Quantum Breakthroughs & Related Programs

INTRODUCTION

Quantum technologies stem from exploiting the counterintuitive behavior of systems at the atomic and sub-atomic scales phenomena like superposition, entanglement, quantum measurement, and coherence. These fundamentals offer new ways of computing, communicating, and measuring which can dramatically outperform classical approaches in certain domains. Key areas include **quantum computation** (designing new ways to process information via qubits and quantum gates), **quantum communication** (secure transmission of information using quantum states), **quantum sensing and metrology** (using quantum systems to make ultra-precise measurements), and **quantum control / measurement** (developing techniques to manipulate and observe quantum systems with high fidelity).

At the University of New Mexico (UNM), there is a strong interdisciplinary program dedicated to advancing such quantum technologies. The **Center for Quantum Information and Control (CQuIC)** brings together physics, engineering, chemistry, and other fields to do research in quantum computation, quantum optics and communication, quantum control/measurement, and quantum metrology. Additionally, UNM is active in cutting-edge projects dedicated to developing integrated hardware and software solutions that overcome current limitations for future photonic quantum computers under NSF's National Quantum Virtual Laboratory (NQVL) program, which aims for scalable, room-temperature photonic quantum technologies.

MARKET OPPORTUNITY

The market for quantum technology is expected to expand rapidly due to notable developments in quantum computing systems and quantum dot fabrication. It is projected to grow at a 33.5% CAGR, reaching a valuation of $86.9 billion by 2031, according to Verified Market Research. Nanostructures and affordable semiconductor integration methods are made possible by quantum dots, which are creating new opportunities in integrated photonics and telecommunications within quantum space. Innovations like the ones below in quantum computing, such as circuit-based leakage detection and randomized dynamical decoupling protocols, are key indicators of growth acceleration in the industry, enhancing the scalability and performance of quantum processors. Sectors such as defense, telecommunications, healthcare, and semiconductor manufacturing are driving rapid investment and adoption in the space. The scalability and performance of quantum processors are being enhanced by innovations in quantum computing, such as randomized dynamical decoupling protocols and circuit-based leakage detection, which create opportunities in the market for technological breakthroughs, as listed below.

TABLE OF CONTENTS:

UNM | Rainforest Innovations

UNM Rainforest Innovations is the University of New Mexico's technology transfer and economic development organization. We help bring UNM research and discoveries to the world by protecting intellectual property and connecting inventors with businesses, investors, and entrepreneurs. As a nonprofit organization, our mission is to support innovation, foster startup creation, and grow New Mexico's innovation economy.

Contact:

(505) 272-7900

info@innovations.unm.edu

https://innovations.unm.edu/

QUANTUM COMPUTING TECHNOLOGIES:

Universal Fault Tolerance with Non-Transversal Clifford Gates

BACKGROUND:

Researchers at the University of New Mexico have developed a novel framework to fully generalize flag gadgets, such that an arbitrary Clifford circuit can be made fault-tolerant to an arbitrary distance. The invention presents a new paradigm for fault-tolerant universality, namely transversal non-Clifford gates and flagged Clifford gates. Additionally, this invention can greatly reduce the cost of universal fault tolerance through its application to many different Clifford subroutines, with optimizations possible for restricted classes. Thus, by implementing this method, with some optimization, quantum computers can greatly reduce the resources needed to solve practical useful problems.

BENEFITS:

- Enables fault-tolerant logical operations
- Allows for a reduction in the resources required for fault-tolerant state preparation and error correction
- This construction can also be used to fault-tolerantly prepare stabilizer states, or code states of stabilizer codes

HIGHLIGHTS:

Reference No:
2026-012

Inventors:
Milad Marvian Mashhad
Benjamin Anker

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Readout of Dynamically Biased APD using an Integrator

BACKGROUND:

Researchers from the University of New Mexico have invented a novel readout circuit that can adjust dynamically based on avalanche photodiodes (APDs). Instead of differential signaling, this invention utilizes a signal processing unit, or integrator-based approach, to eliminate the injected dynamic basing sinewave. These APDs vary based on their voltage and maximum sensitivity to protons, which creates stronger relationships by improving the signal-to-noise ratio and detection speed. A capacitive transimpedance amplifier (CTIA) is used to cancel out the periodic bias signals, which offers 10x as much additional enhancement beyond the ADPs themselves.

BENEFITS:

- A special readout circuit for dynamically biased APDs that eliminates the injected dynamic bias sine wave using a signal processing unit
- This circuit doesn't need any phase or amplitude alignments or synchronization to the dynamic biasing sinewave signal, since the integral of any sinewave over one (or multiple) full period is always zero, independent of its amplitude or its starting point
- Offers easy bias noise removal
- Accepts various waveforms
- Enables high photon sensitivity

HIGHLIGHTS:

Reference No:
2025-084

Inventors:
Majeed M. Hayat
Payman Zarkesh-Ha
Nicholas Gabaldon
Chadi Harmouche
Erum Jamil

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Solenoid-Actuated Press-Contact Cryogenic Thermal Switch

BACKGROUND:

A researcher from the University of New Mexico has developed a press-contact thermal switch designed for commercializing continuous adiabatic demagnetization refrigeration (CADR), a cutting-edge sub-Kelvin cooling technology that minimizes the use of the limited isotope 3He. The development of such 3He-efficient sub-Kelvin cooling technologies is crucial for the expansion of quantum computing, communications, and sensing. This design may also be adapted for single-shot ADR, a widely used low-power sub-Kelvin cooling method. This innovative switch achieves both high on-state and extremely low off-state conductance, which is accomplished by integrating multiple press-contact plates with a high-force linear electromagnet actuation system. Thermal isolation is significantly enhanced by transmitting the actuation force via fiber links in tension. The actuation motion is strictly linear and involves a very short stroke, contributing to a prolonged cycle life suitable for CADR applications.

HIGHLIGHTS:

Reference No:
2025-052

Inventors:
Stephen Thomas Boyd

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BENEFITS:

- Achieves high on-state conductance and very low off-state conductance
- Enables the very long cycle life required for use in CADR
- Improves manufacturability, simplifies design rules, and provides a clear path to scaling to higher cooling powers

Faster Randomized Dynamical Decoupling

BACKGROUND:

A new (randomized) dynamical decoupling (DD) protocol that can improve the performance of any given existing (deterministic) DD methods, by introducing no more than two additional pulses. Specifically, they developed a novel framework that converts any given deterministic DD protocol into a randomized version that can significantly outperform the original deterministic approach. Additionally, they proved that the randomized protocol achieves a quadratic improvement over what was previously considered to be the optimal DD method. To rigorously evaluate the performance, they introduced new analytical methods suitable for analyzing higher-order DD protocols that might be of independent interest.

HIGHLIGHTS:

Reference No:
2025-010

Inventors:
Milad Marvian Mashhad
Leeseok Kim
Changhao Yi

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BENEFITS:

- Improves the performance of any existing deterministic DD protocol
- May inspire experimental implementations and improve performance of current quantum devices
- Both rigorous error analysis and numerical simulations are presented confirming that the randomized protocol can significantly improve many widely used DD protocols such as XY8 and Uhrig DD

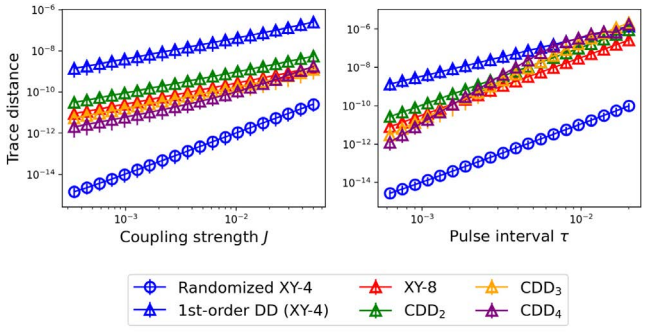

Figure 1: Performance of the sequence-randomized XY4, represented by circles compared to deterministic protocols (CDD_K for $K = 1, 2, 3, 4$, where CDD_1= XY4, and XY8), represented by triangles. Left panel: Fixed $\tau = 10^{-3}$ while varying J. Randomized XY4 protocol scales $\mathcal{O}(J^2)$, outperforming all deterministic protocols that scale as $\mathcal{O}(J)$. Right panel: Fixed $J = 10^{-3}$ while varying τ. Note that CDD_K requires 4^K many pulses but the randomized XY4 sequence uses no more than 6 pulses.

PUBLICATION:

- Faster Randomized Dynamical Decoupling

Circuit-Based Leakage Detection for Neutral Atom Quantum Computing

BACKGROUND:

Researchers at the University of New Mexico, in collaboration with researchers from the Sandia National Laboratory, have developed a novel, circuit-based leakage detection for atom-loss error in neutral atom quantum computers. The invention utilizes circuit-based leakage detection units (LDUs), which can detect the presence of the data atom and map that onto the 0-1 states of an ancilla qubit. The mapping process can be done without disturbing the information in the data qubit in case of no atom loss. The researchers proposed the implementation of SWAP-style LDUs and teleportation LDUs.

BENEFITS:

- This approach has unique advantages for neutral atom quantum hardware in that the data atom is automatically refilled in the case of leakage, providing savings on recompiling costs in the case of an atom loss event
- Provides a potential strategy for mid-circuit mitigation of atom heating and its resulting deleterious effects on atom loss and gate fidelity
- The LDUs can detect all three major leakage pathways (atom loss, Rydberg and hyperfine leakage)
- Provides a strategy for continuous reloading of a small computational array embedded in a large atom array by continually swapping hot atoms with cold ones

HIGHLIGHTS:

Reference No:
2025-002

Inventors:
Sivaprasad Thattupurackal Omanakuttan
Ivan Deutsch
Sri Datta Vikas Buchemmavari
Yuan-Yu Jau
Bethany Jean Little
Matthew Nickolas Helson Chow
Saurabh Pandey

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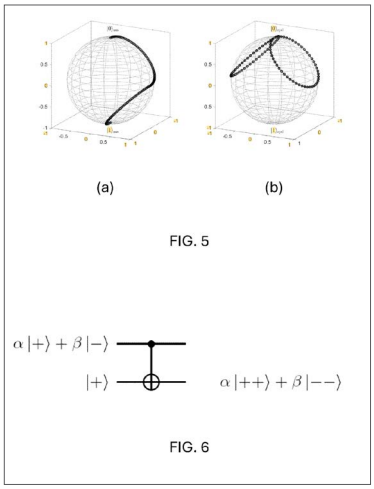
Fault Tolerant Quantum Computation in Spin Systems Using Cat Codes

BACKGROUND:

Researchers have developed a new quantum error-correcting code for spin systems. They have constructed a class of error-correcting spin-cat codes that protects the quantum information against dominant errors in the alkaline-earth atomic systems where quantum information in encoded in a nuclear spin, with multiple levels (a qudit). The dominant errors include dephasing and amplitude damping due to optical pumping when atoms absorb and emit photons. In addition, they have constructed a new universal set of gates that preserves the bias of the dominant errors in these atomic spin systems and enables fault-tolerant quantum computation using spin systems. In particular, a new design for a bias-preserving CNOT gate has been developed and has been used to perform measurement-free error correction. As a result, these codes offer a path to fault tolerance with fewer atoms by taking advantage of the extra available internal degrees of freedom in these atomic systems.



BENEFITS:

- New design of bias-preserving CNOT gate for atomic systems
- New design of measurement-free error correction procedure reduces the resources required to perform reliable computations in the presence of error

HIGHLIGHTS:

Reference No:
2023-042

Inventors:
Sivaprasad Thattupurackal Omanakuttan
Milad Marvian Mashhad
Ivan Deutsch
Sri Datta Vikas Buchemmavari
Jonathan A. Gross

Published Patent Application:
US 2024/0281695 A1

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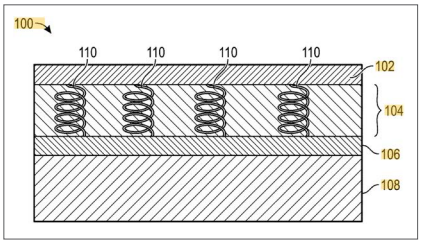
Semiconductor Vertical Spin Valves and Method for Their Production

BACKGROUND:

Researchers at the University of New Mexico and the University of Wisconsin-Madison have developed a vertical spin valve (VSV) based on semiconductor nanomembranes (NMs) engineered with arrays of screw dislocations. The unique symmetry of a screw dislocation generates a helical electric field and a magnetic field that interact with spin-polarized electrons by restricting any changes in spin polarization due to scattering between 0 and 90°. Spin-orbit-coupled electron location deep within the semiconductor bandgap also enables the prevention of hybridization between polarized and unpolarized electrons, resulting in an extended coherence time.

BENEFITS:

- Enables long spin coherence times
- Possibility to control spin texture
- Switches between high and low resistance states, by field or spin torque
- Holds the potential to provide amplification, along with switching functionalities
- Easy integration with traditional semiconductor technology(ies)
- Allows for vertical integration



HIGHLIGHTS:

Reference No:
2021-068

Inventors:
Francesca Cavallo
Max G. Lagally
Mengistie Debasu
Finley Haines
Emma Renteria

Intellectual Property:
Issued Patent No. 12,328,913

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Mid-IR Optical Refrigerators and Athermal Lasers based on New Rare-Earth Doped Crystals: A Path Towards Achieving Sub-80 K Temperatures

BACKGROUND:

Researchers from the Physics and Astronomy department at the University of New Mexico have found an innovative crystal that can potentially outperform Yb-doped refrigeration and laser systems. Optical coolers based on this newly compounded agent have proven to have multiple advantages over previously existing Yb-doped systems. The crystal has an extremely high external quantum efficiency that allows access to lower temperatures even greater than previously achieved. This crystal also offers a high absorption efficiency, which in combination with other key advantages, guarantees the laser cooling efficiency enhancement in the mid-infrared range to achieve cryogenic temperatures as low as 80 Kelvin (-315.67 degrees Fahrenheit or -193.15 degrees Celsius) and below. These are temperatures much lower than previously achieved by systems based on available agents. The compound can allow both coolers and athermal lasers to operate in the eye-safe (~2 µm) region of the spectrum at lower frequencies, proving to be safer than Yb-doped refrigeration and athermal systems in the 1 µm regions. The agent's lack of moisture sensitivity enables achievable preparation of high-quality samples with long-term durability.

BENEFITS:

- Optical cryogenic cooling devices based on this crystal are viable technology to cryogenically cool arbitrary loads such as detectors, electronics and devices
- Silicon and GaAs photonics cooling
- Suitable for Radiation Balanced Lasers (RBLs) in the mid-IR
- Low to no red-shifting for mean emission wavelength

HIGHLIGHTS:

Reference No:
2021-011

Inventors:
Mansoor Sheik-Bahae
Saeid Rostami

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Quantum-Computing in a Scalable Photonic Platform

BACKGROUND:

Researchers from the University of New Mexico and the University of Arizona have developed an on-chip photonic platform to produce 3D continuous variable (CV) cluster states. The platform combines Kerr microcombs and CV quantum information, formulating a one-way quantum-computing architecture. Kerr nonlinearity is utilized with both time and frequency multiplexing to produce reconfigurable one, two, or three dimensional CV cluster states. The quantum-photonic platform's ability to access a large number of spectral modes enables the scalability and robustness required to produce large-scale 3D CV cluster states. This platform can be readily implemented with silicon photonics, opening a promising avenue for fault-tolerant quantum computing at a large-scale.

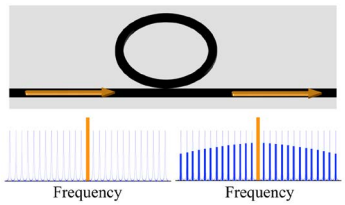

FIG. 1. (Top panel) Classical frequency-comb generation. (Bottom panel) The spectra for the input pump (orange bar) and the output side-mode fields (blue bars).

HIGHLIGHTS:

Reference No:
2020-022

Inventors:
Shuai Liu
Bo-Han Wu
Zheshen Zhang
Rafael Alexander

Intellectual Property:
Issued Patent No. 12,254,381

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BENEFITS:

- One-way quantum computing architecture for mass producible, large-scale, high quality cluster states
- Reprogrammable to produce reconfigurable one, two, or three dimensional CV cluster states
- Readily implemented with silicon photonics

PUBLICATION:

- Quantum-Computing Architecture based on Large-Scale Multi-Dimensional Continuous-Variable Cluster States in a Scalable Photonic Platform

Producing Magic States for Universal Quantum Computation Using GKP Error Correction

BACKGROUND:

Researchers from the University of New Mexico and RMIT University have developed a method for producing continuous-variable magic states for fault-tolerant quantum computing. This specific invention describes a method for achieving all the necessary building blocks for quantum computation using a particular type of qubit. No non-Gaussian resources are required beyond GKP Pauli eigenstates, resolving issues related to current proposed methods that require additional non-Gaussian resources. The described method simplifies the technical requirements for universal, fault-tolerant quantum computing.

BENEFITS:

- Requires only one type of non-Gaussian state for fault-tolerant universal quantum computing
- Solves the problem of creating magic states
- Surpasses other known methods of producing continuous-variable magic states
- Provides a simple and convenient way of preparing magic states that are suitable for a type of quantum error correcting code made from a quantum harmonic oscillator

HIGHLIGHTS:

Reference No:
2019-085

Inventors:
Nick Menicucci
Ben Baragiola
Giacomo Pantaleoni
Angela Karanjai
Rafael Alexander

Intellectual Property:
Issued Patent No. 12,254,382

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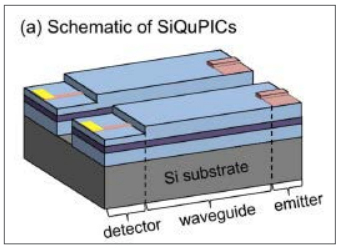
PUBLICATION:

- All-Gaussian Universality and Fault Tolerance with the Gottesman-Kitaev-Preskill Code

Integrated Silicon Photonics Platforms for Scalable Quantum Systems

BACKGROUND:



Researchers from the University of New Mexico and the University of Rochester have developed and provided an integrated platform to implement novel devices for quantum communications. The integrated superconductor platform utilizes an emitter and photodetector for optimal quantum information technology on the same integrated chip. Each quantum application, whether communication, computing, metrology, sensing, etc., has its own requirements that form the basis of silicon quantum photonic integrated circuits. Individual devices such as single-photon sources, detectors, and dielectric waveguides have been largely uncharted in relation to their quantum network but could potentially transform quantum information technology.

BENEFITS:

- Silicon photonics platforms for scalable quantum systems
- Progress in technology related to the generation, manipulation, storage, propagation, and detection of photons for QuIP
- Used in development of large-scale systems

HIGHLIGHTS:

Reference No:
2019-032

Inventors:
Marek Osinski
Ganesh Balakrishnan
Arash Mafi
Roman Sobolewski

Intellectual Property:
Issued Patent No. 12,549,262

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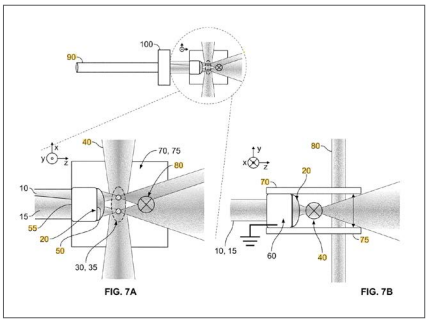
Quantum Information Processing Using Entangled Neutral-Atom Quibits

BACKGROUND:

Researchers at the University of New Mexico and Sandia National Laboratories have developed a new, practical approach that can reliably produce entangled quantum state of an atomic ensemble using Rydberg-dressed blockade. Each atom of the atomic ensemble is loaded into a respective optical trap with the implementation of pump radiation. Every qubit is encoded inside the hyperfine sublevels of a neutral atom from the first atomic quantum state to a second atomic quantum state. By impinging a beam from, e.g., an off resonance Rydberg excitation laser onto the atoms, which have been placed at sufficiently short inter-atomic distances, they can produce the interactions between ground-state atoms that cause some transitions between the states of multiple-qubit basis to be blockaded. The atoms of the atomic ensemble are separated by more than a dipole-dipole interaction length.

BENEFITS:

- Creates an entangled state with one pathway for the Rydberg atom in a two-atom system
- 80% fidelity of generating Einstein-Podolsky-Rosen (EPR)
- Efficient way to generate entangled states with qubit transition pulse
- Can be extended to systems of three or more atoms



HIGHLIGHTS:

Reference No:
2017-048

Inventors:
Ivan Deutsch
Yuan-Yu Jau

Intellectual Property:
Issued Patent No. 9,934,469

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QUANTUM DOT TECHNOLOGIES:

Method for Fabricating Plasmonic Quantum Dots and Related Nanostructures

BACKGROUND:

A method for fabricating plasmonic quantum dots (PQD) as nonlinear optical materials for sensing applications, id described here. This technology will not only help enhance the electric fields in the center of the nanostructure, thus increasing the brightness of the nanoparticles, but will also chemically isolate the QDs from the tissue and significantly reduce the toxicity of such TPAF nanoparticles. This nanoparticle-based material has very high potential for nonlinear optical imaging applications, notably for two-photon absorption fluorescence-based deep tissue imaging.

BENEFITS:

- Method for fabricating plasmonic quantum dots and related nanostructures
- Highly versatile composite material nanoparticle-based plasmonic nanosensors
- High spatial resolution (sub-100 nm)
- Potential use for ultraprecise pH sensing
- Potential for nonlinear optical imaging applications, notably for two-photon absorption fluorescence-based deep tissue imaging

HIGHLIGHTS:

Reference No:
2016-057

Inventors:
Ying-Bing Jiang
Abhaya K. Datye
Ravinder Jain

Intellectual Property:
Issued Patent No. 11,275,089

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Large-Scale Patterning of Germanium Quantum Dots by Stress Transfer

BACKGROUND:

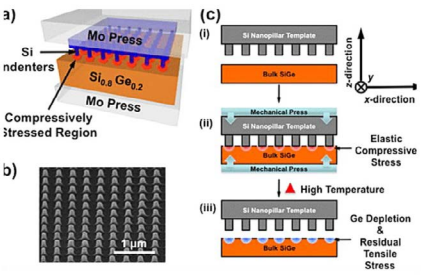
Researchers from the University of New Mexico and the University of Pennsylvania have developed a novel process to produce a 2D array of germanium (Ge) quantum dots on silicon-germanium (SiGe) substrates. The process involves reusable technology that has the potential to offer transformative cost-reductions in fabricating a well-defined 2D array of nanostructures. This technology allows for Ge growth to be steered in a well-defined nanoscale 2D array without forming dislocations, while requiring a high degree of uniformity across large areas.

BENEFITS:

- Single, reusable mold keeps costs low
- Useful across many tech applications
- Even Ge growth across large areas

PUBLICATION:

- Stress-directed compositional patterning of SiGe substrates for lateral quantum barrier manipulation



(a) Schematic representation of assembly used to create patterned stress fields in a SiGe substrate. (b) SEM image of Si nanopillar array used to apply a patterned stress field to the SiGe substrate. (c) Steps in the stress transfer process: (i) place Si nanopillar indenter array on top of SiGe substrate, (ii) press the indenters against the substrate, and (iii) thermally anneal the stack under patterned stress field.

HIGHLIGHTS:

Reference No:
2014-010

Inventors:
Sang M. Han

Intellectual Property:
Issued Patent No. 9,373,547
Issued Patent No. 9,666,431

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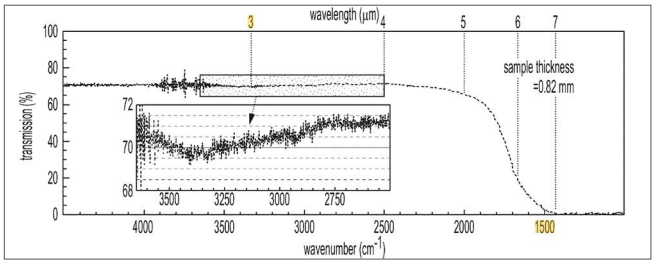
QUANTUM DEVICES:

Titanium Oxide - Rare Earth Oxide Fluorescent Glass Products

BACKGROUND:

Researchers have developed fluorescent glass products based on rare earth metal oxide compositions, which contain optically active ions of rare earth elements. The ability to mix larger and smaller rare earth ions provides a means to optimize compositions to achieve useful optical and possibly other properties. The interaction between optically active components and the host is controlled via composition and processing to control optical properties and fluorescence behavior. Fluorescence behavior is further controlled via wavelength of incident light source(s) and the intensity of the light source in the glass. Due to their high refractive indexes, thermal stability, and high glass transition temperature, rare-earth titanates provide an outmatched alternative to fluoride fibers.

BENEFITS:



- Offer a thermally stable mid-infrared active material from less expensive and more environmentally friendly starting materials than contemporary alternatives
- Ultra-broadband mid-infrared fluorescence from erbium containing samples spanning an entire atmospheric window (from 2.6 to 5.3 microns) under excitation by inexpensive 978 nm laser diodes
- Provide capabilities to achieve optical excitation and emission at various wavelengths

HIGHLIGHTS:

Reference No:
2023-032

Inventors:
Arash Mafi
Brian Topper
Richard Weber
Stephen Wilke

Published Patent Application:
US 2024/0279109 A1

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Actively-Controlled Fast-Switching Gas-Gap Thermal Switch

BACKGROUND:

A gas-gap thermal switch has been developed to achieve ultra-low temperature refrigeration with low 3He usage. Instead of moving helium gas in and out of the switch, thermal conductance has been changed by moving a thermally conductive element (the “shuttle”) within the helium gas. This new thermal switch overcomes a key roadblock to the development of commercial Continuous Adiabatic Demagnetization Refrigeration (CADR) with constant-temperature stages. The design supports CADR with constant-temperature stages without an efficiency or cycle-time penalty and improves performance while simultaneously lowering the barrier to entry into CADR for commercial low-temperature vendors. As a result, this will facilitate the commercial development of CADR as a low-3He drop-in replacement for 3He-dilution refrigeration for wide application in Quantum Information Science and other fields.

BENEFITS:

- Improved thermodynamic efficiency and eliminates the need to heat a sorption pump
- Eliminates the need to pump helium, removing time-consuming uncertainty of attaining fast pump speeds
- Offers fast switching times from fully “on” to fully “off” of 1 second or less
- All of the individual elements have already been well-tested at low temperatures
- Strengthens American competitiveness in cryogenics

HIGHLIGHTS:

Reference No:
2023-004

Inventors:
Stephen Thomas Boyd

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Methods for Spectrally-Selective Laser Circulator for Cryogenic Optical Refrigeration

BACKGROUND:

Researchers from the Physics and Astronomy department at the University of New Mexico have proposed using a spectrally selective element to suppress amplified spontaneous emission (ASE) and parasitic lasing in optical refrigerators. Suppressing ASE and parasitic lasing removes undesired heat generation from the crystal, that degrades the performances of optical refrigerators at cryogenic temperatures, enabling the scaling to high pump power. This selective optical element can be used in a multi-pass pumping cavity of a rare-earth-doped optical refrigerator to efficiently suppress the feedback of the fluorescence at longer wavelengths than that of the pump laser which are responsible for ASE and parasitic lasing in the cooling crystal. The element can be a spectrally selective coating for at least one of the multi-pass pumping mirrors, a wavelength-selective element that can be inserted into the multi-pass cavity to deflect (or absorb) wavelengths longer than the pump wavelength, or a frequency-selective element such as refractive elements, like a prism or diffractive elements.

BENEFITS:

- Prevents amplified spontaneous emission buildup
- Eliminates laser oscillation at longer wavelengths
- Suppresses parasitic lasing
- Removes undesired heat generation from rare-earth doped crystal

HIGHLIGHTS:

Reference No:
2021-075

Inventors:
Mansoor Sheik-Bahae
Alexander R. Albrecht
Azzurra Volpi
Jackston Kock

Intellectual Property:
Issued Patent No. 12,500,386

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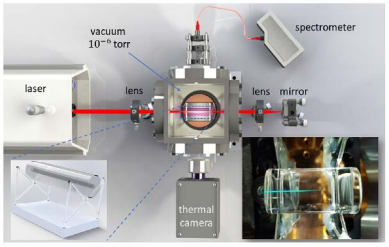
Cooling of Yb-Doped Silica

BACKGROUND:

Researchers at the University of New Mexico have demonstrated radiative cooling of silica glass. Using high-purity Yb-doped silica, they observed an overall cooling of the solid-state fiber. The results obtained prove the feasibility of anti-Stokes fluorescence in silica. This novel discovery sets the foundation for the future of optical refrigeration and strengthens the opportunity for a vibration-free alternative to cryocooling. Additional applications include the use of Yb-doped silica glass for radiation-balanced fiber lasers (RBFLs) in the near-term and photonic-device cooling in the long-term.

BENEFITS:

- First observed cooling of silica glass, which is more widely-used and attainable than the rare-earth-doped crystals and glasses used in the prior art
- Advancement in the future of optical refrigeration, particularly cryocoolers



PUBLICATION:

- Laser Cooling of Silica Glass

HIGHLIGHTS:

Reference No:
2020-041

Inventors:
Mansoor Sheik-Bahae
Arash Mafi
Mostafa Peysokhan
Esmaeil Mobini Souchelmaei
Saeid Rostami

Published Patent Application:
US 2022/0371946 A1

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Device for Photon Statistic Measurement of a Pulsed Light Source

BACKGROUND:

A device has been developed that can distinguish the photon statistics of a given pulsed light source without coincidence counting and without using photon number resolving detectors. This novel method uses an asymmetrical beam splitter rather than a balanced 50:50 beam splitter. Experimental studies using the asymmetrical device confirm the possibility of determining photon statistics of light sources without coincidence counting and avoiding complications due to pulse overlaps from current detectors. This technique can distinguish the thermal light source from a coherent light source and simplify measurement, making the process of photon statistic measurement more cost-effective for a variety of applications.

BENEFITS:

- Does not require coincidence counting and single photon resolving detectors to determine the photon statistics of a light source
- Minimizes errors and uncertainties caused by current methods, while reducing overall cost

PUBLICATION:

- Photon statistics without coincidence counting using an unbalanced beam-splitter

HIGHLIGHTS:

Reference No:
2019-044

Inventors:
Arash Mafi
Hamed Pourbeyram

Intellectual Property:
Issued Patent 11,422,028

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Growth of Cubic Crystalline Phase Structure on Silicon Substrates and Devices Comprising the Cubic Crystalline Phase Structure

BACKGROUND:

An embodiment of the present disclosure is directed to a semiconductor device. The semiconductor device includes a substrate comprising a groove. A buffer layer is formed on a surface of the groove. The buffer layer comprising at least one material chosen from AlN, GaN or AlxGa1-xN, where x is between zero and one. An epitaxially grown semiconductor material is disposed over the buffer layer, at least a portion of the epitaxially grown semiconductor material having a cubic crystalline phase structure.

BENEFITS:

- Inexpensive, large-area substrate for cubic GaN
- Directly compatible with current Si microelectronics technology.
- Eliminates the redshift associated with polarization field in polar wurzite GaN
- High hole mobility (up to 350cm2V-1s-1)
- Low-order optical mode propagation (an effective fiber geometry) and suitable cleavage planes for laser mirrors
- Directed towards the fabrication of both LEDs and transistors

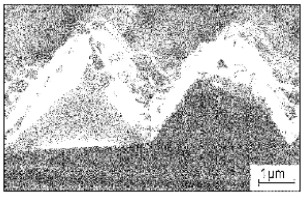

FIG. 4

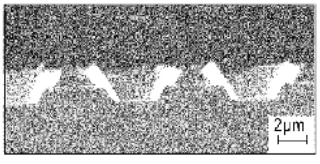

FIG. 5A

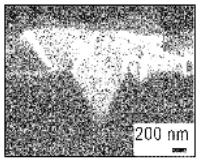

FIG. 5B

HIGHLIGHTS:

Reference No:
2012-110

Inventors:
Steven R.J. Brueck
Seung-Chang Lee
Christian Wetzel
Theeradetch Detchprohm
Christoph J. M. Stark
Mark Durniak

Intellectual Property:
Issued Patents:
9,520,472
10,164,082
10,453,996
10,644,144
10,957,819
12,183,852

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Quantum Key Distribution with Equiangular Spherical Codes

BACKGROUND:

Mutually unbiased-basis protocols have been extensively studied and are simple and effective in quantum key distribution protocols, but they are not optimal. Here equiangular spherical codes are introduced as a more efficient and robust resource for key distribution.

BENEFITS:

- If Alice and Bob use qubits and face the intercept/resend eavesdropping strategy, they can make use of three equally-spaced states, called a trine, to outperform the original four-state BB84 protocol in both speed and reliability.
- Also, the inventor developed specific key creation protocols for the two qubit-based spherical codes, the trine and tetrahedron, and analyzed them in the context of the intercept/resend attack. When compared to the standard unbiased basis protocols, BB84 and six-state, two distinct advantages are found. First, they offer faster key rates and improved security, the trine besting its counterpart BB84 and the tetrahedron the six-state protocol. Second, the key error rate may be computed from the success rate of the protocol itself, removing the need to sacrifice key bits for this purpose. This simplifies the protocol and improves the key rate still further.
- Quantum key distribution protocols based on equiangular spherical codes offer a greater range of security and speed than the mutually unbiased-basis protocols, while also enabling the determination of the channel noise rate without the need to sacrifice key bits.

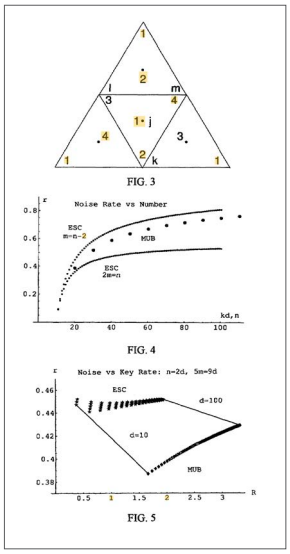

FIG. 3

FIG. 4

FIG. 5

HIGHLIGHTS:

Reference No:
2004-061

Inventors:
Joseph M. Renes

Intellectual Property:
Issued Patent 7,653,199

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QUANTUM SENSING:

Pattern Guided Epitaxy

BACKGROUND:

Researchers at the University of New Mexico have discovered a way to achieve desired shaping during epitaxial growth. The shape of a device can be fully or partially projected into a mask film as a pattern by etching so that the epitaxy can be guided to the growth directions and dimensions predetermined by the pattern. This invention uses the facets generated during pattern-guided epitaxy (PGE) which allows for growth directions not obtainable on the original substrate. This is necessary for the shaping of the desired device and permits additional freedom in the selection of substrate orientation and the 3D mask pattern.

HIGHLIGHTS:

Reference No:
2022-054

Inventors:
Steven R.J. Brueck
Seung-Chang Lee

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BENEFITS:

- Allows for specific growth shaping
- Substrate orientation freedom
- Unlimited mask patterns
- Offers unique growth directions
- Enables 3D nanostructure demonstrations
- Design/control geometric shape of nanostructures with mask profile

Robust, Compact, Fieldable Tunable Integrated Photonic Source

BACKGROUND:

Researchers at the University of New Mexico and University of Southern California have designed an integrated photonic source that can be used in a variety of applications such as telecommunications, chemical sensing, environmental monitoring, and many more. The integrated system consists of chirped grating for tunability, an array waveguide for to direct the spatially variable output channels to a common on-silicon (Si) waveguide platform, an integrated modulator to avoid chirp, gas cell/photo-acoustic spectroscopy for absolute frequency calibration, and an optional power amplifier.

HIGHLIGHTS:

Reference No:
2015-107

Inventors:
Steven R.J. Brueck
Sanjay Krishna
P. Daniel Dapkus

Intellectual Property:
Issued Patent: 10,411,436

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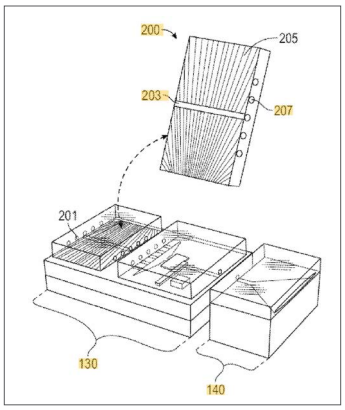
BENEFITS:

- Increased reliability and vibration/environmental insensitivity through utilization of chirped grating as compared with external cavity configurations
- Integrated photonic sensors that are manufacturable and scalable to reduce size, power, and cost
- Accurate frequency calibrations due to gas cell/photo-acoustic spectroscopy
- Power amplifier will allow for increased sensing distances (km)
- Potential integration of HOT detector and optics
- Device works at room temperature



UNM-RELATED QUANTUM PROGRAMS:

Center for Quantum Information and Control (CQuIC)

The Center for Quantum Information and Control (CQuIC) is an interdisciplinary research center located at the University of New Mexico in Albuquerque with activities across the departments of Physics & Astronomy, Electrical & Computer Engineering, and Chemistry & Chemical Biology.

Research at CQuIC is focused on Quantum Information Science, including quantum computation, quantum simulation and complexity, quantum control and measurement, quantum metrology, and quantum optics and communication.

Quantum New Mexico Institute

The Quantum New Mexico Institute (https://qnm.unm.edu) is a joint research entity that seeks to accomplish transformative, long-lasting breakthroughs in Quantum Information Science through the efforts of scientists from the Department of Physics and Astronomy at the University of New Mexico as well as Sandia National Laboratories.

The mission of QNM-I is to expand research & development and education as well as promote efforts to advance the local and regional quantum ecosystem to meet the nation's economic and national security goals.

Quantum Systems Accelerator

The center (https://quantumsystemsaccelerator.org) is one of five Department of Energy Quantum Information Science (QIS) led by Lawrence Berkeley National Laboratory (Berkeley Lab) that will forge the technological solutions needed to harness quantum information science for discoveries that benefit the world. It will also energize the nation's research community to ensure U.S. leadership in quantum R&D and accelerate the transfer of quantum technologies from the lab to the marketplace. Sandia National Laboratories is the lead partner of the center. Research Centers. QSA brings together scientists who are pioneers of many of today's quantum capabilities from the following institutions: Lawrence Berkeley National Laboratory, Sandia National Laboratories, University of Maryland, University of Colorado at Boulder, MIT Lincoln Laboratory, Caltech, Duke University, Harvard University, Massachusetts Institute of Technology, Tufts University, UC Berkeley, University of New Mexico, University of Southern California, UT Austin, and Canada's Université de Sherbrooke.

UNM Rainforest Innovations

Supporting technology transfer and catalyzing economic development at The University of New Mexico

UNM Rainforest Innovations connects groundbreaking research with forward-thinking businesses, entrepreneurs, and investors. We provide a business-friendly, flexible approach to commercializing discoveries. Whether you're seeking innovative technologies, investment opportunities, or startup support, we offer the tools, resources, and expertise to help you thrive while contributing to New Mexico's growing innovation economy.

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Business-Friendly Approach

- Timely and responsive communication with our team
- Streamlined negotiation process for faster deals
- Flexible support tailored to each licensee's needs
- Low-cost standard option agreement to lower entry barriers

Dedicated Support

- Innovation Managers serve as your single point of contact, making it easy to ask questions, get guidance, and stay informed:
- We facilitate access to inventors and university resources throughout the process
- Licensees are actively involved in IP decisions

Funding & Investment Opportunities

- UNM Rainforest Innovations and UNM Foundation Co-Investment program

Tech Scouting & Deal Flow

- Stay up to date with comprehensive technology updates through Flintbox with links that provide publications and patent details if available
- Get matched with relevant innovations and teams

Networking & Visibility

- Engage in events that showcase technologies, connect with researchers, and expand your network in the innovation ecosystem
- UNMRI promotes technologies and startup through tailored presentations that make it easy to evaluate opportunities

Connect with an Innovation Manager:

For more information about any UNM technologies, please contact Alex Roerick, Innovation Manager for Physical Sciences & Engineering at aroerick@innovations.unm.edu.

Explore More Innovations:

Visit our full list of available technologies, searchable by keyword or category, here: UNM Rainforest Innovations' technology portfolio

Alex Roerick
Innovation Manager
Engineering & Physical Sciences
aroerick@innovations.unm.edu

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THE UNIVERSITY OF NEW MEXICO

UNM Rainforest Innovations is the University of New Mexico's technology transfer and economic development organization. We help bring UNM research and discoveries to the world by protecting intellectual property and connecting inventors with businesses, investors, and entrepreneurs. As a nonprofit organization, our mission is to support innovation, foster startup creation, and grow New Mexico's innovation economy.

Contact:

(505) 272-7900
info@innovations.unm.edu
https://innovations.unm.edu/