Micro-Spectrometer for Neural Probe with Wireless Feed

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NASA Space Act Agreement (SAA) #15546 Collaboration Activity

Deep Brain Stimulation (DBS)

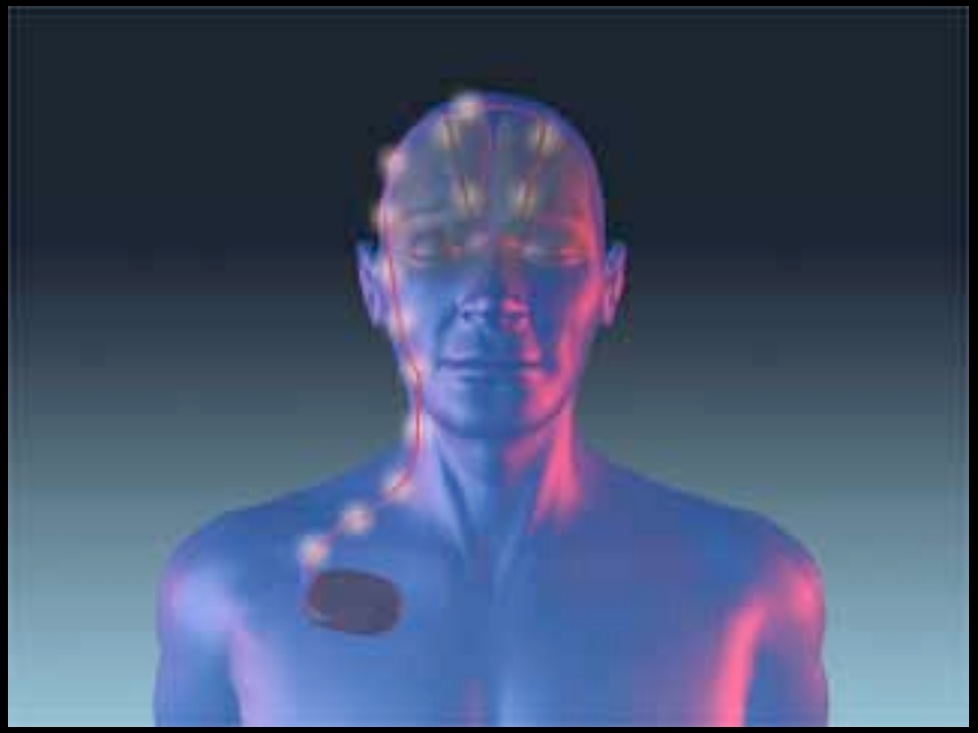
A neurosurgical treatment which stimulates the brain with mild electrical signals

FDA Approval:

- Essential tremors (1997)
- Parkinson's Disease (2002)

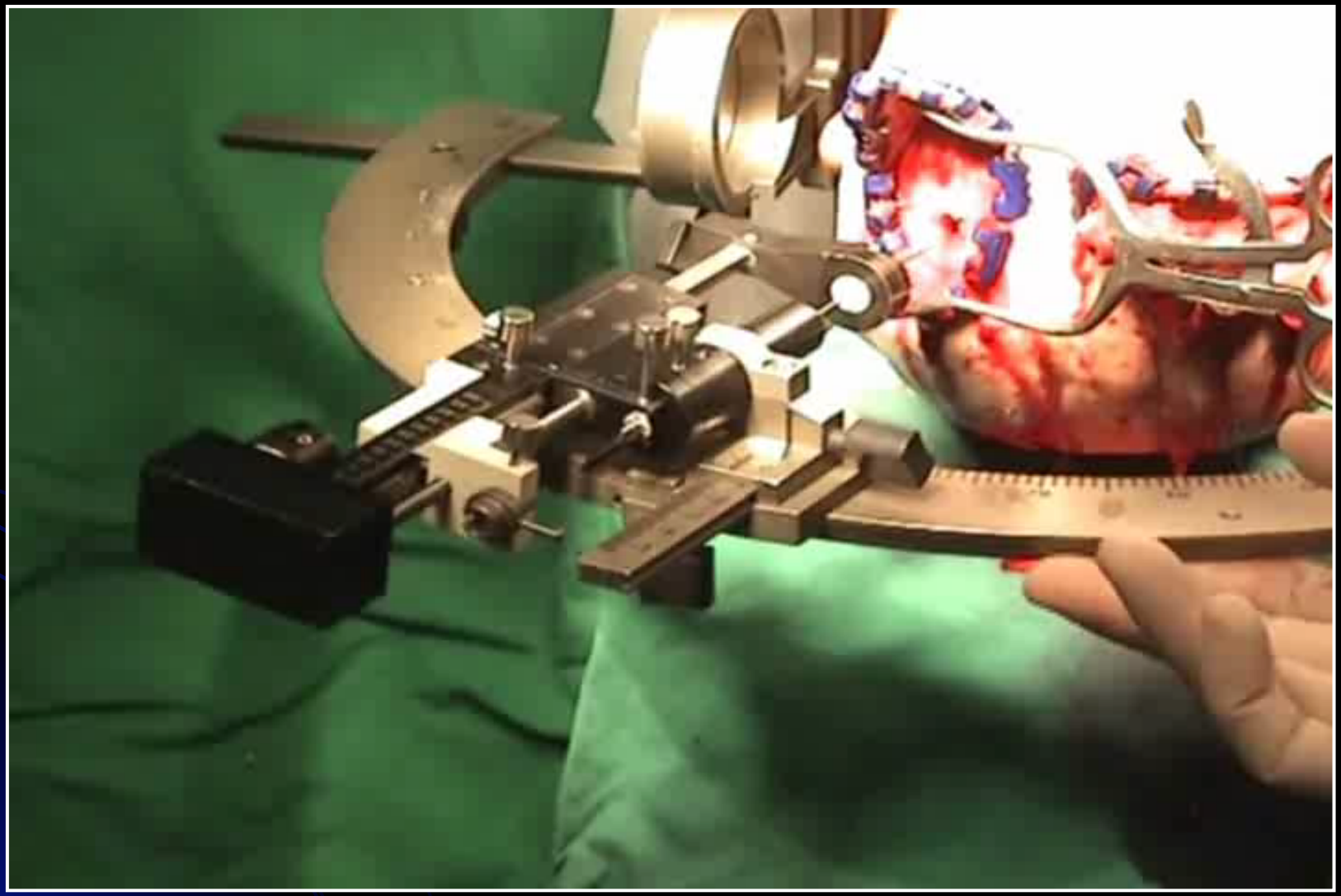
Disease Applications:

- Parkinson's Disease
- Patients with essential tremors
- Epilepsy
- Dystonia
- Obsessive Compulsive Disorder (OCD)
- etc.

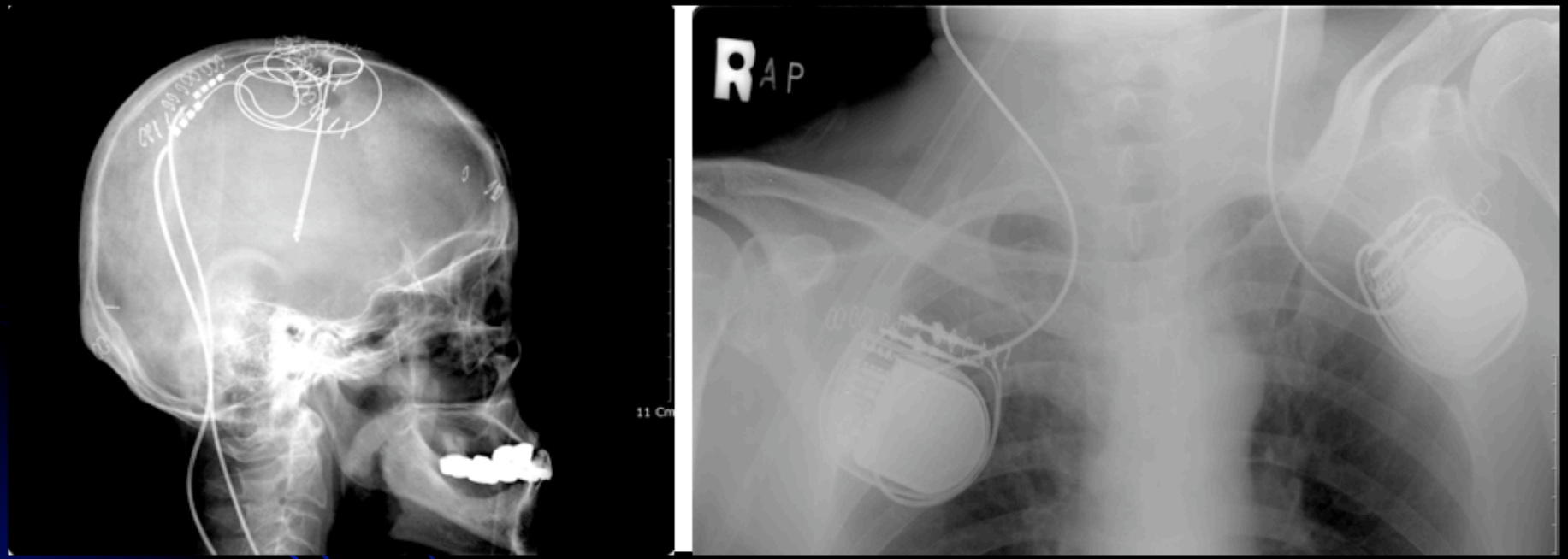


www.stockani.com/parkinson-dbs.html

DBS Surgical Procedure



Implanted Probes & Batteries



Current Limitations

Power Source: Implanted battery with tether line

- Painful and cumbersome
- Battery life: 3-5 years
- Power-line vulnerable to disconnection

Performance: Jolt Suppression Voltage Only

- Diagnosis and search of anomaly required
- A single function

New Approach: *Probe-Pin Device*

Power Source: Wirelessly powered

- Micro-coil with train of magnetic pulses
- Rectenna array for microwave coupling

Performance:

- Diagnosis and search of anomaly required
- Multi-functions integrated
  - Jolt suppression voltage
  - Brain temperature
  - Brain pressure
  - Neuro-electricity
  - Neuro-chemistry by micro-spectrometer

Logic Circuit for Monitoring, Control, & Data Acquisition

New Approach: *Probe-Pin Device*

Green = NASA Langley's Involvement

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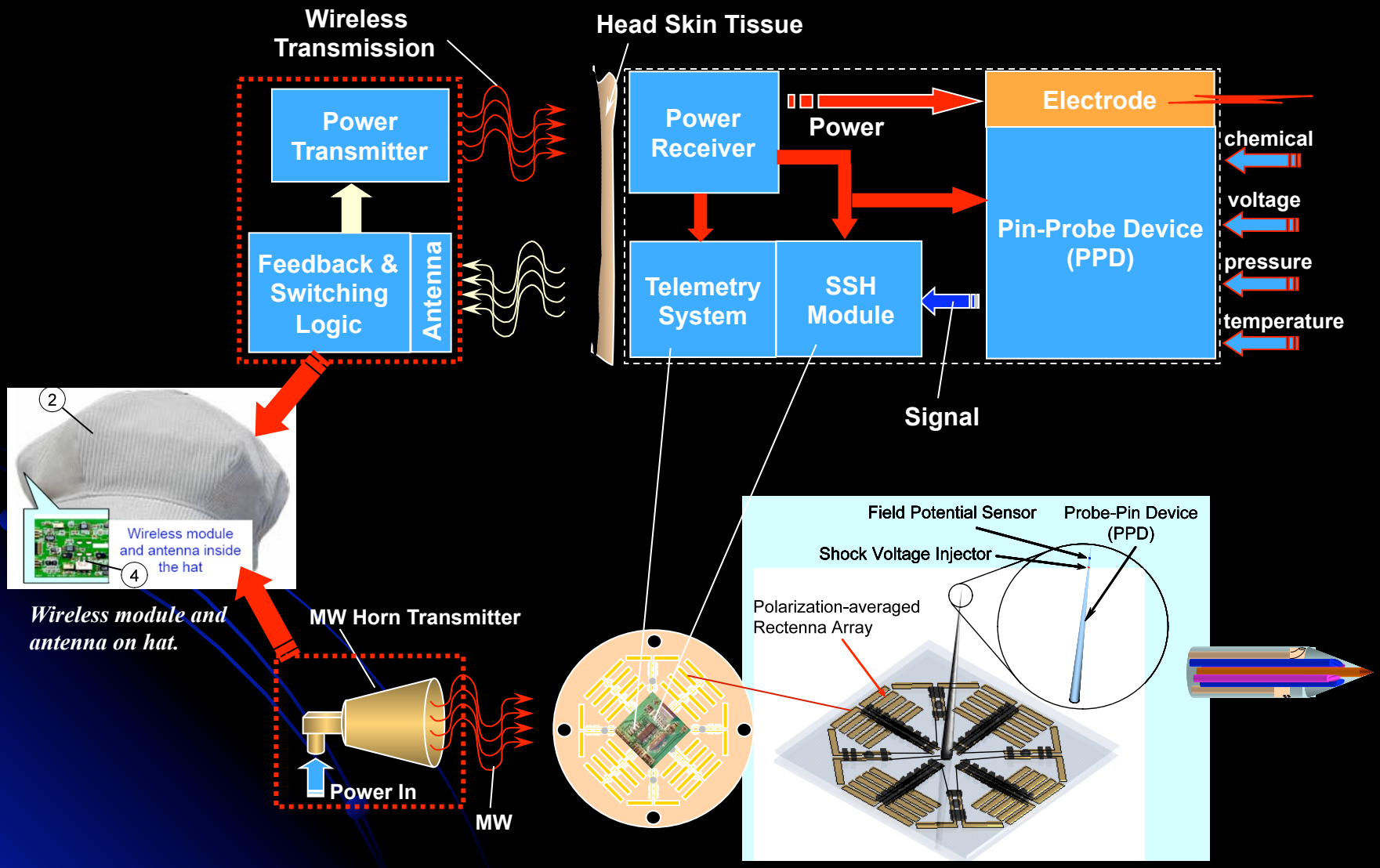
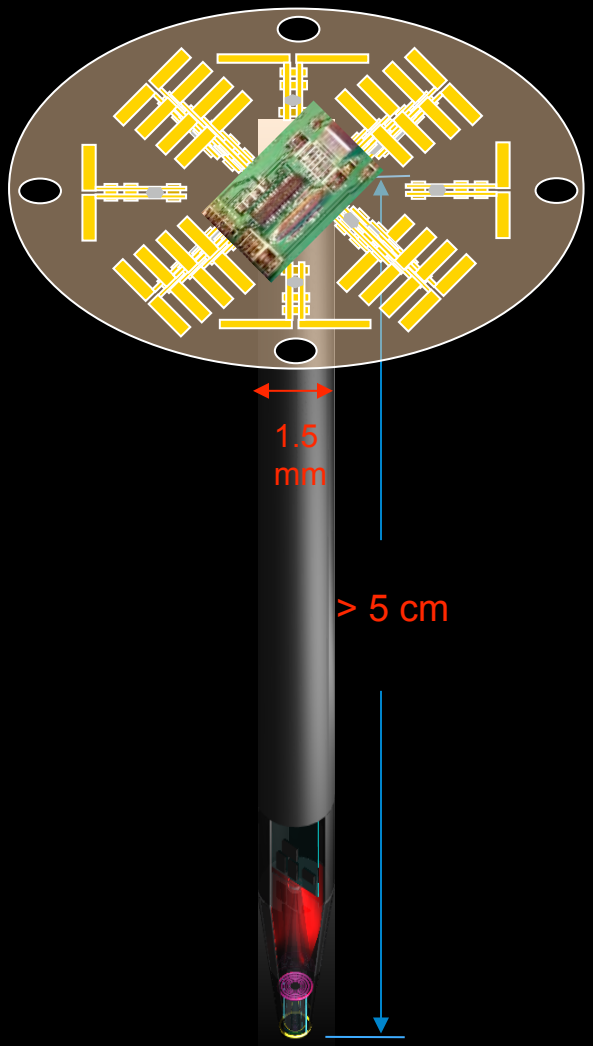
Logic Circuit for Monitoring, Control, & Data Acquisition

Master Logic Dependent Pin Probe Device (PPD)



Pin Probe Device (PPD)

- Selection of Targeted Spectral Line for μ-SM:
  600 nm < λ < 1000 nm
- Spectral Resolution: ≤ 10 nm
- Downsize of Micro-Spectrometer:
  < 2 mm
- Platform Design for Other Sensors Integration:
  p, T, V, and chemicals
- Wireless Power Feeder and Integration:
  both MIC and MW
- Telemetry Circuit and Test with Skin Tissue:
  FM mode
- Chip-scale Design of Electronics:
  Miniaturization



Micro-Spectrometer Development Plan

1. Negative Zone Plate (NZP)
2. Characterization of NZP
3. Broadband level of Micro-Spectrometer
4. Smart Optical Materials for Micro-Spectrometer
5. Smart Optical Materials Characterization

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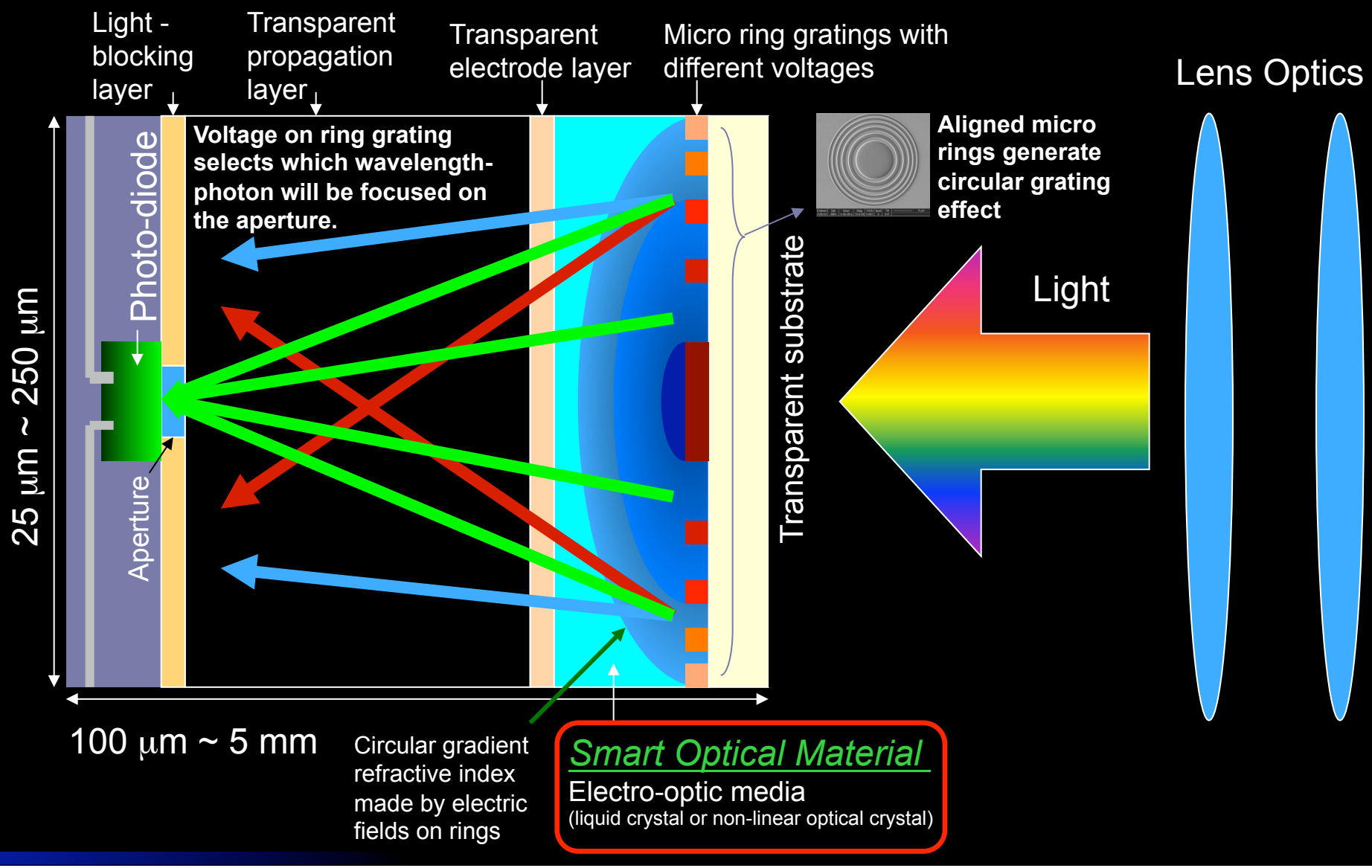
5. Smart Optical Materials Characterization

Red = NASA seeking collaborators in these areas

Micro-Spectrometer Development Plan



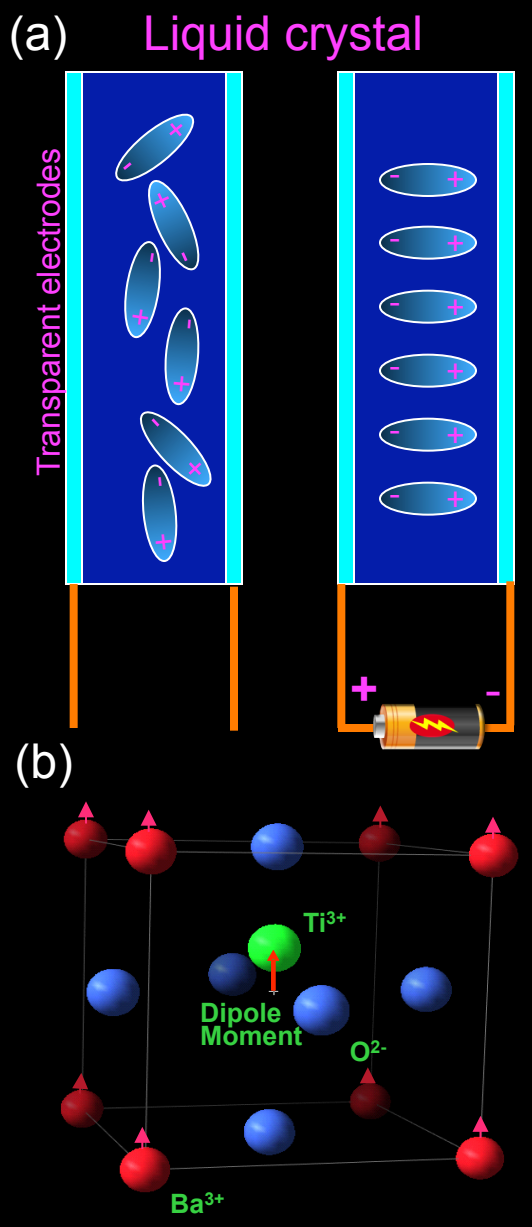
Smart Optical Materials

Smart Optical Materials (SOM) are new optical materials that can control deep properties (intensity, phase, polarization, coherence) of passing light, including

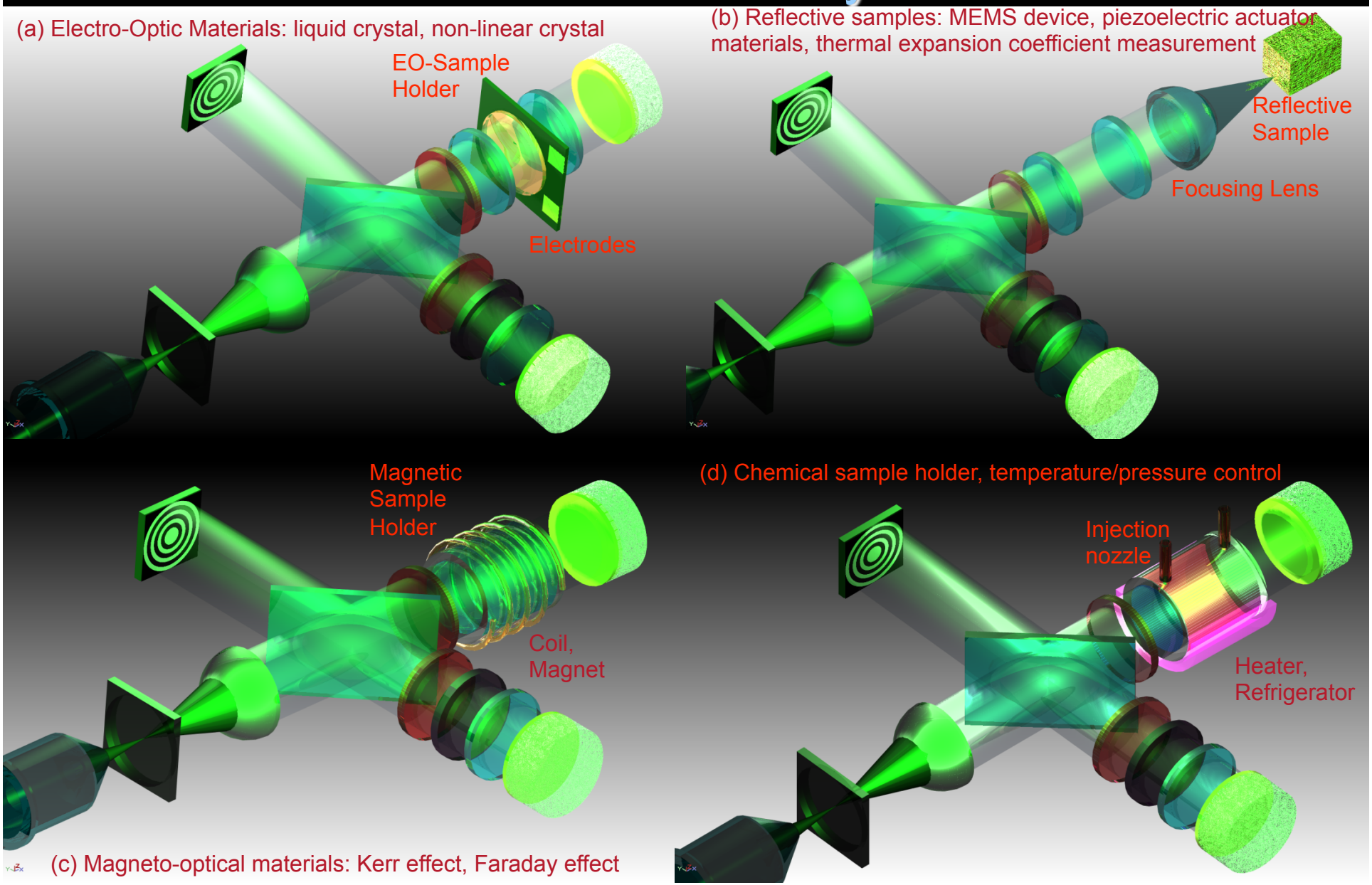
- electro-optic materials (non-linear optical crystals, liquid crystals, electro-optic polymers)
- magneto-optic materials (Faraday Effect and Kerr Effect),
- electro/thermo-chromic materials
- chemicals that induce refractive index changes
- optical materials that depend on temperature and pressure

New prototype SOM characterization system with advanced software is under development at NASA LaRC.

- Intensity, phase, and polarization of passing lights through many new optical materials while applying various physical/ chemical quantities on the materials.
- A miniaturized compact system has USB interface and exchangeable components for various R&D and commercial applications.
- This innovative versatile SOM characterization system and characterized optical materials will be used for complete micro spectrometer system.
- Commercialization of this system accelerates development of new optical materials and devices.



Smart Optical Materials
Characterization System



Development Summary

- Neural Sensing Probe Pin Device with micro-spectrometer is under development.
  - Micro Spectrometer Component Test Platform was set up.
  - The world's smallest optical path volume ($1mm^3$ was achieved with 0.75mm diameter.)
  - This is $1/1000^{th}$ volume compared with today's smallest commercial spectrometers ($1cm^3$)
  - Demo model developed with actuator-controlled focal length as a stop-gap approach
  - All basic electronics for sensor, telemetry, and power coupling were fabricated, but required chip-scale miniaturization
- Prototype SOM characterization system is developed to measure intensity, phase, and polarization of passing lights through many new optical materials while applying various physical/chemical quantities on the materials.
  - A miniaturized compact system has USB interface and exchangeable components for various R&D and commercial applications.
  - SOM system and software are Tech-Transfer ready
- Wireless Power Transmission test using polyurethane layers and pig skin was satisfactorily performed.
  - MIC was proven to be effective for short range power transmission, like a hat system
  - TFRA was effective for short (near-field capacitive coupling) and long (far-field) range power transmission.

Collaboration Opportunities

Seeking expertise in

Smart Optical Materials

via a

Space Act Agreement

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