Objectives of the Project

We conduct our research in groups for respective areas. The issues the groups will address are outlined below. Specific goals are tabulated in Table 1 in the following page.

Information Technology Group

Super high speed, super high density recording and quantum information processing

This group attempts to make a breakthrough in writing and reading speed on the basis of the photoinduced magnetization, a new physical phenomenon this group has found, in combination with near-field optics and nanostructured magnetic materials prepared via self-assembly processes. The group will also develop quantum information technologies aiming at super high capacity transmission of information, super high speed computing, and super secure encryption. To be specific, the group will develop (1) a single photon source, (2) a low-noise single photon detector, (3) a photon number resolving detector, (4) a quantum memory, and (5) quantum bit devices. This group will also study physical processes in light-plasmon interconversion for possible applications to plasmonic devices.

Energy Technology Group

Harnessing solar energy with nanostructures

This group will develop technologies based on nanostructures and nano processes to harness solar energy as efficiently as possible. Specifically, (1) artificial photosynthesis through molecular assemblies and the understanding and control of the processes involved, such as excitation, energy transfer, electron transfer, and catalytic reactions, (2) light-assisted hydrogen storage, a new concept, (3) high strength fuel cells, (4) inexpensive, high efficiency dye-sensitized solar cells on the basis of light confinement effect with nanostructures, and (5) bioreactions in photosynthetic bacteria driven by solar energy.

Medical Technology Group

Nanobiotechnology for medical applications

This group will develop nanobiotechnology for medical applications via approaches from nanobiology and chemical biology, combined with newly developed nanomaterials. The four major objectives are: (1) development of molecules for cancer diagnosis and therapy, (2) DNA binding molecules for amplified oncogene detection and silencing, (3) development of a novel radiation dynamic therapy against cancer cells in internal organs, and (4) peptide nucleic acid molecules for over-expressed genes for disease diagnosis and therapy.

Nanoscience and Nanotechnology Groups: Supramolecules and Self-Assembly Group; Nanomaterials and Nanotechnology Group; Quantum Theory and Computation Group

These groups will conduct basic scientific and technological studies on nanomaterials and nanostructures as the basis for the above-mentioned application oriented developments. Bottom-up approaches including self-assembly as well as top-down approaches including electron beam lithography, combined with controlled reaction at the nanometer level, are exploited to prepare nanomaterials and nanostructures. Photonic and quantum mechanical properties will be elucidated with experimental approaches, together with theoretical and computational approaches. These studies will lay the basis for the development of information, energy, and medical technologies being developed by other groups as mentioned above. These groups will also provide a forum for the interaction of researchers, facilitating the progress of this interdisciplinary project.

Table 1. The goals set at the beginning of the project.

Items	Status quo	Original technologies	Target
1. Information technology: super high speed/density recording and quantum information			
writing speed	0.25 Gbits s^{-1}	photoinduced magnetization	25000 Gbits s^{-1}
recording density	0.2 Tbits $inch^{-2}$	nanomagnetic material through self-assembly	2 Tbits $inch^{-2}$
writing density	0.6 μm^2/bit	near-field thermally assisted recording	0.003 μm^2/bit
single photon source	emission efficiency＜10%	quantum dots	30%
low-noise single photon detector	q. efficiency 1% dark count~10^{-8}	superconducting thin wire	50%, 10^{-8}
photon number resolving detector	resolution 0.2 ev repetition 100 kHz	superconducting transition edge sensor	0.2 ev, 1 MHz
quantum memory	1 ms, low temp.	Bose condensates	10 ms
quantum bit device	q. efficiency ~1% temp. <0.3 K	THz plasmonic quantum bit	>5%, rt to 1.8 K
2. Energy: Harnessing solar energy with nanostructures			
water photolysis with supramolecules	not exist	self-assembly of sensitizer and redox catalysts	to realize
light assisted hydrogen storage	a new concept	light triggered desorption that we have found	q. yield >0.1 >6 wt%
high strength fuel cell	strength 60 MPa temp 900 ℃	a new preparation process from micro/nano particles	2–5 fold , 600 °C
DSSC with inexpensive dyes	energy efficiency 3%	light confinement effect of nano structure	5%
bioreaction of photo-synthetic organisms	rate 34 nmol/h/mg	genetically engineered photosynthetic organisms	an order of magnitude increase
3. Medicine: Nanobio technologies for medical applications			
probe compounds for cancer	under investigation	cancer specific compounds identified	to realize
luminescent compounds	safety, sensitivity	safe, long wavelength luminescent compounds	detection of cancer marker with compounds
ex vivo diagnosis	low diagnosis rate	highly sensitive and specific diagnosis	diagnosis rate >80% small error <10%
in vivo image diagnosis	early detection of cancer is difficult	improvement and low-cost detection system	candidate compounds for in vivo use
treatment of cancer and other diseases	affecting normal region	cancer-specific drugs and new treatment	preclinical trial