

Revolutionary Components based on High-Performance Materials



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DARPA/MTO

Report Documentation Page

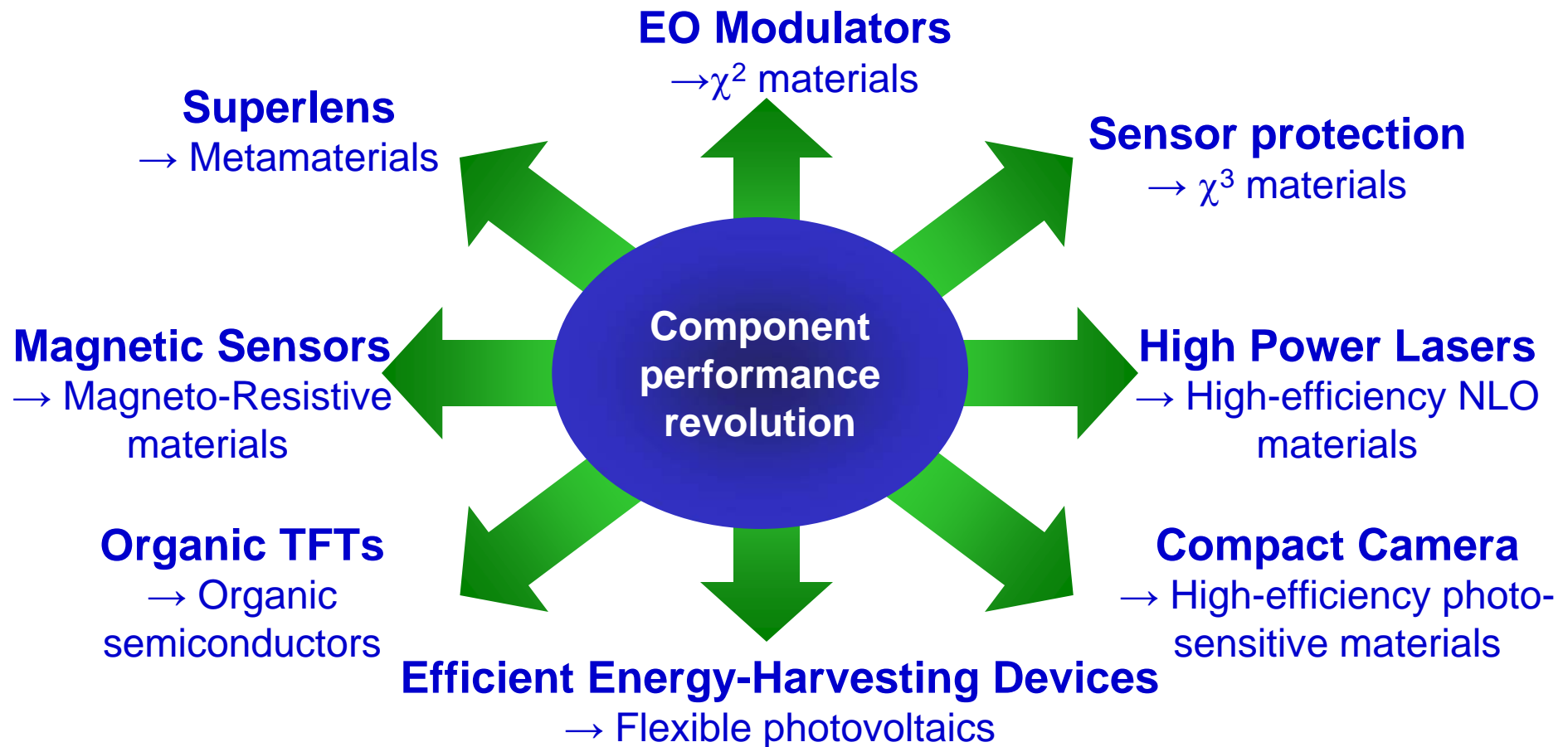
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Components and Devices for the Future Military



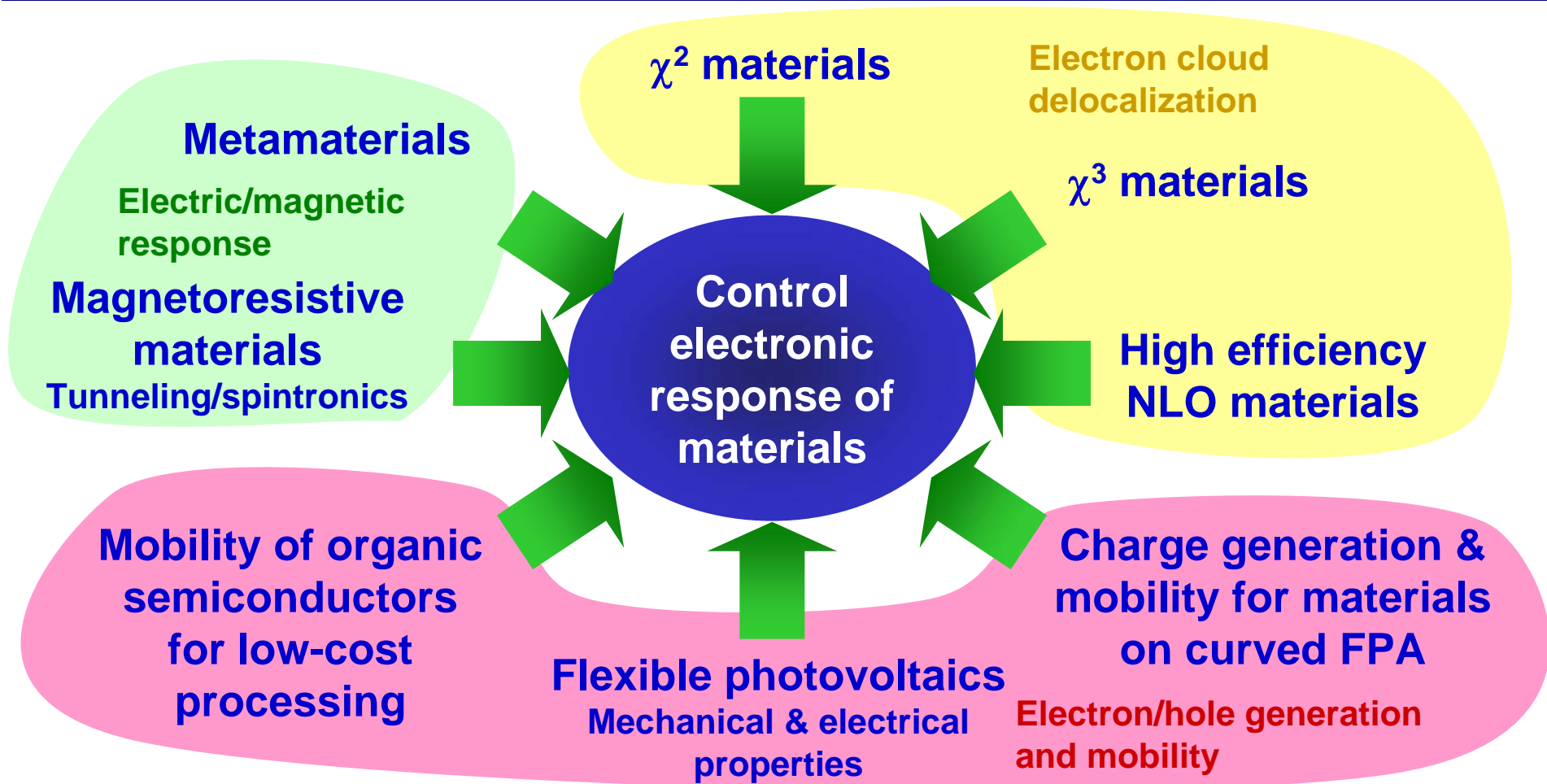
Leverage High-Performance Materials for Revolutionary Photonic, Electronic, & Magnetic Components

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Engineering at the Nanoscale



Control of electronic and photonic properties at the nanoscale to drive material and device performance

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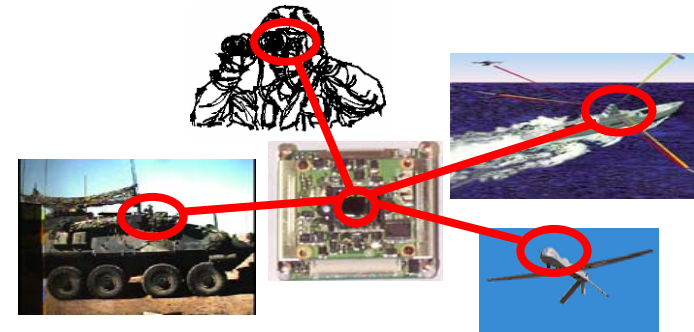


MORPH PROGRAM

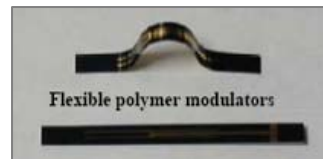
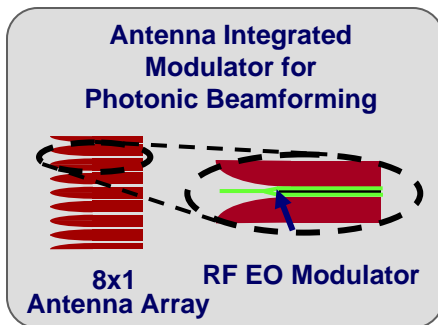
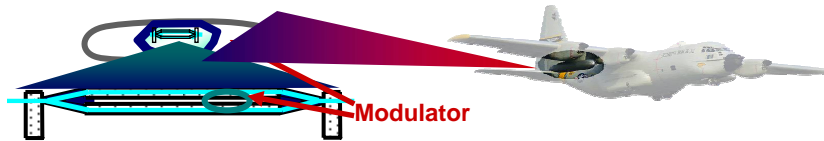


Objectives:

- Develop highly non-linear optical materials for applications in RF photonics and sensor protection
- Develop high-bandwidth, low drive-voltage EO modulators



Protect from ultra-short pulsed and broadband tunable lasers



Flexible polymer modulator

Military Impact:

- Enhanced Performance of Phased Array Radar
- Protection for DoD personnel and sensor systems from laser threats





EO Modulators

$\chi^{(2)}$ Materials and Components

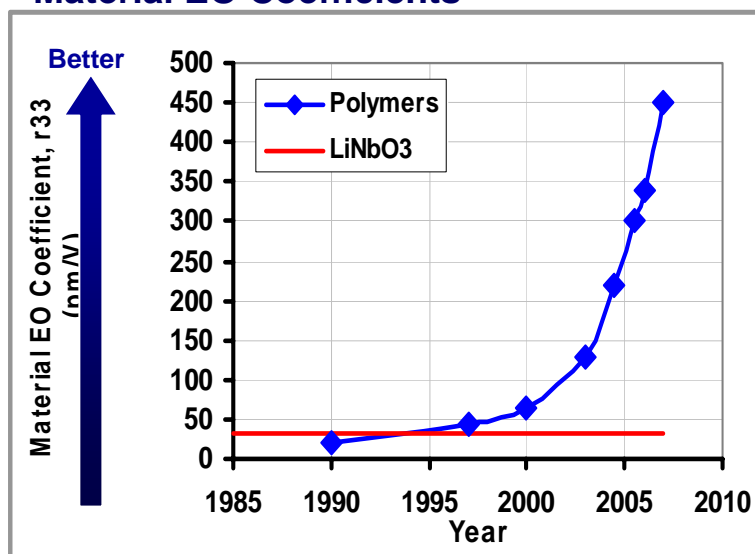


Program Goals



NLO coefficient r_{33} @1.5 μm	>1200 pm/V
Absorption loss	<1 dB/cm
Polymer T_g	>200 C
Fiber coupling	<0.75 dB
Bandwidth	100 GHz

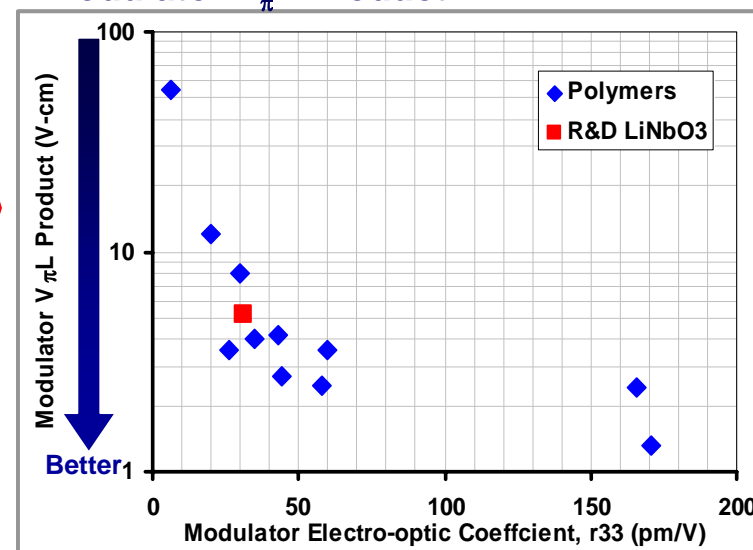
Material EO Coefficients



Exploit exceptional polymer r_{33} for better modulator performance

$$V_{\pi} L = \frac{\lambda d}{n^3 r_{33}}$$

Modulator $V_{\pi} L$ Product

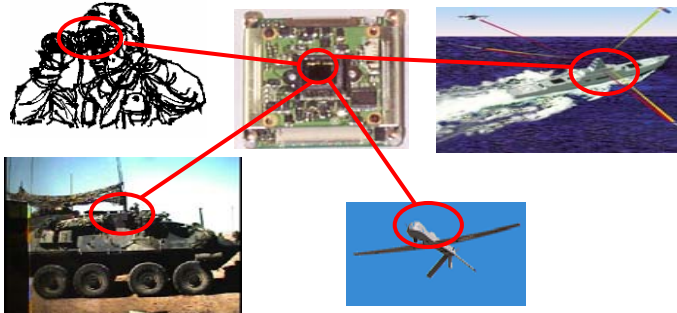


New $\chi^{(2)}$ Optical Materials are Enabling Revolutionary Electro-Optic Modulators



Sensor Protection

$\chi^{(3)}$ Materials and Components



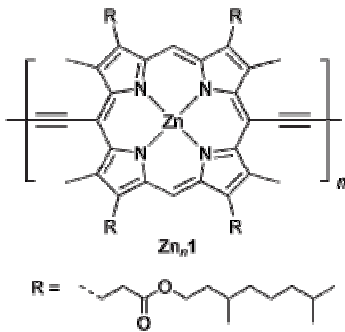
Program Goals



Transmission @ 700-900 nm	>80%
Transmission @ 1530-1640 nm	>70%
Suppression	30 dB

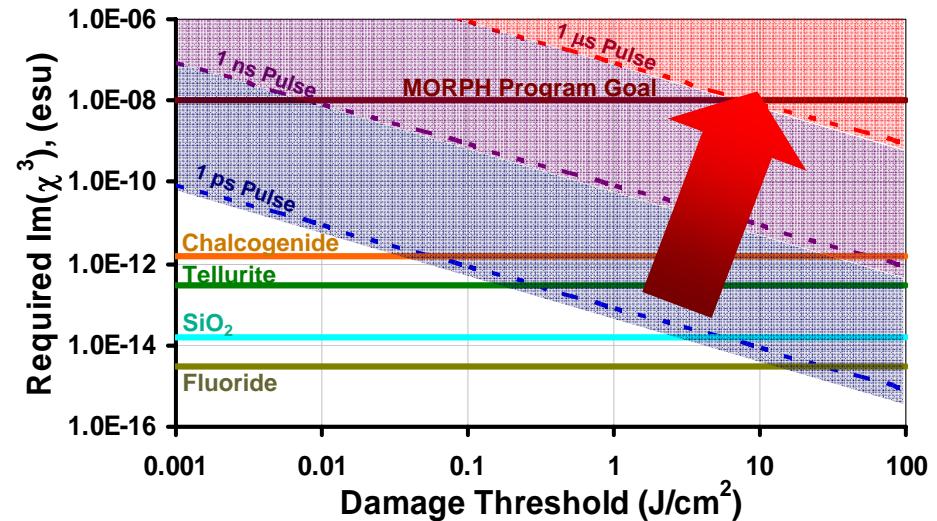
Protection from ultra-short pulsed and broadband tunable lasers

femto \rightarrow pico \rightarrow micro-second pulses



HLApol-Zn

$\chi^{(3)}$ versus Sensor Damage Threshold

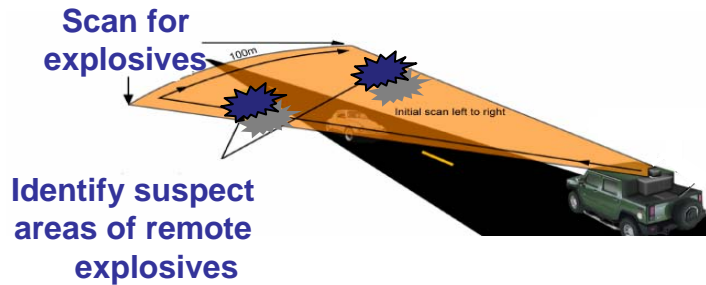


New $\chi^{(3)}$ Optical Materials will Enable Sensor Protection Systems

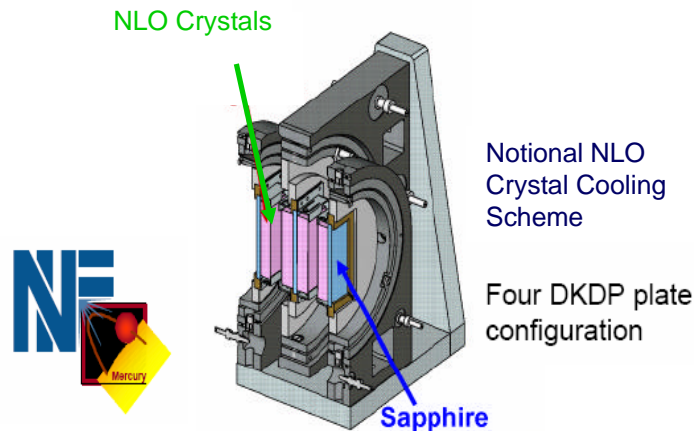


High-Power Lasers

High-efficiency NLO materials



Explosives detection at a distance using compact short-wavelength high power lasers and orthogonal optical spectroscopy techniques



Exploit compact high-power lasers at long wavelengths and use NLO crystals to convert to desired wavelength

- Thermal and defect damage resistance
- High-efficiency NLO materials for high-fluence applications



High-efficiency NLO materials will enable remote explosives detection

Dr. Devanand Shenoy

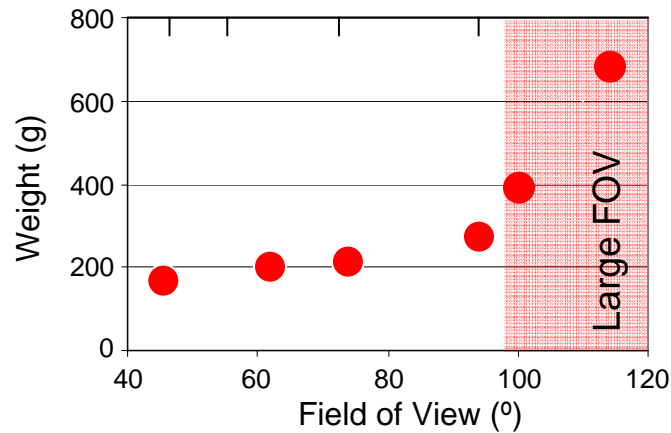
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Compact Camera New Materials & Processes

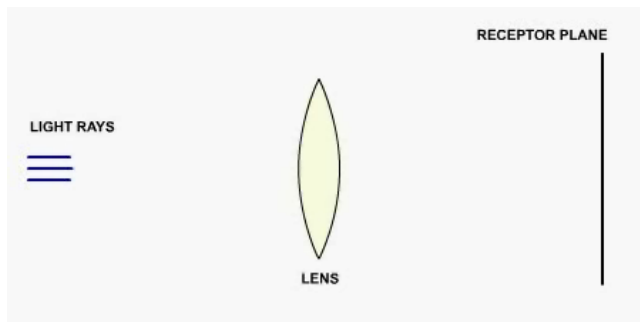


14 lenses, 2 aspherics

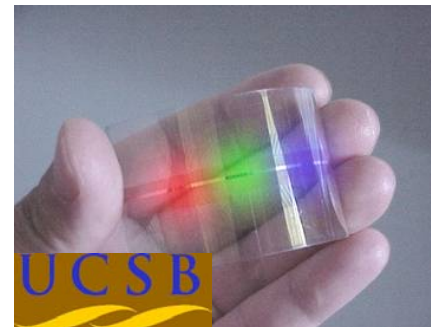


Source: Nikon

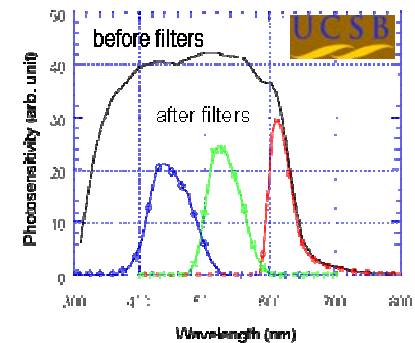
Large field-of-view cameras need multiple lenses to correct for aberrations due to a flat focal plane



Enabled by recent results



Organic photo-detector in VIS



Exploit process able photo-diodes to manufacture curved focal planes for the VIS, NIR and SWIR bands



Efficient Energy-Harvesting Devices

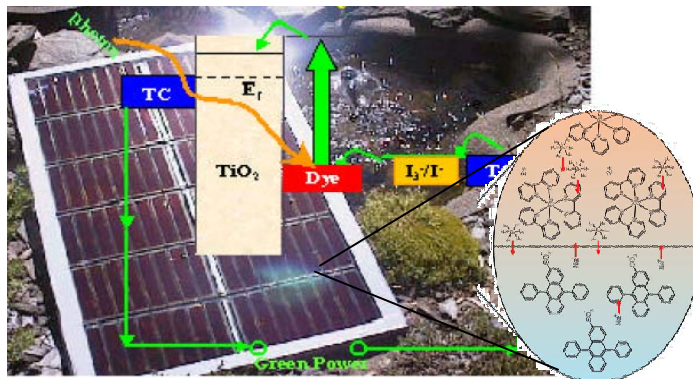
Flexible Photovoltaics



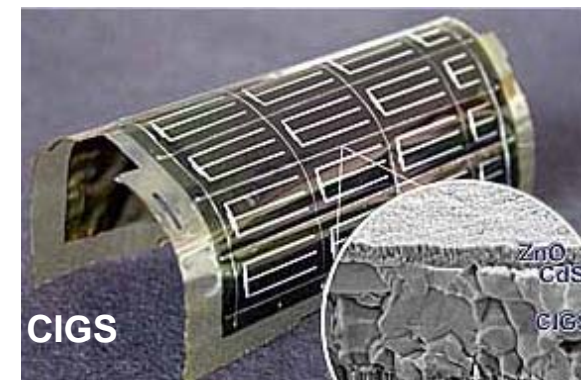
- Low efficiency
- Heavy
- Poor flexibility
- High cost

• New Organic/bioinspired materials

• Thin film inorganics (CIGS)



3rd generation technologies with increased stability and efficiency



Enabling low-cost, versatile photovoltaics for large-scale power generation

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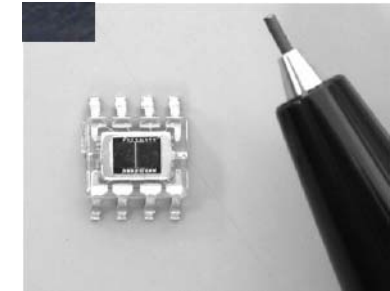
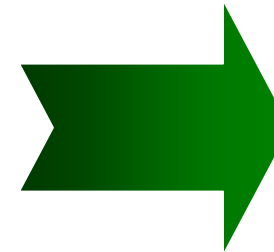
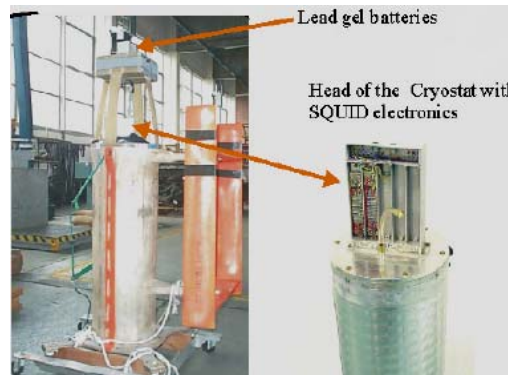


Magnetic Sensors

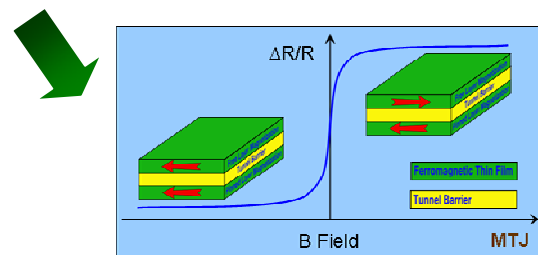
New Magneto-resistive Materials



Current high-sensitivity magnetic sensors are bulky

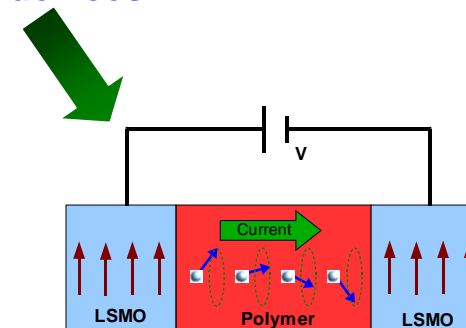


Novel Materials enable MR in excess of 400%!



MTJ Devices

Novel polymer-based devices



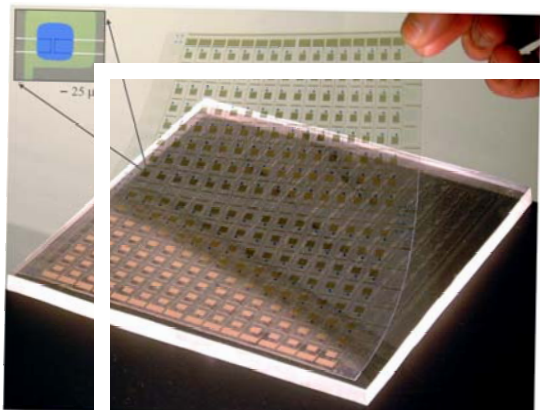
Spin Injection Based Devices

Miniature room-temperature, low-frequency magnetic sensors

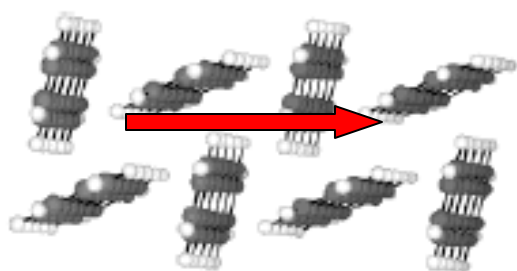


Organic TFTs

Organic Semiconductors

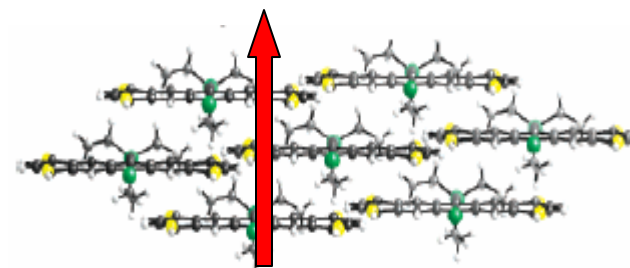


Organic transistors are process able at low-cost but have poor performance



Crystal engineering

$$\mu \propto t_{ij}^2 \sqrt{\frac{\pi}{\hbar k_B T \lambda}} e^{-\frac{(\Delta E - \lambda)^2}{4 \lambda k_B T}}$$

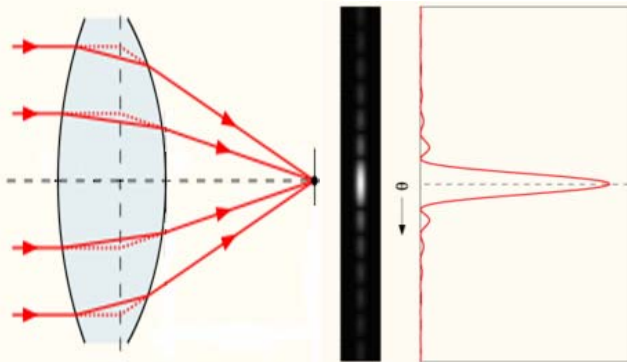


Control of the relative arrangement of the molecules in a solid coupled to theoretical semiconductor performance

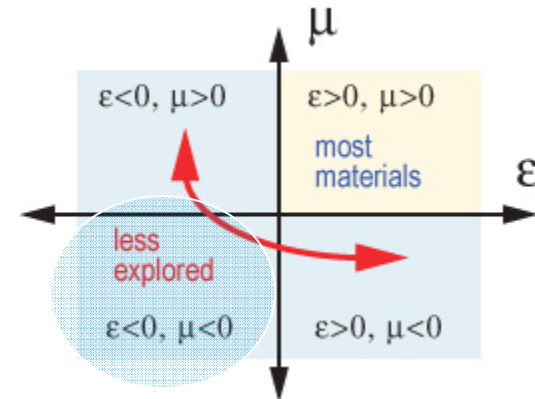
Ordered organic semiconductors for higher-end performance and flexible distributed electronics



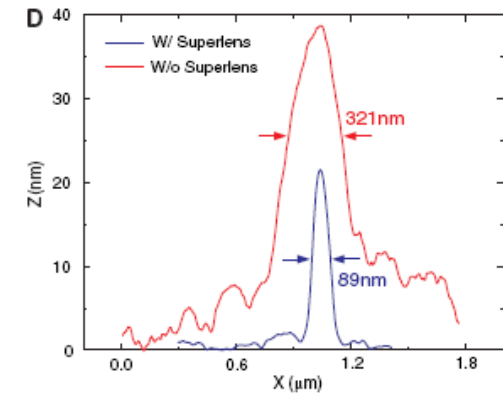
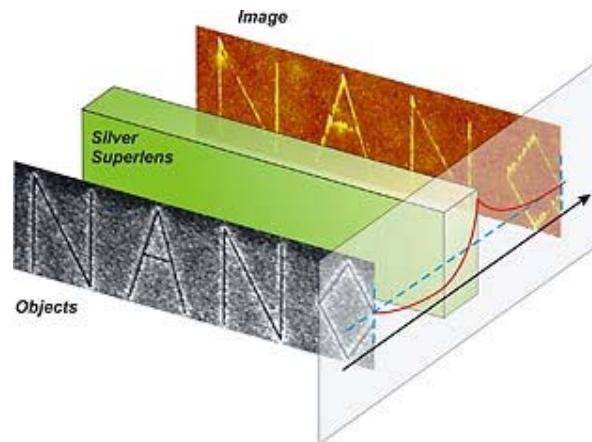
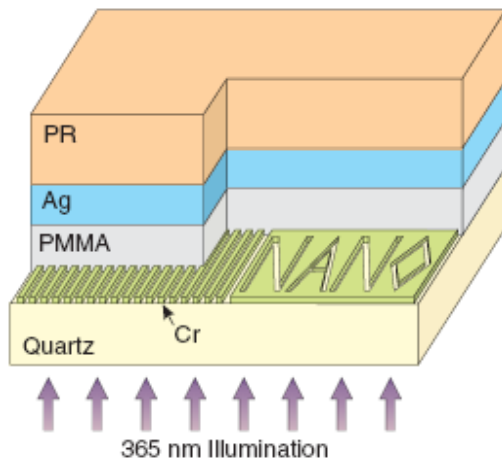
Superlens Negative Index Materials



Diffraction limits the performance of current optical elements



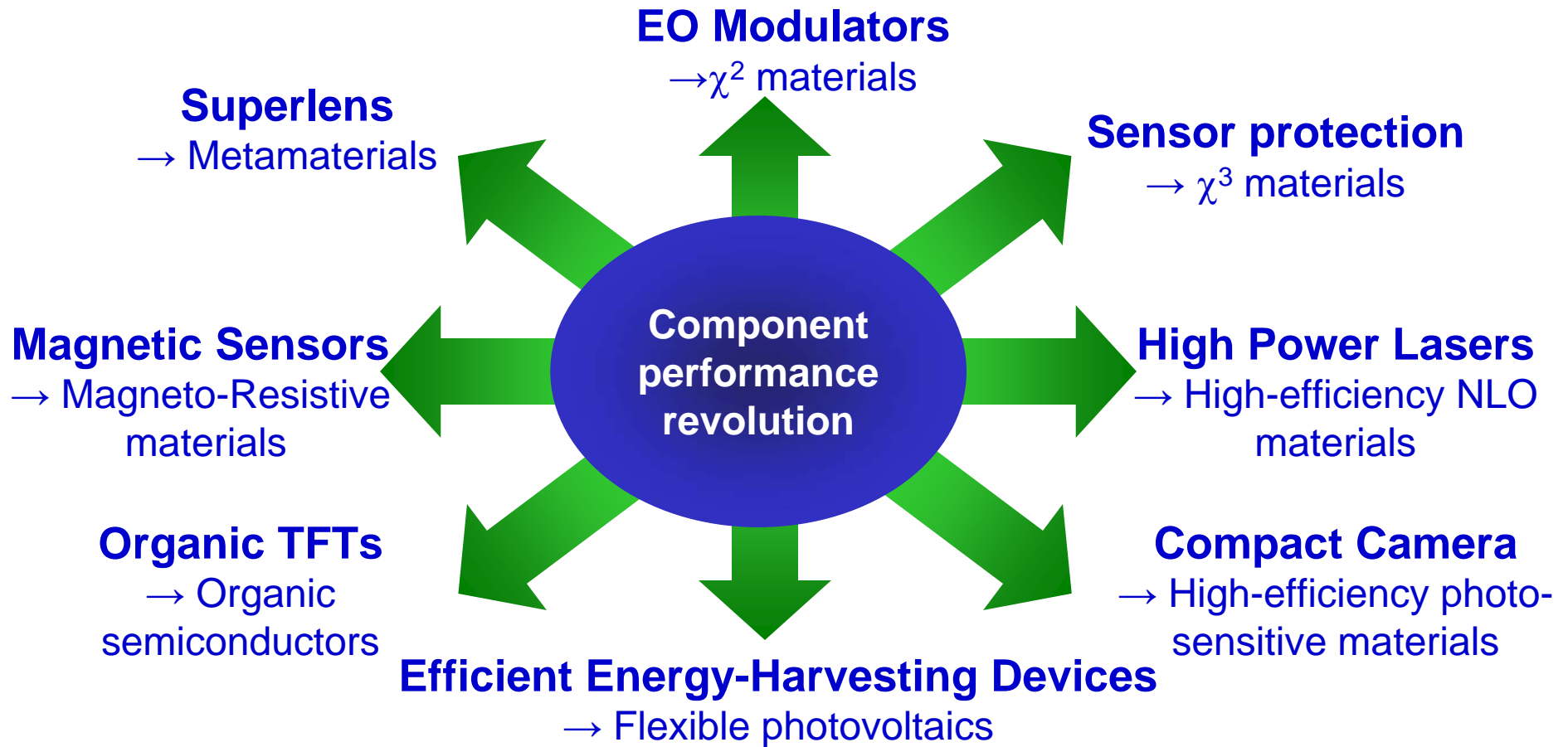
Metamaterials for sub-diffraction limited imaging



Sub-diffraction optical imaging



Components and Devices for New Military Capabilities



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