
- Rain gauges and sensors
- Snow gauges
- Stream gauges
- Tide gauges
- Air---fuel ratio meters
- Crank sensors
- Curb feelers
- Defect detectors
- Engine coolant temperature sensors

- Manifold absolute pressure (MAP) sensors
- Parking sensors
- Radar guns
- Speedometers
- Throttle position sensors
- Tire---pressure monitoring sensors,
- Transmission fluid temperature sensors
- Turbine speed sensors
- Vehicle speed sensors
- Wheel speed sensors
- Air speed indicators
- Altimeters
- Attitude indicators
- Depth gauges
- Inertial reference units
- Magnetic compasses
- MHD sensors
- Ring laser gyroscopes
- Turn coordinators
- Variometers
- Vibrating structure gyroscopes
- Yaw rate sensors

Actuators formed of ELR Materials

Just as motors can benefit from the efficiency, smaller size and lighter weight made possible through the use of ELR materials, actuators can also benefit from ELR material and the patent portfolio describes such usage. Applications for such actuators can include uses in underwater sonar systems, dynamic vibration absorbers, diesel fuel injectors, laser gyroscopes, precision position controlled actuators, ultrasonic motors, inchworm motors, etc. These devices, if efficient enough, may also convert mechanical energy into electrical energy or magnetic energy, which may be useful in sound or vibration sensors (such as geophones), in energy harvesting, etc. and include:

- Capacitive Displacement Actuators Using Modified ELR Materials
- Piezoelectric/Piezomagnetic/Magnetostrictive Actuators Using Modified ELR Materials

- Electrochemical Actuators Using Modified ELR Materials (based on the principle of applying, for example, a small voltage to electrodes that catalyze a gas, and then increase pressure within a closed cell)
- Shape Memory Actuators Using Modified ELR Materials
- Electrorheological/Magnetorheological Fluid Actuators Using Modified ELR Materials

Filters formed of ELR Materials

The portfolio describes filters employing ELR materials include a substrate on which a film, tape, foil, wire, nanowire, trace or other conductor is formed or placed, and where the film, tape, foil, wire, nanowire, trace or other conductor employs a modified ELR. Other types of filters are constructed where certain components of the filters employ the modified ELR material. The modified ELR materials are manufactured based on the type of materials, the application of the modified ELR material, the size of the component/element employing the modified ELR material, the operational requirements of a device or machine employing the modified ELR material.

These filters have extensive use as RF filters in cell networks to differentiate spectrum more sharply to reduce crosstalk and allow for much more efficient use of the spectrum. In addition the reduced Q factors enable greater selectivity, sensitivity and allows for greater distance between cell towers. (This aspect of the Ambature patent portfolio can be usedsymbiotically with the licensed technology on *High Performance Microwave Dielectric* that is described separately). Several applications of ELR materials in filters include:

- Inductors Having Modified ELR Materials
- Capacitors Having Modified ELR Materials
- Delay---line/Slow---wave Transmission Line Filters Having Modified ELR Materials
- Planar Lumped Element Filters Having Modified ELR Materials
- Acoustic Wave Filters Having Modified ELR Materials

Antennas Formed of ELR Materials

The patent portfolio describe how modifying the ELR material may be selected based on various considerations and desired operating and manufacturing characteristics including radiation resistance, loss resistance, and reactance. For example, the reactance of the short dipole antenna can be modeled as a capacitance and the reactance of the small loop antenna can be modeled as an inductance. The radiation resistance can be considered to be an equivalent resistance, such that any power dissipated in it will actually represent power radiated.

As the size of an antenna (relative to wavelength) decreases, the loss resistance and radiation resistance also decrease. However, the radiation resistance decreases much more rapidly. At some point, particularly in electrically small antennas, the loss resistance will be more dominant than the radiation resistance and the antenna will become too inefficient to be practical. But, forming the antenna element from a modified ELR material will reduce the loss resistance and will allow for smaller antennas to be more efficient, among many other benefits. The applications of this technology include:

- Resonant Antennas Having Modified ELR Materials
- Broadband Antennas Having Modified ELR Materials

- Antenna Arrays Having Antenna Elements Formed of Modified ELR Materials
- Matching Networks Having Modified ELR Materials

Energy Storage Devices formed of ELR Materials

Energy storage is a major problem in many fields including computing, electric cars and efficient usage of the electrical grid. In the latter case it has been impractical to store electricity other than to a limited extent with hydroelectric power making it difficult to address imbalances between the generation and consumption. Alternative energy sources such as wind and solar are particularly impacted by this problem due to the lack of predictability of the weather and the intermittent nature of its generation.

Superconductivity offers the potential to address this issue as lossless or largely lossless storage is possible either in superconducting currents or, by utilizing the Meissner effect it is possible to have frictionless flywheels store significant kinetic energy. Energy storage utilizing superconductivity and ELR materials are described in the patent portfolio in a number of applications:

- Batteries
- Fuel Cells
- Flywheels
- Magnetic Energy Storage (MES)
- Capacitors and Supercapacitors Having Modified ELR Components

The individual energy storage devices listed above can be joined together to form energy storage grids or arrays. And can be implemented in a multi---component system that is at least partially formed from the modified ELR material.

Fault Current Limiters Formed of ELR Materials

Traditional Fault Current Limiters have slow response times and, following a surge from an event such as a short circuit resulting from an overhead powerline break in a storm, these slight delays can cause significant damage through the grid and its associated equipment. The economic damage is far greater than the cost of the Fault Current Limiter. FCL’s built with superconducting technology have much faster reaction times and significantly reduce damage to the grid to such an extent that it is anticipated that superconducting FCL’s will be broadly adopted within the near time horizon.

Various types of fault current limiters employing inductor coils formed of extremely low resistance (ELR) materials are described ranging in scale from large FCL’s to protect an electrical grid to one small enough to be deployed on a hip that could be used to protect electronic circuitry.

Transformers Formed of ELR Materials

Conventional transformers dissipate energy in the windings, and core, primarily as a result of resistance in conductors. Existing transformers using superconducting windings have achieved efficiencies of over 99%, because most losses are due to electrical resistance in the windings. However, transformers with superconducting windings have the drawback of requiring costly, unreliable cryogenic cooling to achieve the high efficiency.

However transformers employing or inductor coils formed of modified, apertured, and other new extremely lowresistance (ELR) films and materials, as described in the patent portfolio, overcome most problems of existing transformers and thereby approach that of an ideal transformer with close to 99% efficiency. The transformers reduce winding resistance to zero. Other losses in transformersresult from eddy currents, hysteresis losses, magnetostriction, and stray field losses and account for the small losses that remain. In addition transformers utilizing superconducting technology are significantly smaller and do not need the environmentally hazardous oil that can restrict their placement.

These benefits to small transformers such as those that may be employed as chargers for in small electronic devices such as mobile phones, in power supplies for larger electronic devices such as televisions or stereo systems, or they may be used in large scale applications such as in substation equipment or in regional electric transmission and distribution systems that carry thousands of amperes and even in very small chip level transformers.

These transformers can be of several types of transformers, including:

- Autotransformers
- Polyphase transformers,
- Matching transformers
- Isolation transformers
- High leakage reactance transformers
- Resonant transformers
- Step---up or step---down transformers

The portfolio describes various manufacturing methods and materials for these transformers.

Transmission Lines Formed of ELR Materials

Much of the electrical power generated for the grid is dissipated through transmission or distribution. We are in effect heating the atmosphere. By utilizing ELR materials power transmission components, such as power transmission lines, wires, and cables can transmit, carry, and transport power from one location to another without incurring resistive losses or incurring reduced resistive losses, among other benefits. The materials and manufacturing techniques are described in the patents. In addition to making more power available throughout the grid it reduces the carbon output resulting from the generation of power with fossil based fuels that is lost due to the resistance of the transmission components. Within cities the conduits are frequently to full capacity yet demand continues to increase. Superconducting cables have a power carrying capacity up to fifty times greater than traditional cables so it is possible to continue to upgrade capacity within the constraints of the existing conduit.