

# Photovoltaically Powered Optical Data Link

Naval Research Laboratory

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## At a Glance

### What is it?

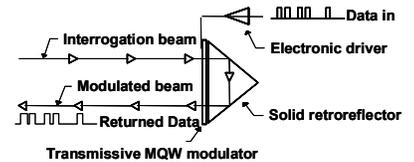
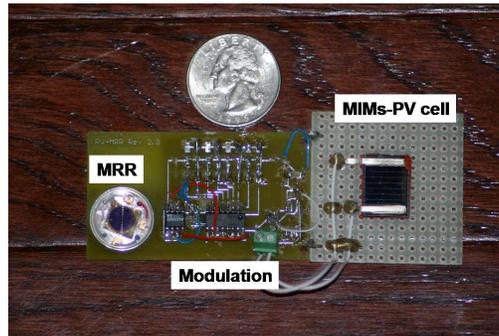
NRL is developing photovoltaics based on monolithically integrated modules (MIM-PV) “tuned” to the laser wavelength of an optical data link to enable direct integration and form a self-powered, covert data link for deployed sensors.

### How does it work?

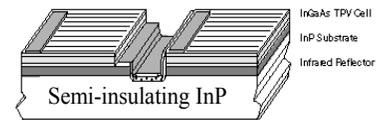
The optical link transfers data by impressing data on a laser beam. The specialized solar cell (MIM-PV) is engineered to convert the laser light into electricity. Also, the MIM structure allows the solar cell output power to be conditioned to match the system requirements for maximum energy transfer efficiency.

### What will it accomplish?

Directly integrated MIM-PV with an optical data link will provide continuous power for long-duration remote sensor missions. This will be a self-powered communication system enabling covert, remote sensor deployment in hostile or denied areas.



Schematic diagram of MRR optical datalink



Schematic diagram of MIM-PV solar cell

NRL is developing a miniature, self-powered sensor system with communication capabilities that can operate autonomously for extended time periods in remote and extreme environments. The system builds on an optical communication technology developed by NRL consisting of a modulating retro-reflector (MRR), which is a specialized, quantum well semiconductor structure that absorbs incident laser light, impresses data upon it, and reflects the light back to the sender (see schematic above). The current effort is focused on developing a PV technology specifically engineered to convert a portion of the laser light to electricity to power a sensor payload and the data link. The target operating parameters are 50 mW of power transmitting data at 100 kHz at a duty cycle of 30 minutes within a package approximately 2 cm × 2cm × 0.5 cm thick with a range of several meters. This is achievable since the MRR is an extremely low power system, and solar cells tuned to absorb a single wavelength (i.e., laser light) can be very efficient (>50%).

The PV technology is based on the NASA Glenn Research Center (GRC) patented monolithically integrated module (MIM) technology that has been developed for thermophotovoltaics (TPV). A MIM consists of many individual solar cells series connected on a single substrate (see schematic above). An example of a 1 × 1 cm<sup>2</sup> MIM consisting of InGaAs solar cells grown on an InP substrate is shown in the photograph. Series connecting the cells allows the output voltage to be increased. In the example in the photograph, the device consists of 15 cells in series with an open circuit voltage of ~5 V and a short circuit current ~1 A/cm<sup>2</sup>. The MIM technology offers the design versatility necessary to allow efficient conversion of both incident sunlight and the system laser light. Furthermore, the MIM technology allows the design flexibility to match the PV output to the MRR requirements.

### Research Challenges and Opportunities

- Optimize MIM for electrical conversion efficiency
- Develop charge control electronics for system level efficiency

List of publications:

"Multiple quantum well based modulating retroreflectors for inter- and intra-spacecraft communication"

Peter G. Goetz; William S. Rabinovich; G. Charmaine Gilbreath; Rita Mahon; Mike S. Ferraro; Lee Swingen; Robert J. Walters; Scott R. Messenger; Linda M. Wasiczko; James Murphy; N. Glenn Creamer; Harris R. Burris; Mena F. Stell; Christopher I. Moore; Steven C. Binari; D. S. Katzer SPIE Proceedings Vol. 6308, 28 August 2006

"Photovoltaically powered modulating retroreflectors"

R. J. Walters, J. L. Murphy, W. S. Rabinovich, G. C. Gilbreath, D. M. Wilt, M. A. Smith, M. J. Krasowski, P. P. Jenkins, D. Scheiman, J. H. Warner, S. R. Messenger, J. R. Lorentzen, G. P. Summers Optical Engineering 453, 1 March 2006

"Photovoltaically powered modulating retroreflector optical data links"

R. J. Walters, J. H. Warner, G. P. Summers, G. C. Gilbreath, J. L. Murphy, W. S. Rabinovich, S. R. Messenger, J. R. Lorentzen, D. M. Wilt, M. J. Krasowski, P. P. Jenkins, and M. A. Smith Thirty-first IEEE Photovoltaic Specialists Conference, 2005. Page(s): 735 - 738