

**OPTICS AND PHOTONICS**

## Optics and Photonics Research for Montana Economic Development

**Principal Investigator:**

- Joseph Shaw · Optical Technology Center · Montana State University

**Funding Amount:** \$2,500,000

**Brief:**

This research expands core competencies developed through previous investments in optics and photonics to make important contributions to new, high-value Montana problems in agriculture, health and biomedical sciences, energy, materials and manufacturing, and information technology. New commercial products enabled by this research will range from compact optical sensors for precision agriculture to advanced imaging and laser systems for detecting skin cancer and monitoring cell growth. This research also will position MSU and partnering companies to compete strongly in the multi-billion-dollar markets of defense and commercial markets involving optical waveguides and integrated photonic circuits.

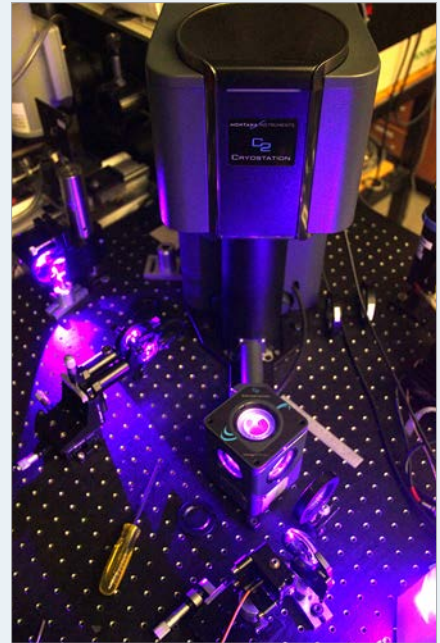
**Objectives and Progress:**

1. Ultra-compact spectral imagers for precision agriculture and mapping of wildfires and natural resources:
  - A. Ongoing development of ultra-compact imaging and laser systems for weed mapping in precision agriculture, UAV mapping of wildfires, and a wide variety of ground-based and airborne remote sensing.
2. High-performance, real-time image processing for hyperspectral imaging:
  - A. Designs underway on a high-speed hyperspectral waterfall sorting system to fuse object edge information with hyperspectral data to sort agricultural products quickly and efficiently using Resonon's Hyperspectral Imagers and remove rejected items via air jets.
3. Remote sensing algorithms for precision agriculture:
  - A. Methodology in development for using hyperspectral imagery for determining optimal narrow spectral band combinations for identifying targeted invasive weeds in specific crops.
4. Machine vision algorithms for precision agriculture:
  - A. Machine vision algorithms for weed detection and food sorting using spectral imaging data in development.
5. Microcavity sensors for hyperspectral imaging:
  - A. Technological advancements in MSU/Advanced Microcavity Sensors LLC (AMS) are focused on imaging sensors towards commercial applications in agriculture and engineering tests to determine feasibility of mountain sensor technology on UAV; secondary objective solving Montana problems in agriculture and skin cancer detection.



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6. Hyperspectral imaging for monitoring cell growth:
  - A. Designs underway for a hyperspectral imaging system for monitoring the metabolic state of live cells in culture. Applications to stem cells for understanding disease mechanisms in individuals, drug testing in cells from individuals, and potentially optimize personal nutrition.
7. Translational research to commercialize micro-mirror technology:
  - A. Ongoing work to translate MSU-developed deformable mirror technology to a commercially sustainable product.
8. Active waveguides and integrated optical circuits:
  - A. Researchers are integrating Montana products, expertise and capabilities to improve marketability, performance and enable additional products: Building interdisciplinary connections among MUS and Montana optics industries to integrate (a) optical crystals by FLIR/Scientific Materials Corp. (SMC); (b) waveguide photonic components of AdvR, Inc.; (c) Montana Instruments (MI) cryogenic systems; and (d) S2 Corp. (S2C) signal processing devices.
9. Optical parametric oscillator for tunable lasers:
  - A. Investigations underway for optical parametric oscillator performance in support of characterizing large aperture periodically poled non-linear optical crystals and in support of continued development of large area methane detection.
10. Nonlinear optical detection of surface contaminants:
  - A. A new method for detecting organic contaminants that accumulate on the surface of water based on nonlinear vibrational overtone spectroscopy (NVOS) is in development.



### Return on Investment:

- **Jobs**
  - Full time engineer at Revibro (new private sector company spun off from MREDI)
  - 13 faculty
  - 6 research engineers/research scientists
  - 12 graduate students
  - 5 undergraduate students
  - 2 non-MSU people starting new companies
- **Leverage—additional grant funds received:**
  - \$5,340,095 in 15 grants awarded
  - \$3M in related NSF grant
- **Output**
  - Up to nine new commercial products in progress for Montana companies; two new companies.
- **Connections—private sector partnerships:**
  - Advanced Microcavity Sensors LLC—Bozeman
  - AdvR, Inc—Bozeman
  - Agile Focus Designs—Bozeman
  - Flat Earth, Inc.—Bozeman
  - FLIR/Scientific Materials Corp.—Bozeman
  - Montana Instruments—Bozeman
  - Meridian Flying Services—Sidney
  - Freeman Farms—Fairfield
  - Nugent Farms—Fairfield
  - Montana Photonics Industry Alliance
  - NWB Sensors, Inc.—Bozeman
  - Resonon, Inc.—Bozeman
  - Revibro—Bozeman
  - S2 Corp.—Bozeman

