Hybrid Electro-Optics for Integrated Photonics

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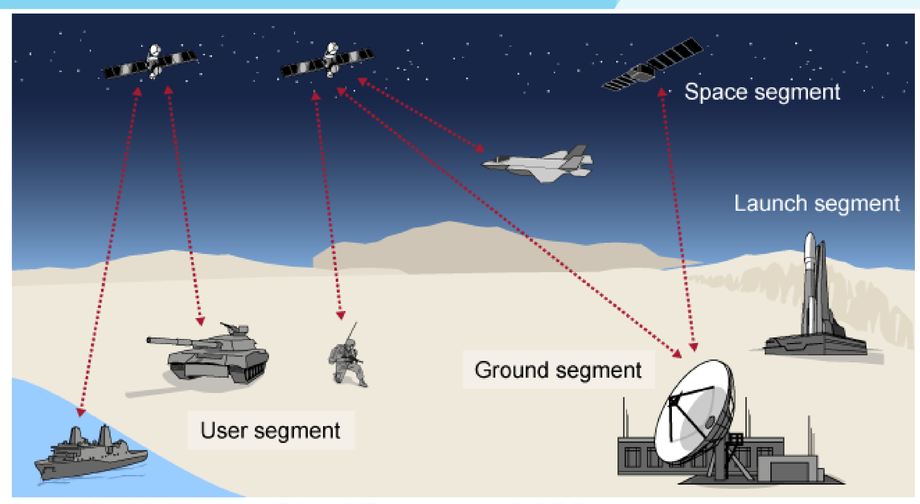


Source: GAO analysis of Department of Defense (DOD) documentation. | GAO-20-80

PROBLEM

There is a growing need in both defense and civilian markets for high-bandwidth communication, computing, and sensing abilities that are more robust and reliable and fit within rigid **C-SWaP** (cost, size, weight, and power) constraints. As a result, **material advances for electronic, photonic, electro-optical, and quantum materials** are needed that can provide high performance within power budget and harsh environmental conditions of DoD missions, spacecraft, and datacenter applications. Within the defense ecosystem, surveillance and reconnaissance, **(ISR)** electronic warfare, **(EW)** and quantum technologies represent key applications.

PROPERTIES OF NLM'S HYBRID OEO TECHNOLOGY

LESS POWER

Reduced operating voltage and system complexity

10x – 1000x enhanced modulation efficiency ($V_\pi L$), capable of 0.05 - 0.5 V-mm at telecom wavelengths

HIGHER BANDWIDTH

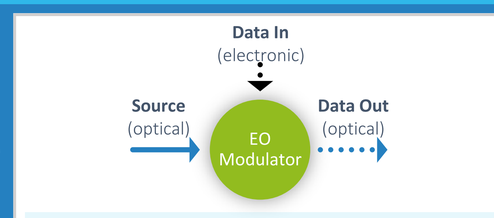
Faster networks, devices, and computing infrastructure

2x – 10x+ enhanced modulation bandwidth (100+ GHz-THz)

SMALLER SIZE

Compact devices for dense integration in photonic integrated circuits (PICs)

4x – 100x reduction in modulator area



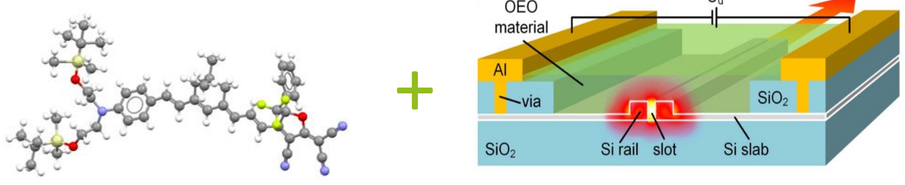
NLM Hybrid Organic EO
Combining engineered organic materials with semiconductor platforms for efficient electrical to optical signal conversion

Application	Datacom	mmWave (Satcom & 6G+)	Quantum	Optical ML	LIDAR
Value Prop	SWaP	THz Bandwidth	Cryo Performance	SWaP	SWaP

OUR SOLUTION

Hybrid OEO Technology

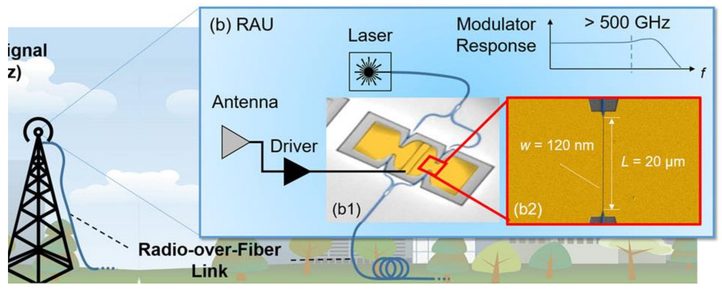
organic electro-optic (OEO) material + nanoscale slot modulator



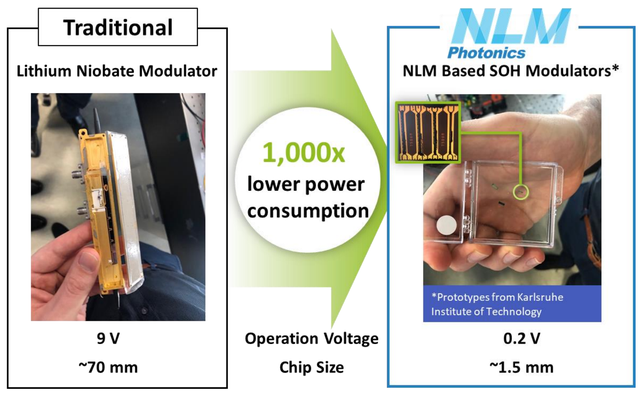
NLM Photonics' **hybrid organic electro-optic (OEO) modulation technology** for high-performance wireless communication, computing and networking applications combines engineered organic materials with semiconductor platforms enabling **EO modulation** with record **size, bandwidth, and power efficiency.**

NLM's commercially deployed OEO materials and processes may be coupled with cutting-edge silicon, plasmonic, SiN, and other integrated photonic architectures to address the DoD, Intelligence Community, and industry needs for lightweight, high-performance, low-power (improved C-SWaP) **telecommunications, sensing, and computing systems.**

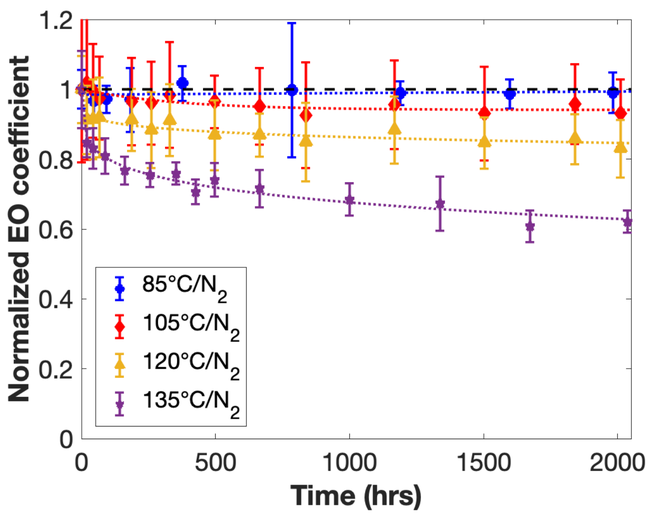
NLM develops **materials, devices, and process technology** enabling chip-scale photonic integrated circuits, deployed as an IP block through partner fabs. NLM works with partners in the US, Europe, and Japan to deploy our technology in high performance photonic systems.



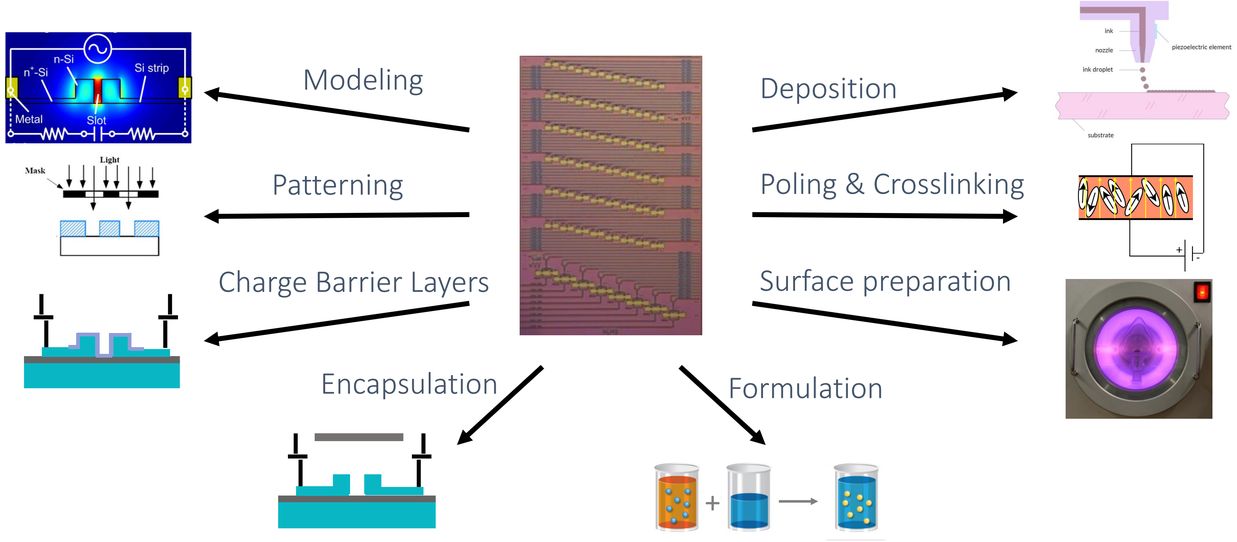
500 GHz-THz Bandwidth



Superior modulation efficiency of organics + hybrid device design = low power and small footprint



Unique crosslinking technology yields excellent thermostability



- EO coefficient up to 1100 pm/V (30 x lithium niobate)
- Operating temperature range of < 4K to 120 °C
- Superior modulation efficiency ($V_\pi L$) enables < 1 V drive voltage in compact devices
- Flat frequency response to high operating bandwidths

References: [1] L. E. Johnson, D. L. Elder, H. Xu, S. W. Hammond, S. J. Benight, K. O'Malley, B. H. Robinson and L. R. Dalton, *Proceedings of SPIE 11812*, (San Diego) 2021, 1181202. [2] H. Xu, F. Liu, D. L. Elder, L. E. Johnson, Y. de Coene, K. Clays, B. H. Robinson and L. R. Dalton, *Chemistry of Materials*, 2020, *32*, 1408-1421. [3] H. Xu, D. L. Elder, L. E. Johnson, W. Heni, Y. de Coene, E. De Leo, M. Destraz, N. Meier, W. Vander Ghinst, S. R. Hammond, K. Clays, J. Leuthold, L. R. Dalton and B. H. Robinson, *Materials Horizons*, 2022, *9*, 261. [4] S. R. Hammond, K. M. O'Malley, H. Xu, D. L. Elder and L. E. Johnson, *Proceedings of SPIE 11998,* (San Francisco) 2022, 119980C. [5] C. Kieninger, Y. Kutuvantavida, D. L. Elder, S. Wolf, H. Zwickel, M. Blaicher, J. N. Kemal, M. Lauermann, S. Randel, W. Freude, L. R. Dalton and C. Koos, *Optica*, 2018, 5, 739-748. [6] U. Koch, C. Uhl, H. Hettrich, Y. Fedoryshyn, C. Hoessbacher, W. Heni, B. Baeuerle, B. I. Bitachon, A. Josten, M. Ayata, H. Xu, D. L. Elder, L. R. Dalton, E. Mentovich, P. Bakopoulos, S. Lischke, A. Krüger, L. Zimmermann, D. Tsiokos, N. Pleros, M. Möller and J. Leuthold, *Nature Electronics*, 2020, *3*, 338-345.

Development Partners & Key Funding:

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