Electro-Optic Modulators at Cryogenic Temperatures

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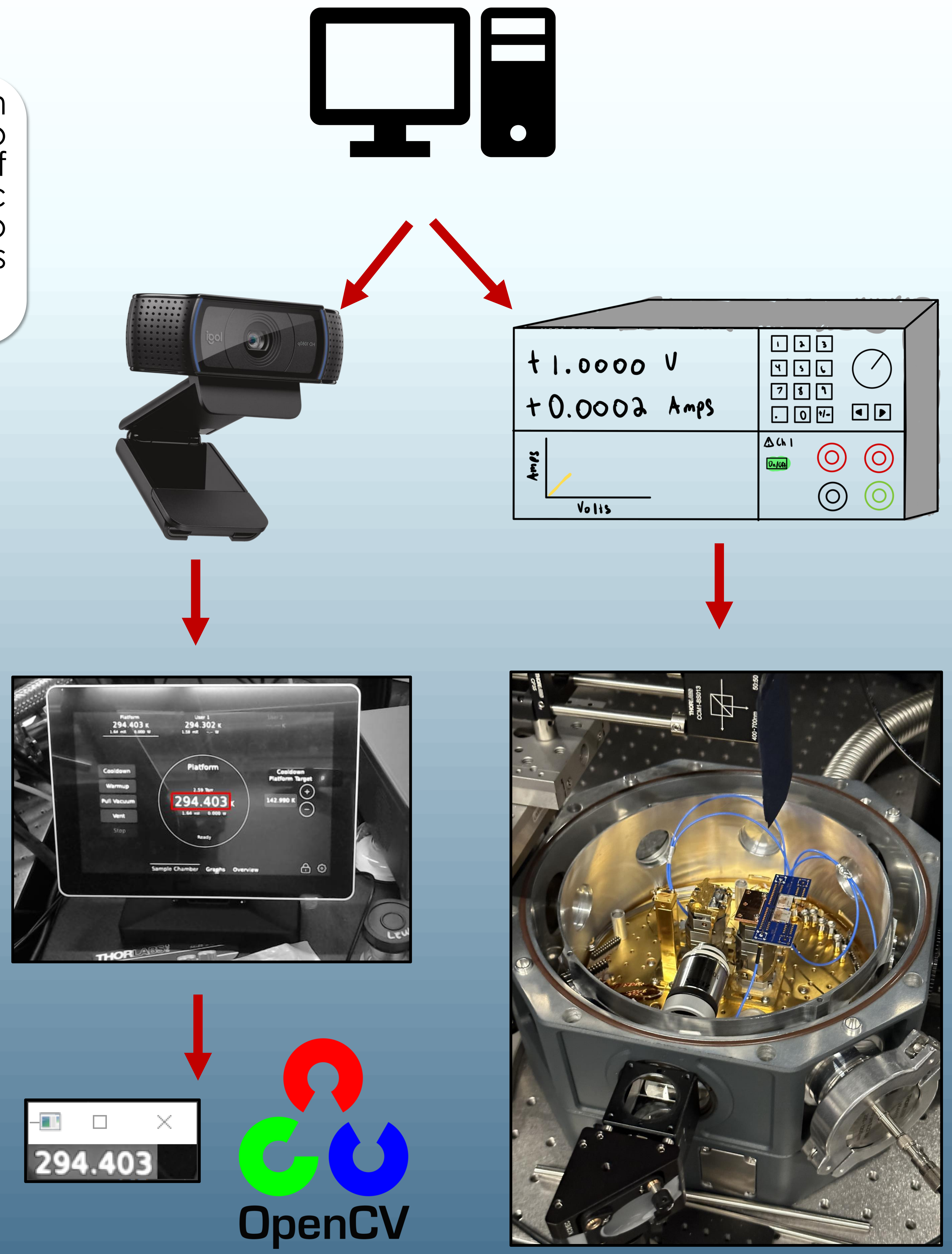
Background

Integrated photonics is a growing market that enables the current world-wide data communication network. They have also been shown to have vital roles in the development of quantum technology such as quantum networks and quantum sensing platforms. Satellite-based communication systems are attractive because they have demonstrated the ability for widespread coverage compared to land-based options. Furthermore, satellite-based quantum networking has also been demonstrated as a proof-of-concept. To further scale up this technology, all-on-chip integration of classical and quantum light sources, passive photonic components for data processing, and on-chip detectors are necessary to achieve low size and weight requirements for satellite-based applications of this technology[1]. Here, we characterize a microring resonator-based electro-optic modulator (EOM) as a function of temperature.

Methods

To investigate the effect of carrier freeze out on the device operation, we perform electrical characterization as we cool the EOM from room temperature down to cryogenic temperatures nearing 4 K. This requires automation and interfacing of electrical characterization tools with a Montana Instruments S200 cryogenic system. The automation of temperature-dependent electrical measurements also finds fruitful applications in the testing of quantum photonic integrated circuits and chip-integrated quantum light sources in the Moody group at UCSB.

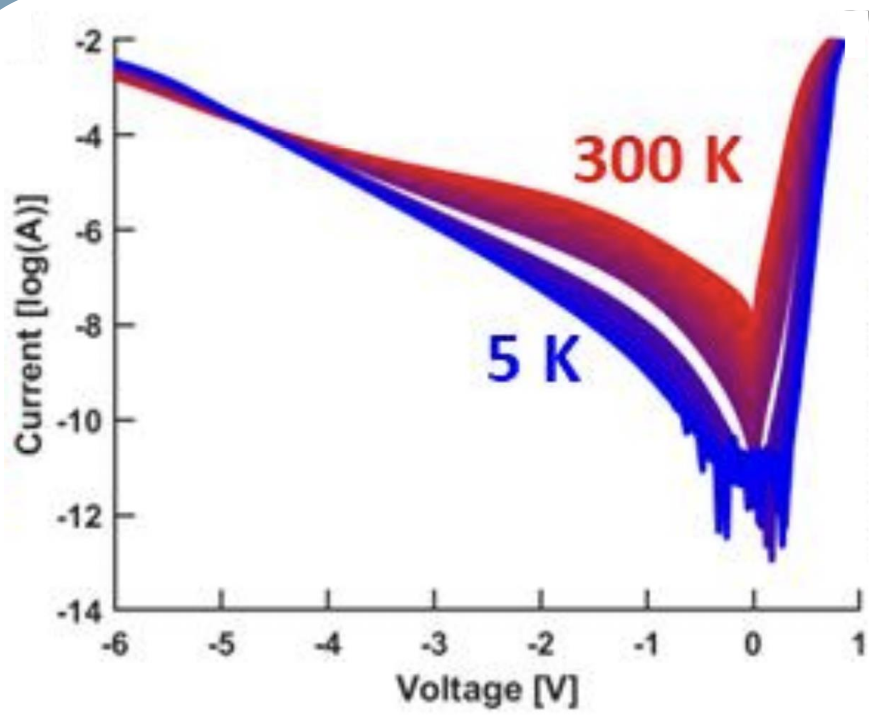


Workflow showing the interfacing and automation that enables simultaneous temperature detection using image recognition, and current-voltage electrical measurement data acquisition.

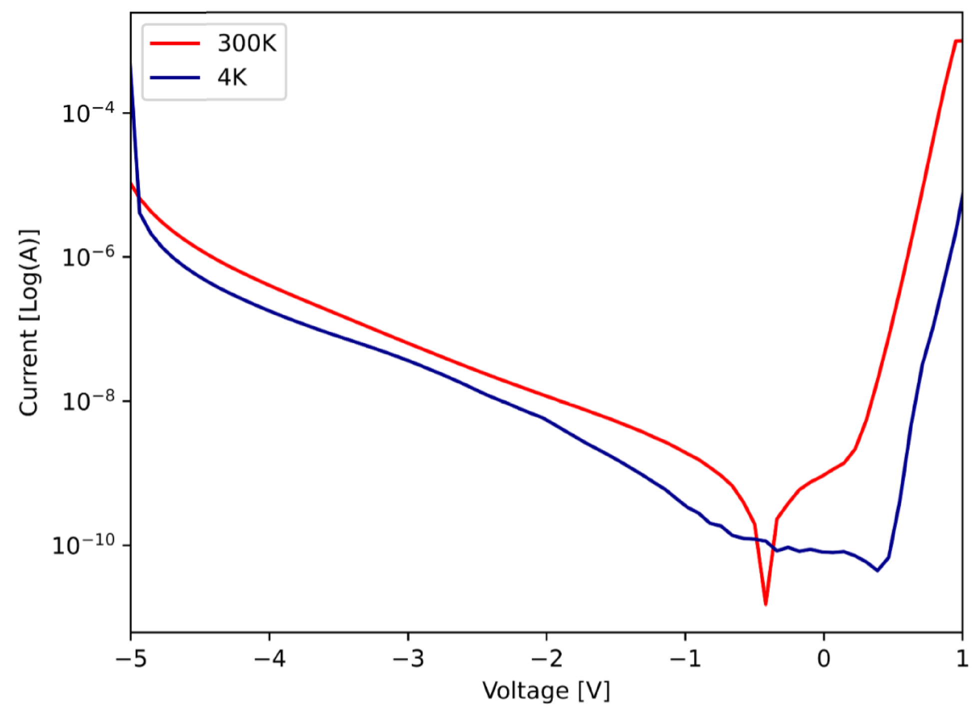
Our Device

The EOMs we tested are micro ring resonators that have a p-n junction doping profile across the waveguide. The devices are made on a silicon platform using a Global Foundries manufacturing process. Optical images of the packaged device are shown on the left

Results for EAMs (Prior Data[2])



Results for EOMs (New Data)



Left: temperature-dependent data showing the I-V characteristic of prior electro-absorption modulators.

Right: temperature-dependent data taken as part of this work, showing the I-V characteristic of electro-optic modulators.

Conclusion

A current challenge in the progression of quantum photonic technologies is the lack of effective light modulation methods in cryogenic environments, which is required for good quantum circuit operation. The EOMs from Lucidean are tested and characterized in cryogenic environments, yielding valuable insight into the development of next-generation technologies for satellite-based applications[3].

Acknowledgements

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References

[1] Dorch, Thomas P., Victoria Rosborough, and Steven Estrella. "Low loss cryogenic optical interconnects using photonic wire bonds." *Optical Interconnects XXIII*. SPIE, 2023.

[2] Chansky, Evan, et al. "High-Speed SiGe EAMs at Cryogenic Temperatures." *2022 IEEE Photonics Conference (IPC)*. IEEE, 2022.

[3] Estrella, Steven Brian. "Silicon Photonics for Harsh Environments." Order No. 29254216 University of California, Santa Barbara, 2022. United States -- California: *ProQuest*. Web. 13 Aug. 2023.

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